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The Hartz Reforms, the German Miracle, and Labor Reallocation

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Abstract

We analyse the recent history of unemployment and labor reallocation in the German economy using a variant of Lucas and Prescott's (1974) reallocation model, modified to include unemployment benefits, rest unemployment, and aggregate shocks. We focus on the implied effects of the Hartz reforms and the Great Recession the model, and compare them with the corresponding movements in German data. We find that the model's qualitative predictions for reallocation and unemployment correspond well with the observations. When we calibrate the model to assess its quantitative performance, however, we find that it significantly overestimates the changes of both reallocation and unemployment since the introduction of the Hartz reforms.

JEL Codes: E24, E43, E65, J24, J62, J65

Keywords: Labor market reallocation, unemployment, policy, Hartz reforms

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1 Introduction

Since the turn of the millennium, the German economy has experienced a remarkable sequence of events which have had a significant impact on the structure of its labor market, and which have led to some outcomes that have puzzled some observers. Facing a high and rising unemployment rate (persistently above 10 percent) the German government instituted a series of labor market reforms, known as the Hartz reforms, phased in over the period of 2003 to 2005. These reforms were aimed at improving the flexibility of the market, the mobility of workers, and incentivizing workers to seek work more actively (Jacobi and Kluve, 2007)[1]. As shown in Figure 1, starting in 2005, the unemployment rate declined significantly, dipping below 10 percent for the first time in 2007.

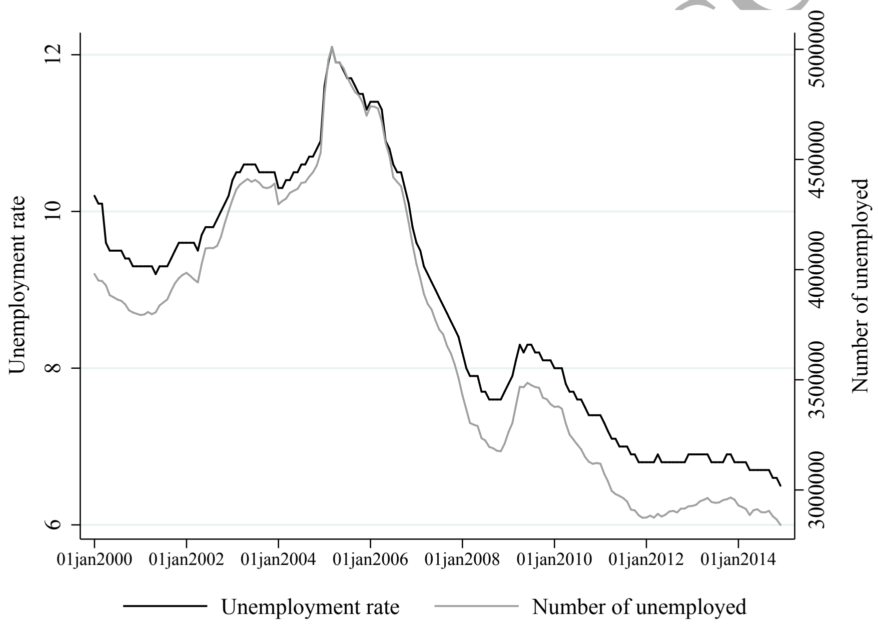

Figure 1: German unemployment rate from 2000-2014, seasonally adjusted
Source: Federal Employment Agency, Statistics Office, "Arbeitsmarkt in Zahlen"

[1] In their classic study, Jacobi and Kluve (2007) identified three "cornerstones" of the Hartz reforms: "increasing effectiveness and efficiency of labour market services and policy measures", "activating the unemployed" and "fostering employment demand by labour market deregulation".

In 2008, like most other economies in the world, Germany was hit hard by the Global Financial Crisis and the Great Recession (GFC, for short). German GDP fell by 6.6 percent (Q1/2008 to Q1/2009) – a drop even more significant than the one experienced by the US at the time (Burda and Hunt, 2011). Productivity fell by a similar percentage – 6.3%, as shown in Figure 2.

However, unlike most countries (including the US) the German unemployment rate did not rise significantly at that time. As shown, once again, in Figure 1 it remained remarkably stable – leading some to call this "Germany's jobs miracle" (see, for example, Krugman (2009)). Viewing Figure 1, and considering the fall in unemployment since that time, it appears that the German unemployment rate was in a dramatic secular decline when the GFC hit, and this decline was temporarily suspended – leading to a relatively stable unemployment over the 2008-2010 period.

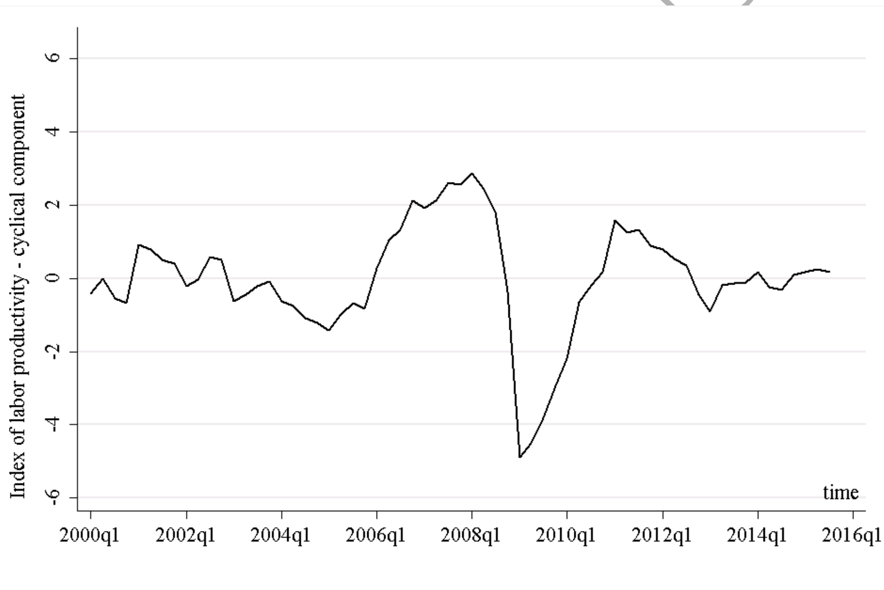

Figure 2: Labor Productivity per employed, chain-index, base year 2010, seasonally adjusted, cyclical component of Hodrick-Prescott filter ($\lambda = 1600$)
Source: Destatis, Genesis Online Database, "VGR des Bundes".

Interestingly, also, although the Hartz reforms were implemented to improve labor market outcomes through more flexibility and mobility, reallocation rates across occupations in Germany have been rather stable over the period (Bauer, 2013; Jung and Kuhn, 2014). Figure 3 presents data on the proportion of job findings that involved an occupational switch, from 2000-2011. At the beginning of the millenium, this number was approximately 37%. From 2003-2006 it was higher, averaging near 40%. It declined back down near 38% over 2007-2009, and climbed back up near 40%, again, subsequently. Thus, arguably, since the introduction of the Hartz reforms, there has been a long run increase in the rate from approximately 37% to approximately 40%, with a short-term interruption, during the GFC which temporarily reduced it to 38%. [2].

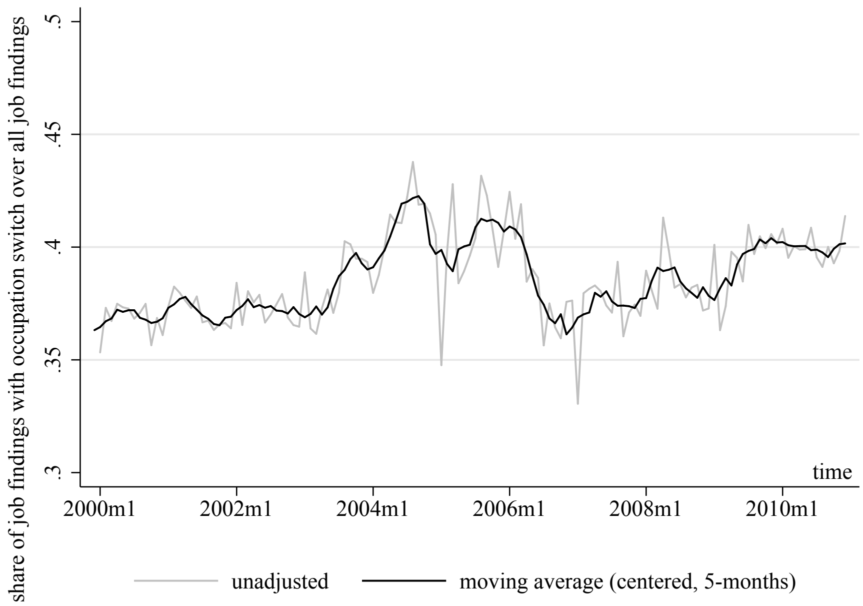

Figure 3: Share of job findings with occupational switch over all job findings
Source: Own calculations, see Appendix B.

In this paper we argue that this reallocation pattern is *qualitatively* consistent with a reallocation model, which is based on Lucas and Prescott (1974), but the *quantitative* predictions of the model are quite different from those observed in the data. In particular, while the model predicts that reallocation would rise in response to the Hartz reforms, then fall back during the GFC, then recover to

[2]In Appendix B.1 an alternative measure based on Lilien (1982) is considered, with similar results.

levels similar to the post-Hartz, pre-GFC levels, it predicts much more dramatic swings in reallocation over time.

Following Jovanovic (1987), Gouge and King (1997), Alvarez and Shimer (2011), and others, we construct a model that includes two types of unemployment: reallocation and rest unemployment, where workers can choose to collect benefits while rest unemployed. Following Jovanovic (1987) and Gouge and King (1997), the model also includes an aggregate shock, to capture business cycle fluctuations. Following King (1990), it also includes explicit moving costs, which allows us to capture some of the key features of the Hartz reforms.

We characterize the stationary equilibrium of the model, focusing on how reallocation, rest unemployment, and total unemployment vary over the cycle – and how these also respond to the changes in benefits and reallocation costs associated with the Hartz reforms. We then calibrate the model to the period before the Hartz reforms (and before the GFC) – choosing reallocation costs, Markov switching probabilities, and productivity levels, to match the observed reallocation rates and total unemployment rates over the pre-Hartz period. We then reduce benefit levels and reallocation costs in a way that is quantitatively consistent with the Hartz reforms, and generate new values for reallocation and unemployment. We then simulate the effect of the GFC by considering a drop in productivity consistent with the unemployment rate over the GFC period and, once again, compute the implied reallocation rate.

We find that, holding productivity levels constant, as the Hartz reforms are introduced, the model predicts a significant decline in rest unemployment (down to zero) and a dramatic rise in reallocation rates – well beyond the changes in the observed data. We also find that, as productivity falls due to the GFC, reallocation rates fall, but not down to the levels in the data. Overall, the model overestimates the effects of the Hartz reforms on both reallocation and unemployment.

1.1 Related Literature

1.1.1 The German Miracle

Some papers about the "German labor market miracle" argue that the relatively mild reaction of unemployment to the GFC wass largely due to labor hoarding induced by "pessimistic expectations" which led to only moderate hiring in the previous expansion and, thus, fewer workers being laid off when the recession occured, (Burda and Hunt, 2011, p.314) paired with flexibility in working hours induced by working time accounts and short-time work (see Burda and Hunt (2011); Möller (2010)). However, other studies argue that wage moderation and the transition to a new (higher) employment level induced by institutional changes through the Hartz reforms were the main driver (Boysen-Hogrefe et al., 2010; Boysen-Hogrefe and Groll, 2010). Effectively, we follow the latter strand of the literature but emphasize a different margin of the "miracle": the role of reallocation and its interaction with the Hartz reforms and the GFC.

1.1.2 The Role of Reallocation

Though a vast literature evaluates the effects of the Hartz reforms on different labor market outcomes, the effects of these reforms on reallocation have not been studied extensively. The main aim of the reforms were to decrease long-term unemployment by increasing labor demand and enhancing labor market flows. The reform was launched in three waves, as discussed at length in other studies (see for example, Jacobi and Kluve (2007) and references therein). Here, we focus on the aspects of the reforms, as discussed in the literature, that one would expect to have affected reallocation significantly.

In the first wave of reform, training measures were restructured. Previously, the training system was "characterized by strong lock-in effects, zero (or even negative) post-participation effects and substantial dead-weight losses" (Tompson and Price (2009, p. 227), Fitzenberger (2008)). The change included measures that were oriented towards labor demand[3], where caseworkers now carefully select people for training (cream-skimming, with a target re-employment rate of 70 percent of the participants) and where the average duration of the measures was shortened to prevent lock-in effects. This realignment aimed to help to update workers' skills and provide long-term unemployed workers with skills that have stronger demand.

[3]The "determination of necessity of further training also considers labor market conditions. This means that the Employment Agency must decide whether e.g. unemployment could be terminated also without further education, whether other instruments of labour market policies are more promising and whether integration in the labour market can be expected with sufficient probability with the aspired education aim" (see https://www.arbeitsagentur.de/ web/content/EN/Benefits/FurtherTraining/Detail /index.htm?dfContentId=L6019022DSTBAI486073).

Furthermore, most of these training measures are dedicated to "further vocational training (FbW)". Studies that evaluate measures of further vocational training find that they improve the prospects of finding a job for the unemployed (Kruppe and Lang, 2014) and that these training measures lead to a "higher probability ... of working in a job whose occupational tasks match the occupational field for which they received vocational training" (Grunau and Lang, 2016). We believe it is reasonable to presume that the new setup of training measures encouraged workers to change their occupation which should increase reallocation.

Secondly, the second wave of reform (Hartz III) changed the organizational structure of the Federal Employment Agency. "Job Centres" were established which, generally speaking, aimed at improving the placement processes through a higher contact rate between unemployed and the placement officers and intensified advice for long-term unemployed workers. We would expect this to have an impact on reallocation in two ways: on the one hand, it should improve the placement process. On the other hand, it might broaden the view for unemployed workers to search for potential jobs in other fields than their previous profession – again, leading to more reallocation.

Thirdly, the last (and, arguably, the most important) of the reforms reduced unemployment compensation for long-term unemployed. Whereas the benefit system was "status preserving" before the reforms, the benefit system for long-term unemployed workers became means-tested. This introduced financial pressure for the long-term unemployed. Combined with the change in the regulation for the "reasonableness" for employment, workers were encouraged to take up jobs in different professions.[4] Moreover, under the new regime, if a benefit recipient refuses to accept a new job then that recipient's benefit level will be cut, initially, by 30%. If the recipient continues to refuse jobs then his/her benefit payments will be replaced by in-kind transfers. Thus, under the new regime, many unemployed workers face the choice of accepting almost any job offered or losing a significant fraction of their transfers (Lohse et al., 2005, p. 9).

Given the changes in the German labor market through the Hartz reforms, we find it surprising that the fluctuations in reallocation were not substantial.

[4]Regulations about the definition of the "reasonableness" of work, and its implications, have been controversial. Some have argued that, under current regulations, almost all work is deemed as "reasonable". In particular, a job for an individual is not seen as unreasonable if it differs from the worker's previous job or if it is more distant, geographically.

A closer look on the reallocation rate reveals that, indeed, reallocation increased to some extent after the Hartz reforms, however this effect appears to be rather small. The reallocation rate depicted in Figure 3 is calculated on a 2-digit occupational level (KldB88, 84 occupational groups after refinements). The absolute change between the starting point in January 2000 and December 2010 is below 5 percentage points, which is small compared to other countries. For instance, Carrillo-Tudela et al. (2016, Figure 4a, dashed line) present the same measure for occupational reallocation for the UK labor market. They find that the reallocation rate for just 9 different occupations is around 50 percent with changes up to 5 percentage points. Similarly, Carrillo-Tudela and Visschers (2013, Figure 2) find for 12 different occupations a reallocation rate of 55 percent with changes around 10 percentage points for the US. As we should expect the share of switchers to rise when the number of occupations under consideration increases, the results for Germany are not just low in levels but also in fluctuations over time.

The remainder of this paper is structured as follows. In Section 2 we introduce the model, identify its equilibrium allocations, derive the key formulas, and present the qualitative effects of the Hartz reforms and the GFC on reallocation and unemployment. In Section 3 we discuss the empirical strategies for choosing the parameters of the model. In Section 4, we present the quantitative results. In Section 5 we present our conclusions. Appendices provide additional details on the data and calculations.

2 The Model

The model is based on Gouge and King's (1997) adaptation of Lucas and Prescott's (1974) model (allowing for both local and aggregate shocks), but differs from Gouge and King's model by the introduction of explicit moving costs (as in King (1990)) when workers reallocate across labor markets. This allows for a more natural interpretation of the effects of the Hartz reforms.

The economy has a large number of spatially distinct competitive local labor markets (we will refer to these local labor markets as *occupations*)[5] and a large

[5]We prefer to interpret each labor market as an occupation although other interpretations are available, in particular: geographic locations, or sectors. As Fahr and Sunde (2009) point out "usually, firms post vacancies for certain qualifications in terms of occupation or education

number of infinitely-lived risk neutral workers, with an average of $\bar{l}$ workers per occupation. Time is discrete and the demand for labor in each occupation is subject to both local and aggregate shocks. In occupation i at time t, the wage w_t^i is determined by

$$w_t^i = \gamma_t^i \theta_t g(n_t^i) \tag{1}$$

where γ_t^i denotes a local shock, θ_t denotes the aggregate shock, n_t^i denotes the employment level in that occupation, and g is an invertible and continuously differentiable function, $g'(n) < 0$, $\lim\limits_{n\to\infty} g(n) = 0$, and $\lim\limits_{n\to 0} g(n) = \infty$.

The local and aggregate shocks follow independent first-order Markov processes, and each shock can take two values: $\gamma \in \{\gamma_H, \gamma_L\}$ where $0 < \gamma_L < \gamma_H$, and $\theta \in \{\theta_H, \theta_L\}$ where $0 < \theta_L < \theta_H$. The transition matrix P for the local shocks is assumed to be symmetric with persistence parameter $\pi > 1/2$ and the transition matrix Q for the aggregate shock is assumed to be symmetric with persistence parameter $\rho > 1/2$. For ease of exposition, we refer to times when the aggregate shock takes the value θ_H as "booms", and times when it takes θ_L as "busts".

Workers observe all current information, have rational expectations, and choose their occupations, in each time period, to maximize the expected discounted value of their income streams, using the discount factor $\beta \in (0, 1)$. Workers can work in only one occupation at any time and, in any period, are identical except for the occupation that they start the period in.

Let l_t^i denote the number of workers that start period t in occupation i. The pair (l, γ) defines the *state* of an occupation. Let $\upsilon_t(l, \gamma)$ denote the equilibrium mass of occupations with state (l, γ) in time t. In the absence of any aggregate shocks, a stationary equilibrium exists in this model in which $\upsilon_t(l, \gamma)$ is constant over time.[6] In the presence of aggregate shocks, however, a stationary equilibrium of this type does not typically exist. In environments such as this, with both local and aggregate shocks, equilibrium behavioral functions may depend on both current and future distributions over the states of occupations. In this paper, however (as

(which are closely related, given the German dual-track education system), and workers primarily look for jobs in their occupation. Given the German dual-track education system, with a strong emphasis on occupational education through the apprenticeship system, occupations are best suited to capture differences in qualificatory demands, differences in skill requirements, particular search channels and search intensity, screening problems and matching speed".

[6] This is the assumption in the original Lucas and Prescott (1974) model, and in King (1990).

in Gouge and King (1997)) we restrict attention to regions in the parameter space where stochastically stationary equilibria exist, where agents need only forecast the evolution of the exogenous aggregate shocks – so behavioral functions are stationary.[7] We therefore use the triple (l, γ, θ) to index types of occupations, and re-write equation (1) in the following way:

$$w(l, \gamma, \theta) = \gamma\theta g(n(l, \gamma, \theta)) \tag{2}$$

At the beginning of any period, in any occupation, any worker can choose from the following three options: work (i.e., supply one unit of labor) in the current occupation at the prevailing wage $w(l, \gamma, \theta)$, stay in the current occupation but not work – and collect benefit payment $b > 0$, or pay an amount $\kappa > 0$ to move from the current occupation to one with a higher beginning-of-period expected value of wage payments. Following Alvarez and Shimer (2011), workers who choose the second option are said to experience "rest" unemployment and, following Lucas and Prescott (1974), workers who choose the third option are said to experience "search" unemployment. Since all workers who choose to search are reallocated, search unemployment is synonymous with worker reallocation in this model.[8]

Let $m(l, \gamma, \theta)$ denote the number of net migrants in occupations of type (l, γ, θ).[9] In any occupation of type (l, γ, θ), then, employment is constrained by

$$n(l, \gamma, \theta) \leq l + m(l, \gamma, \theta). \tag{3}$$

The dynamics of (beginning-of-period) labor supply, in any occupation of type (l, γ, θ), are determined by

$$l_{t+1} = l_t + m(l_t, \gamma_t, \theta_t). \tag{4}$$

[7]In the language of Menzio and Shi (2010), these are block recursive equilibria. As pointed out by a referee, restricting attention to the regions of the parameter space that admit this type of equilibrium is non-trivial, and other equilibria may exist outside of these regions. However, the purpose of this exercise is to assess the performance of a reallocation model in the spirit of Lucas and Prescott (1974), Jovanovic (1987) and Gouge and King (1997) – all of which implicitly restrict attention to block recursive equilibria. While we consider studying equilibria outside of this class to be an interesting exercise, we also consider this to be beyond the scope of this paper.

[8]See Carrillo-Tudela and Visschers (2013) for an interesting model where these two are distinct, due to the existence of search within occupations. We discuss the implications at the end of the paper.

[9]Note that $m(l, \gamma, \theta)$ may be positive, negative, or zero.

Let $\widetilde{V}(l,\gamma,\theta)$ and $V(l,\gamma,\theta)$ denote the expected value, for a worker, associated with an occupation of type (l,γ,θ), before any migration takes place, and after any migration takes place, respectively. Thus:

$$\widetilde{V}(l,\gamma,\theta) = \max\{b,\ \gamma\theta g(l)\} + \beta E\left[V(l',\gamma',\theta')|l,\gamma,\theta\right] \tag{5}$$

$$V(l,\gamma,\theta) = \max\{b,\ \gamma\theta g(l+m(l,\gamma,\theta))\} + \beta E\left[V(l',\gamma',\theta')|l,\gamma,\theta\right]. \tag{6}$$

Now, let $\lambda(\theta)$ denote the expected value that a worker receives if that worker chooses to move, which depends on the value of the aggregate shock θ. Individual workers in occupations of type (l,γ,θ) make the following decisions:

$$\begin{array}{c} If \quad \widetilde{V}(l,\gamma,\theta) \leq \lambda(\theta) - \kappa \quad \textit{the worker is willing to move} \\ If \quad \widetilde{V}(l,\gamma,\theta) > \lambda(\theta) - \kappa \quad \textit{the worker will stay} \end{array} \tag{7}$$

Assuming that all workers who move are allocated so that, in equilibrium, they are indifferent about whether or not they moved,[10] this decision rule implies the following migration rule in occupations of type (l,γ,θ):

$$\begin{array}{c} If\ \widetilde{V}(l,\gamma,\theta) \leq \lambda(\theta) - \kappa\ \textit{then}\ m(l,\gamma,\theta) \leq 0\ \textit{so}\ V(l,\gamma,\theta) = \lambda(\theta) - \kappa \\ If\ \widetilde{V}(l,\gamma,\theta) > \lambda(\theta)\ \textit{then}\ m(l,\gamma,\theta) > 0\ \textit{so}\ V(l,\gamma,\theta) = \lambda(\theta) \\ If\ \lambda(\theta) - \kappa < \widetilde{V}(l,\gamma,\theta) < \lambda(\theta)\ \textit{then}\ \ m(l,\gamma,\theta) = 0\ \textit{so}\ V(l,\gamma,\theta) =\ \widetilde{V}(l,\gamma,\theta) \end{array} \tag{8}$$

2.1 The Stationary Equilibrium

We start by defining what we mean by a stationary equilibrium in this setting.

Definition 1 *A stationary equilibrium, given an initial distribution over the state υ_0 and an initial value for the aggregate shock θ_0, is a collection of functions $V(l,\gamma,\theta)$, $w(l,\gamma,\theta)$, $n(l,\gamma,\theta)$, $m(l,\gamma,\theta)$, $\lambda(\theta)$, and a distribution υ_t such that:*
a) Workers are choosing their occupations to maximize the expected value of their income streams $V(l,\gamma,\theta)$. That is, (7) and (8) are satisfied, given (5)

[10] That is, in an occupation where some workers leave, workers continue to leave until the equilibrium wage in that occupation is driven up to the point where workers are indifferent about leaving or not, as is standard in migration models.

and (6).

b) Wages $w(l,\gamma,\theta)$ are determined by (2).

c) Employment $n(l,\gamma,\theta)$ is determined by (3).

d) Migration $m(l,\gamma,\theta)$ and the value $\lambda(\theta)$ are determined by (8) and aggregate net migration $\int m(l,\gamma,\theta)d\nu = 0$.

e) Local labor force dynamics are determined by (4).

f) The following condition is satisfied for the distribution:
$\upsilon_{t+1} = \int 1_{\{l+m=l'\}}(l)P(\gamma'|\gamma)v_t(dl,d\gamma)$.

In this paper we restrict attention to equilibria where both rest unemployment and search unemployment exist in both booms and busts. This requires certain restrictions on the parameters. In particular, the benefit amount b and the moving cost κ must be in a certain range. Let n_{LH} and n_{LL} denote employment levels in low productivity occupation in booms and busts, respectively. In equilibrium, these are determined where the wage is equated, in each case, with the benefit payment:

$$\gamma_L\theta_H g(n_{LH}) = \gamma_L\theta_L g(n_{LL}) = b. \tag{9}$$

Given (9), as will become clear, the following conditions are sufficient for the co-existence of reallocation and rest unemployment in booms and busts:

$$\gamma_H\theta_H g(2\bar{l} - n_{LH}) < b + [1 + \beta(1-2\pi)]\,\kappa < \gamma_H\theta_L g(\bar{l}) \tag{10}$$

where n_{LH} is determined in (9).

In this restricted equilibrium all workers in high productivity occupations are employed and some workers in low productivity occupations choose rest unemployment, in both booms and busts. The equilibrium value functions for any occupation can take only four possible values $\{V_{HH}, V_{LH}, V_{HL}, V_{LL}\}$ where the first and second subscripts refer to the values of the local and aggregate shocks respectively. Similarly, the equilibrium local labor force values for each type of occupation are given by $\{l_{HH}, l_{LH}, l_{HL}, l_{LL}\}$. Using these values in (6), we have:

$$\begin{aligned} V_{HH} &= \gamma_H\theta_H g(l_{HH}) + \\ &\quad \beta\left\{\rho\left[\pi V_{HH} + (1-\pi)V_{LH}\right] + (1-\rho)\left[\pi V_{HL} + (1-\pi)V_{LL}\right]\right\}. \end{aligned} \tag{11}$$

$$\begin{aligned} V_{LH} &= b + \\ &\beta \left\{ \rho \left[\pi V_{LH} + (1-\pi) V_{HH} \right] + (1-\rho) \left[\pi V_{LL} + (1-\pi) V_{HL} \right] \right\}. \end{aligned} \tag{12}$$

$$\begin{aligned} V_{HL} &= \gamma_H \theta_L g(l_{HL}) + \\ &\beta \left\{ \rho \left[\pi V_{HL} + (1-\pi) V_{LL} \right] + (1-\rho) \left[\pi V_{HH} + (1-\pi) V_{LH} \right] \right\}. \end{aligned} \tag{13}$$

$$\begin{aligned} V_{LL} &= b + \\ &\beta \left\{ \rho \left[\pi V_{LL} + (1-\pi) V_{HL} \right] + (1-\rho) \left[\pi V_{LH} + (1-\pi) V_{HH} \right] \right\}. \end{aligned} \tag{14}$$

Also, given these restrictions, the migration rule (8) implies:

$$V_{HH} = V_{LH} + \kappa \tag{15}$$

and

$$V_{HL} = V_{LL} + \kappa \tag{16}$$

Using equations (11), (12), (13), (14), (15), and (16), we can solve for the following unique equilibrium values for the variables:

$$V_{HH} = V_{HL} = \frac{b + (1-\beta\pi)\kappa}{1-\beta} \tag{17}$$

$$V_{LH} = V_{LL} = \frac{b + \beta(1-\pi)\kappa}{1-\beta} \tag{18}$$

$$\gamma_H \theta_H g(l_{HH}) = \gamma_H \theta_L g(l_{HL}) = b + \left[1 + \beta(1-2\pi) \right] \kappa \tag{19}$$

It may appear puzzling that the value functions in (17) and (18) are independent of the value of the aggregate shock – only the local shock matters for the value of an occupation. This follows, though, from (15) and (16) and our restriction that we are in the region of the parameter space where both reallocation and rest unemployment exist in both booms and busts. Together, these imply that there are only two possible wages in the economy. In low productivity occupations (regardless of the aggregate shock), the equilibrium wage is driven equal to the value of the benefits: b. In high productivity occupations (again, regardless of the aggregate shock) workers earn more but the premium is determined purely by the migration rules (15) and (16). As given in (19), wages in high productivity occupations are equal to $b + [1 + \beta(1 - 2\pi)]\,\kappa$. This is the wage in the low productivity occupations b plus the moving cost κ adjusted by discounting and the probability of switching productivity. As the economy moves (for example) from a boom to a bust the aggregate levels of employment and output both decrease. However, in this case, due to the fact the relative wages for workers in high and low productivity occupations are unchanged as the economy moves from boom to bust, the fact that workers in low productivity occupations receive the same payoffs whether they are working or not, and the fact that the fractions of high and low productivity occupations are independent of the aggregate shock, the *equilibrium* (i.e., post-migration) values associated with being in a high productivity occupation (and with being in a low productivity location) are independent of the aggregate shock.

Thus, we can write the equilibrium wages as:

$$w_{LH} = w_{LL} = b \tag{20}$$

$$w_{HH} = w_{HL} = b + [1 + \beta(1 - 2\pi)]\,\kappa \tag{21}$$

Although wages are independent of the aggregate shock, labor supply and employment levels in each occupation are not. The values of l_{HH} and l_{HL} are determined by (19) and can be found by inverting the function $g(\cdot)$ in each case:

$$l_{HH} = g^{-1}\left(\frac{b + [1 + \beta(1 - 2\pi)]\,\kappa}{\gamma_H \theta_H}\right) \tag{22}$$

$$l_{HL} = g^{-1}\left(\frac{b + [1 + \beta(1 - 2\pi)]\,\kappa}{\gamma_H \theta_L}\right) \tag{23}$$

With l_{HH} and l_{HL} determined, we can find the values of l_{LH} and l_{LL} easily. In the stationary equilibrium, with the symmetric transition matrix P, we know that half of the occupations draw high productivity and half draw low productivity. With the average population per occupation being $\bar{l}$, we obtain:

$$l_{LH} = 2\bar{l} - l_{HH} \tag{24}$$

$$l_{LL} = 2\bar{l} - l_{HL} \tag{25}$$

Also, employment levels are equal to population levels in high productivity occupations:

$$n_{HH} = l_{HH} \tag{26}$$

$$n_{HL} = l_{HL}. \tag{27}$$

Employment levels in low productivity occupations are determined from (9):

$$n_{LH} = g^{-1}\left(\frac{b}{\gamma_L \theta_H}\right) \tag{28}$$

$$n_{LL} = g^{-1}\left(\frac{b}{\gamma_L \theta_L}\right) \tag{29}$$

We can now make a complete ordering of employment and population levels in the different types of occupations.

Lemma 1 *In the stationary equilibrium:*[11]

$$n_{LL} < n_{LH} < l_{LH} < l_{LL} < l_{HL} = n_{HL} < l_{HH} = n_{HH}. \tag{30}$$

Proof. From (22) and (23), since $\theta_L < \theta_H$, it is clear that $l_{HL} < l_{HH}$.[12] Given this, (24) and (25) imply that $l_{LH} < l_{LL}$. From (28) and (29) it is also clear that $n_{LL} < n_{LH}$. Now, using the right hand side of (10) and the right hand side of (19) we get $\gamma_H \theta_L g(\bar{l}) > \gamma_H \theta_L g(l_{HL})$, which implies: $\bar{l} < l_{HL}$. Using this in (25) we get: $l_{LL} < l_{HL}$. Now, from the left hand side of (10) and (19), we have $\gamma_H \theta_H g(2\bar{l} - n_{LH}) < \gamma_H \theta_H g(l_{HH})$. This implies that $2\bar{l} - n_{LH} > l_{HH}$. Using (24), this implies that $2\bar{l} - n_{LH} > 2\bar{l} - l_{LH}$, or $n_{LH} < l_{LH}$. Finally, using (26) and (27) we have the result. ■

[11]From this point forward, we restrict attention only to the stationary equilibrium where the above restrictions hold. Thus, when we refer to the stationary equilibrium it should be understood that the restrictions apply.

[12]Note that our assumption that $g'(\cdot) < 0$ implies that $g^{-1\prime}(\cdot) < 0$.

2.2 Reallocation and Unemployment Over the Cycle

We are now in a position to analyse the values of reallocation, rest unemployment, and total unemployment in the stationary equilibrium, and examine how they vary over the cycle. The following lemma provides formulas for these variables.

Proposition 1 *In the stationary equilibrium, per occupation, for $j = H, L$:*

a) Reallocation in the boom (denoted r_H) and in the bust (denoted r_L) are given by $r_j = (n_{Hj} - \bar{l})(1 - \pi)$.

b) Rest unemployment in the boom (denoted U_H) and in the bust (denoted U_L) are given by $U_j = \bar{l} - (n_{Hj} + n_{Lj})/2$.

c) Total unemployment in the boom (denoted TU_H) and in the bust (denoted TU_L) are given by $TU_j = r_j + U_j$.

Proof. Part (a): In the stationary equilibrium, one half of occupations draw high productivity and one half draw low. Also, a proportion $(1-\pi)$ of low productivity occupations switch to high in the next period. Thus, $.5(1-\pi)$ occupations switch from low to high productivity in any period. These are the only occupations that draw new workers in any period. We know that each of these occupations starts that period with l_{Lj} workers and, from (25) and (24), $l_{Lj} = 2\bar{l} - l_{Hj}$. In equilibrium, at the end of the period, each of these occupations has the population l_{Hj}. Thus, the number of new workers in each of these occupations is $l_{Hj} - (2\bar{l} - l_{Hj}) = 2(l_{Hj} - \bar{l})$. Multiplying this by the fraction of occupations of this type $.5(1-\pi)$ we have $r_j = (l_{Hj} - \bar{l})(1-\pi)$. Finally, using (26) and (27) we have the result.

Part (b): The average population per occupation is $\bar{l}$. One half of these occupations draw high productivity and have employment n_{Hj}. The other half draw low productivity and have employment n_{Lj}. The remainder $\bar{l} - (n_{Hj} + n_{Lj})/2$ choose rest unemployment.

Part (c): This holds by the definition of total unemployment. ■

We can now identify the cyclical properties of reallocation and unemployment.

Corollary 1 *In the stationary equilibrium:*

a) Reallocation is procyclical: $r_L < r_H$.

b) Rest unemployment is countercyclical: $U_H < U_L$.

c) Total unemployment is countercyclical: $TU_H < TU_L$.

Proof. Part (a): From Proposition 1, $r_L - r_H = (1-\pi)(n_{HL} - n_{HH})$. The result then follows from Lemma 1.

Part (b): From Proposition 1: $U_H - U_L = [(n_{HL} - n_{HH}) + (n_{LL} - n_{LH})]/2$. The result then follows from Lemma 1.

Part (c): From Proposition 1: $TU_H - TU_L = (n_{HH} - n_{HL})(1 - \pi - 1/2) - (n_{LH} - n_{LL})/2$. The result follows from Lemma 1, since $\pi > 1/2$. ■

These results are similar to those found in Gouge and King (1997), and for similar reasons. From Proposition 1, it is clear that reallocation is proportional to the employment level in high productivity occupations. This is higher in booms, because the larger value of θ in booms requires a higher employment level to drive the wage in high productivity locations down to its constant value $b + [1 + \beta(1-2\pi)]\kappa$ (implicitly, through the diminishing marginal product of labor). Rest unemployment is lower in booms because this is decreasing in the employment levels in both high and low productivity occupations, which are higher in booms. Reallocation and rest unemployment move in different directions over the cycle but their sum, total unemployment, is countercyclical, being influenced more by rest unemployment than reallocation.

2.3 The Qualitative Effects of the Hartz Reforms

As described in subsection 1.1.2, generally speaking, as outlined above, there were three major initiatives in the Hartz reforms. From the first initiative the quality of training was improved which, should reduce the cost, to the worker, of training. In the model, this is represented by a decrease in the cost of reallocation, κ. The second change was aimed at improving the efficiency of the placement process of the Federal Employment Agency (FEA). Through the reorganization of the responsibilities in the public employment services, a reduction in the number of unemployed workers per job adviser was achieved. This should have helped the workers to receive more appropriate job offers. In the model, this means, once again, κ is reduced. The third initiative consolidated unemployment assistance for long-term unemployed with social assistance benefits to means-tested unemployment benefit (UB II), while insurance-based unemployment benefit (UB I) were mainly unchanged. Essentially, that led to a reduction in the average level of unemployment benefits b. We now consider each of these effects, in turn, using the model.

2.3.1 Training Subsidies and Improvements in the FEA

Both the change in the training subsidies and the improvements in the placement process of the FEA reduce the cost of moving, κ, in this model. From Proposition 1 and the chain rule, it is straightforward to derive the following, for $j = H, L$.

$$\frac{\partial r_j}{\partial \kappa} = \frac{(1-\pi)\left[1+\beta(1-2\pi)\right]}{\gamma_H \theta_j g'(n_{Hj})} < 0 \tag{31}$$

$$\frac{\partial U_j}{\partial \kappa} = -\frac{\left[1+\beta(1-2\pi)\right]}{2\gamma_H \theta_j g'(n_{Hj})} > 0 \tag{32}$$

$$\frac{\partial TU_j}{\partial \kappa} = \frac{(1/2-\pi)\left[1+\beta(1-2\pi)\right]}{\gamma_H \theta_j g'(n_{Hj})} > 0 \tag{33}$$

Thus, the training subsidies and improvements in the placement process (by *reducing* moving costs) increase reallocation and reduce rest unemployment. These effects are both very intuitive: with moving costs reduced, more workers choose to move – reallocate – and, consequently, fewer workers choose to stay in their current occupations for rest unemployment, and collect benefits when times are bad for their current occupation. These effects work in opposite directions on total unemployment, but the downward pressure of rest unemployment outweighs the effect on reallocation, so total unemployment falls.

2.3.2 Reducing Unemployment Benefits

To consider the effects of the reductions in average unemployment benefits, once again, we can use Proposition 1 and the chain rule to derive the following.

$$\frac{\partial r_j}{\partial b} = \frac{1-\pi}{\gamma_H \theta_j g'(n_{Hj})} < 0 \tag{34}$$

$$\frac{\partial U_j}{\partial b} = -\frac{1/2}{\gamma_H \theta_j g'(n_{Hj})} - \frac{{g^{-1}}'(b/\gamma_L \theta_j)}{2\gamma_L \theta_j} > 0 \tag{35}$$

$$\frac{\partial TU}{\partial b} = \frac{1/2-\pi}{\gamma_H \theta_j g'(n_{Hj})} - \frac{{g^{-1}}'(b/\gamma_L \theta_j)}{2\gamma_L \theta_j} > 0 \tag{36}$$

Intuitively, a reduction in unemployment benefits makes rest unemployment less attractive in an occupation hit by hard times – so fewer workers stay and more workers choose to relocate themselves to more productive occupations. Once again, these effects work in opposite directions on total unemployment, but the downward pressure of rest unemployment outweighs the effect on reallocation, so total unemployment falls.

2.3.3 The Overall Effects of the Hartz Reforms

According to this theory, then, the expected effects of all three of the major Hartz reform initiatives would be to *increase* reallocation and *decrease* both rest unemployment and total unemployment. Improved training subsidies, enhanced efficiency of the FEA, and reductions in unemployment benefits all have the same qualitative effects on these economic variables. This, of course, is what we observed in the German economy subsequent to the introduction of these reforms over 2003-2005. Referring, once again, to Figure 1, the unemployment rate fell dramatically, after 2005, stabilized briefly during the GFC period of 2007-2009, then resumed its fall from 2010 onwards. Figure 3 also shows that reallocation increased slightly (from roughly 37% to 40% of job findings) when the Hartz reforms were first introduced, then decreased back down during the GFC, and rose back up to roughly 40% by 2010.

Qualitatively, then, this model is consistent with the experience of the German economy over the entire period. We now turn to consider the question of the quantitative performance of the model over the same period.

3 Calibration

In the following section we divide our observation period into four sub-periods, which we call "regimes". Regime I runs from 2000-2003, covering the time before the Hartz reforms were introduced and Germany faced a high unemployment rate, and low reallocation rate. Regime II runs from 2003-2006, when the Hartz reforms were introduced, and the economy experienced an increase in the reallocation rate and a decrease in unemployment. Regime III covers the GFC: running from 2007 to 2009, where the reallocation rate declined, the secular decrease in unemployment slowed down and productivity dropped. Finally, Regime IV covers the period after the Hartz reforms and the GFC, when the reallocation rate increased again and unemployment started to decline further, while productivity reverted back to the pre-GFC levels.

According to this definition, our empirical targets are the following:

Table 1: Overview of targets

	reallocation rate	unemployment rate
Regime I	0.3740	0.0983
Regime II	0.3985	0.1101
Regime III	0.3836	0.0830
Regime IV	0.4002	0.0768

3.1 Before the Hartz reforms - Regime I

For the parameterization of the model we target the empirical values for the reallocation and the unemployment rate in the first regime by choosing reallocation costs, Markov switching probabilities, and productivity levels. We use equations 22) - (29) in combination with Proposition 1 for this purpose. For the functional form of g, we assume the following: $g(n_t) = \alpha n_t^{(\alpha-1)}$, where we set α according to labor's share in Germany (0.62, see , for example, Karabarbounis and Neiman (2014)).

The discount factor β is set to 0.9625 which corresponds to an average interest rate on long-term government bonds of 3.9 percent (see Appendix E). The value $\bar{l}$ denotes the average workforce per occupation. We divide the average labor force

over the observation window by the number of occupations under consideration (84 occupations, 2-digit KldBB88 classification). This yields a value of 848,000 workers. To assess the level of unemployment benefits in the period before the Hartz reforms, we take the average replacement rate before 2005, which was approximately 60% and multiply by the average annual wage over the period (see Appendix F and C for details). This gives us a value of 21,850 Euros.
We then chose reallocation costs κ, the productivity levels $\gamma_H\theta_H$ and $\gamma_L\theta_H$ and the Markov switching probability π such that the ranking in Lemma 1 is fullfilled. Accordingly κ then amounts to 9,559 Euros,$\gamma_H\theta_H$ to 6,684,280 and $\gamma_L\theta_H$ to 5,651,561. This implies a ratio between γ_L and γ_H of 0.85, meaning that low productivity occupations are 15% less productive than high productivity occupations. The persistence parameter for the local shocks, π, is set equal to 0.9750.

3.2 After the Hartz reforms- Regime II

We introduce the Hartz reforms by lowering both the unemployment benefits (b) and the reallocation costs (κ) as described above. To measure the change in the level of unemployment benefits, we follow existing studies that evaluate the impact of the Hartz reforms. However there is more disagreement than consensus in the calibration of this parameter and its impact in the reduction of the unemployment rate. While Krause and Uhlig (2012) find that the reduction of unemployment benefits account for a drop of 2.8 percentage points in unemployment, Krebs and Scheffel (2013) find that the effect amounts rather to 1.4 percentage points and Launov and Wälde (2013) find a very low impact of 0.3 percentage points. As pointed out by Launov and Wälde (2013), this range is caused by the calibration of the unemployment benefit cut: the stronger the cut, the higher the impact on the unemployment rate[13]. They conclude that "modest numbers of an average benefit reduction under 10 percent ... appear empirically more convincing than the assumption of extreme cuts" (Launov and Wälde, 2013, p. 26). Following this conclusion, we calculate the reduction in unemployment benefits as a 10 percent cut from the benefit level before the Hartz reforms. This yields a reduction in the unemployment benefit level of 2,185 Euros (in real terms) to 19,665 Euros.

[13] Krebs and Scheffel (2013) assume a reduction about 11 percentage points from 0.57 to 0.46, Launov and Wälde (2013) find a reduction of 7 percentage points and Krause and Uhlig (2012) use cuts ranging between 70 and 30 percent.

For the change in κ we measure the decrease from peak to trough in the series of the inverse for average training costs per participant, which implies that moving costs decreased about 30 percent. This gives us a new moving cost level of 7,259 Euros.

The implied unemployment rate out of this calibration is 1.1 percent, and the reallocation rate (the share of job findings that involved an occupational switch) is 100 percent. In this setting, rest unemployment falls completely to zero. This result is caused by the fact that the drop in both unemployment benefits and moving costs is large enough to extinguish rest unemployment – so that all unemployment, in this setting is due to search and reallocation.

3.3 After the Hartz reforms during the GFC- Regime III

To calibrate the GFC we lower the productivity levels, $\gamma_H\theta_H$ and $\gamma_L\theta_H$, to $\gamma_H\theta_L$ and $\gamma_L\theta_L$ so that we match the unemployment rate of 8.3 percent over the period. The implied values for $\gamma_H\theta_L$ and $\gamma_L\theta_L$ are 6,025,210 and 5,094,317 (preserving the ratio γ_L/γ_H to be, once again, 0.85). This yield a reallocation rate of 51 percent, which is again significantly higher than observed in the data (38.4%).

3.4 After the Hartz reforms, after the GFC- Regime IV

Productivity recovered in this period and so Regime IV and Regime II are equivalent in the way the model is calibrated. In both cases, the calibration has high productivity and low (post-Hartz) values for benefits and reallocation costs. Thus, the outcomes for reallocation and unemployment in Regime IV are the same as in Regime II. This is consistent with the view that the decline in unemployment subsequent to the Hartz reforms in 2005 was interrupted by the GFC, but resumed after 2009. Furthermore, the result implies that the Hartz reforms, in combination with a high labor productivity, were sufficient enough to eliminate rest unemployment and reduce the unemployment rate in the long run to approximately 1 percent, according to the model. [14]

[14] For an overview of the calibration exercise, see Appendix G.

3.5 Summary of the calibration results

Table 2 shows our quantitative results in comparison to the data. It is clear that, once again, the model is able to mimic the evolution, qualitatively, of the reallocation rate over time, namely an increase from Regime I to II, a decrease from Regime II to III, and a further increase from Regime III to Regime IV. However, quantitatively, the range of values is too high. According to the data, as the German economy moved from Regimes I to II, it experienced a mild increase of of approximately 3 percentage points of the reallocation rate. The model predicts an increase that is much higher (63 percentage points). This also makes it impossible to target the unemployment rate given in the data, since rest unemplyment drops to zero in the model in Regime II. While our model predicts an unemployment rate of 1.1 percent, the unemployment rate in the data amounts to 11.0 percent. Furthermore the drop in the reallocation rate going from Regime II to Regime III amounts to 2 percentage points in the data, while it is around 50 percent in the model. Hence the reallocation rate in the model is much more volatile than in the data. The reason here is that the drop in unemployment benefits is strong enough to extinguish wait unemployment, which increases the reallocation rate to 100 percent. In the long-run, ceteris paribus, the model predicts that unemployment might drop to 1.1 percent in Germany (see Regime IV) and so the reallocation rate is 100 percent. This clearly overstates the fall in unemployment and the share of job findings that involve occupational switching. Presumably, a key contributing factor for the overestimation of reallocation is that our model abstracts from unemployment due to search *within* occupations. In this model, search is synonymous with reallocation. In a more general model, which includes search within occupations, the share of job findings due to occupational switching would not be 100%, even if rest unemployment were zero.

Table 2: Overview of results

	reallocation rate		unemployment rate	
	model	data	model	data
Regime I	0.37	0.37	0.098	0.098
Regime II	1.00	0.40	0.011	0.110
Regime III	0.51	0.38	0.083	0.083
Regime IV	1.00	0.40	0.011	0.077

4 Conclusion

To the best of our knowledge, this is the first study that uses a Lucas and Prescott (1974) reallocation model for policy evaluation of the Hartz reforms in Germany[15]. We found that the the model predicts that the reduction in unemployment benefits and decrease in reallocation costs of the Hartz reforms in the long-run should significantly reduce unemployment in Germany, as has been observed. Studies that evaluate the impact of the Hartz reforms typically emphasize the role of the reduction in unemployment benefits (Krause and Uhlig, 2012) and the role of the improvement in the efficiency of the FEA (Launov and Wälde, 2013). Our model has similar implications, and we also find that the relative importance of the reduction in moving costs is rather limited compared to the reduction in unemployment benefits.

Our model has the advantage that it explicitly addresses structural unemployment, which was the kind of unemployment the Hartz reforms, arguably, aimed to reduce. Furthermore it examines the link between reallocation and unemployment. While the model successfully captures with this link qualitatively, it has less success quantitatively. One reason for that might be that our model allows for just two types of unemployment: unemployment within islands (wait unemployment) and unemployment across islands (search unemployment). Although the drop in unemployment benefits is calibrated conservatively, it is strong enough to eliminate wait unemployment from the model. Other models, e.g. Carrillo-Tudela and Visschers (2013), feature search not just across but also within islands. This additional type of unemployment might be the key to reconcile the model predictions with the data qualitatively as it prevents within-island unemployment from being eliminated.

We believe that further work, which examines this link between unemployment and the role that reallocation plays in response to aggregate shocks, more generally, is warranted.

[15] Other studies use search models according to Ljungqvist and Sargent (1998) or search and matching models a la Diamond-Mortensen-Pissarides Diamond (1982a,b); Mortensen (1982a,b); Pissarides (1985); Mortensen and Pissarides (1994).

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A Sample of Integrated Employment Biographies (SIAB) of the Insitute for Employment Research (IAB)

The Sample of Integrated Employment Biographies (SIAB) of the Insitute for Employment Research (IAB) covers about 80 percent of the German workforce, excluding civil servants and self-employed. It contains individual employment and unemployment benefit records, episodes for job search and participation in training measures from 1975 to 2010. Next to the common workers characteristics, such as age, gender, nationality, education and vocational training, the data set contains information on the wage, full vs. part-time, the occupation, the industry and a firm identifier, which allows to expand the sample for firm characteristics. The episodes are partly overlapping or even parallel as they are coming from different sources. For example, there might be parallel spells if a workers is receiving unemployment benefits while on a training measure, or is searching for a job but not (yet) receiving unemployment benefits. One advantage of this data set it that the spells are accurate on a daily basis, which allows us to also construct time series and variables such as tenure (firm, occupation, industry).
In this paper, in all our calculations with the SIAB, we define employment as working as a full-time employee (excluding self-employed, family assistants, civil servants, regular students and trainees) and unemployment as actively searching for a job and being available (excluding sickness up to 6 weeks, on the job search and registration at the Federal Employment Agency for seeking advice). To handle parallel notifications, we exclude unemployment benefit receipt, periods in active labor market measures and spells of workers on maternity leave. See vom Berge et al. (2013) for details on the data and `http://fdz.iab.de/en/FDZ_Data_Access.aspx` for information on how to access this data.

B Calculation of reallocation rate

The data used to calculate the measure of reallocation is a similar sample to the SIAB, however with a higher sampling rate of 5%. We used this higher sampling rate, in order to be able to observe transitions between unemployment and employment (and vice versa) on a very disaggregated level without meeting lower bounds of observations. To calculate the measure of reallocation with that sample, we first count the number of transitions between unemployment and employment (job findings) between consecutive months (evaluated at the 10th of each month). Secondly, we count the number of job findings that occur in a different occupation than the one the worker had in the previous employment spell. For this procedure we rely on the 2-digit classification of occupations (KldB88, almost 100 occupations[16]). Note, that we are only interested in whether the occupation is different or not, but not to which occupations worker switch to and come from. We then seasonally adjusted the data to calculate the following statistics:

$$rr_t = \frac{JF_t|_{o=switch}}{JF_t} \tag{37}$$

We then smoothed this monthly statistic by using a 13-month centered moving average filter. For calculating the alternative measures of reallocation we relied on the same sample and the same selection criteria.

B.1 Alternative measures and details on reallocation

To check whether the "reallocation puzzle" holds under another measure of reallocation, we constructed Lilien's (1982) employment dispersion index across 2-digit occupations. While the measure used in the body of the paper relies on gross flows across occupations, Lilien's (1982) measure relies on net flows. To be more precise, Lilien (1982) measures the weighted sum of employment growth deviations across occupations. As can be seen in Figure 4, this alternative measure shows the same picture: A modest increase in reallocation in the mid of the 2000's.

This can also be confirmed by looking at reallocation at a longer time horizon. Figure 5 shows the reallocation rate for Germany since the 1980's. While large movements occurred in the 90's and after 2010, the period between 2000 and 2010 is remarkably stable, which is extraordinary since this is the period where the most comprehensive labor market reforms in the history of Germany happened.

Differences between this graph and the previous one are a result of different

[16] https://statistik.arbeitsagentur.de/Navigation/Statistik/Grundlagen/Klassifikation-der-Berufe/KldB1975-1992/KldB1975-1992-Nav.html

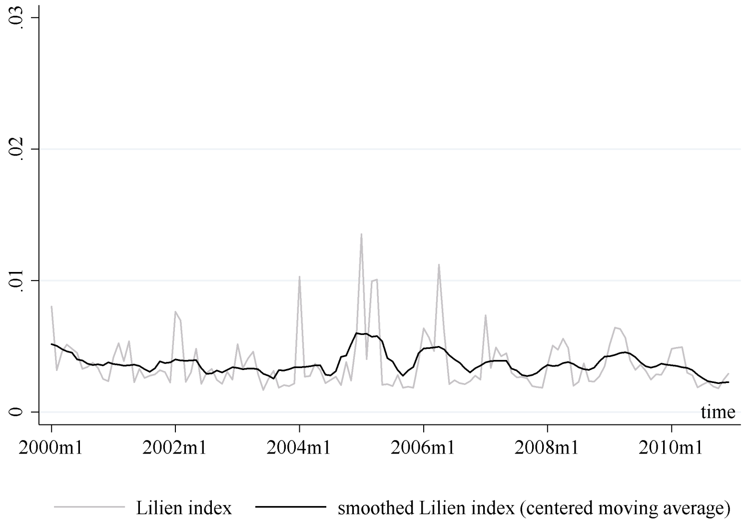

Figure 4: Alternative reallocation measure based on Lilien(1982)

notions of unemployment. While Figure 3 (see main text) uses data on registered unemployment, Figure 5 relies on unemployment benefit receipt to proxy unemployment.

C Wages and Occupations

We also use the SIAB to generate a wages series from 2000 to 2010, aggregated and for every occupation. We restrict the analysis to wages of full-time employees (excluding self-employed, family assistants, civil servants, regular students and trainees) and deflate them by the German consumer price index. As the wage information in these data is censored we impute wages using interval regressions that control for the workers' age and its square, firm tenure, occupational tenure, general labor market experience, education, and occupational status (white-collar, blue-collar, etc.). We impute the wage separately for men and women, for East and West Germany, and by year. The aggregate time series (monthly) given this procedure is as given in Figure 6.

We also generate time series for every occupation in the 2-digit occupational classification. We do so by averaging the wages across all individuals in a certain occupation at a certain month. We exclude occupations that show less than 20

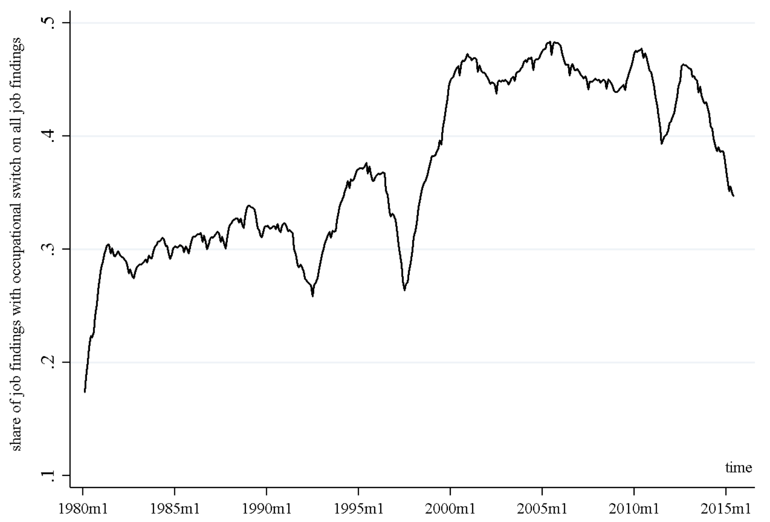

Figure 5: Share of job findings with occupational switch over all job findings – long series

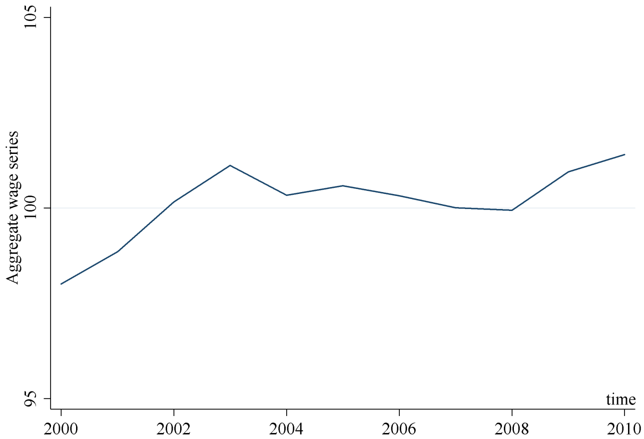

Figure 6: Wage series, 2000 - 2010, Euros, non-seasonally adjusted

observations on average over the period, which leaves us with 84 occupations.

D Reallocation Costs

To measure the change in moving costs, we use the inverse of the average expenditures per participant on training measures that aim at "further occupational training" provided by the Federal Employment Agency. We then multiply this change by the average expenditure on further occupational training per participant. The measure is rather a proxy as it does not cover the expenditures of people that do training without funding of the Federal Employment Agency. We assume that workers face the same costs as the Federal Employment Agency for a training measure. As the training system was already changed in 2003, the data

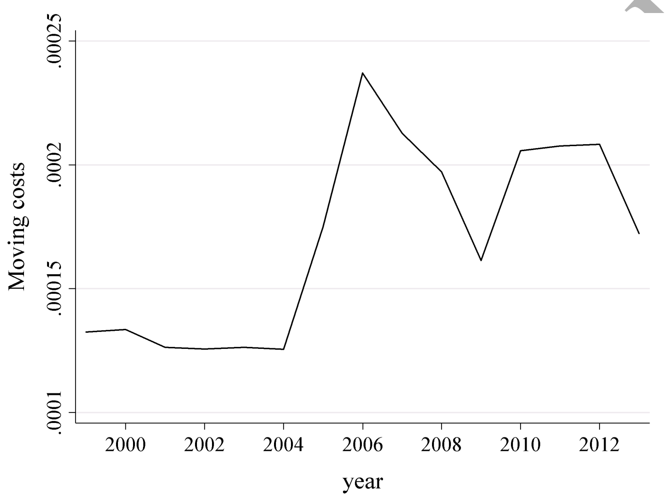

Figure 7: Reallocation costs 2000 - 2010

appears to be at odds with what we expected. The time series shows an increase in the reallocation costs around 2003/2004, and a decrease (what we would have expected) only after 2006. This might reflect that the change in the system took some time to be realized and that the instruments were not used instantaneously by the unemployed workers as supposed. The training system was reorganized by giving training vouchers to the unemployed. However, in the beginning not all of these vouchers were redeemed[17]. Also, training measure (often) have long durations, hence the full effect of appears years later. Hence, we account for that

[17] Not all of the vouchers were redeemed, because e.g. workers were not sure which measure to choose or applied for measures that didn't reach a critical amount of participants (Fitzenberger, 2008, p. 15).

longlasting implementation lag by considering the drop from the peak in 2006 to the trough 2009.

E Discount Factor

The discount factor is calculated as $1/(1+r)$, where r refers to the yield of the current 10 year federal bond (Bundesbank, 2015). This bond yield is available from October 2001 until recently on a daily basis. We averaged this yield to a yearly measure which spans the period from 2001 to 2010. The average yield amounts to 3.9 percent and is decreasing over time.

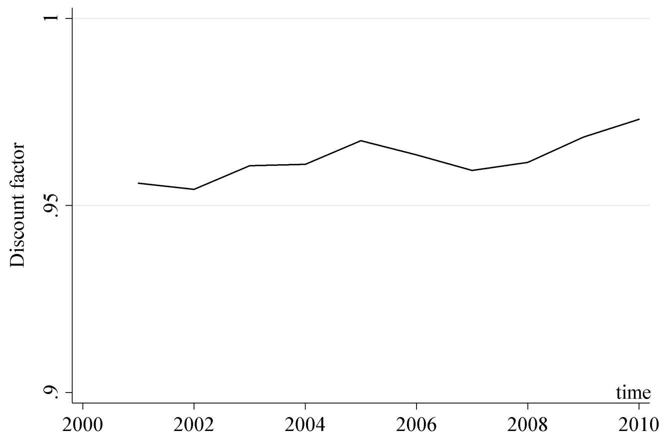

Figure 8: Discount factor 2001 - 2010
Source: Bundesbank (2015), own illustration.

F Replacement Rate

The data from the the DICE (Database for Institutional Comparisons in Europe) (2013) provided by the CESIfo Group Munich reports the average net unemployment benefit replacement rate in the period 2001 to 2010. In detail the measure is calculated as the average over 67 percent and 100 percent of the average worker's earnings level and for different family types (single, the only earner in a married couple, or married to another earning person, with and without children etc..) (CESifo, 2005). The average worker corresponds to an adult full-time worker whose wage earnings are equal to the average wage earnings.

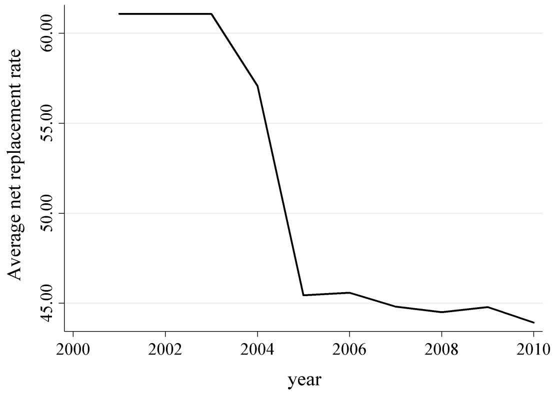

Figure 9: Average net replacement rate over time

The time series shows a decrease in the replacement rate over time from 60 to 44 percent with a substantial drop from 2003 to 2005 which reflects the effects of the Hartz reforms.

G Overview of Calibration

The following table gives an overview of the parameter setting and the results given the targets as outlined in the sections above.

Table 3: Overview of parameters

	π	α	κ	b	$\gamma_H\theta_H$	$\gamma_L\theta_H$	$\gamma_H\theta_L$	$\gamma_L\theta_L$
Regime I	0.9750	0.62	9,559	21,850	6,684,280	5,651,561		
Regime II	0.9750	0.62	6,691	19,665	6,684,280	5,651,561		
Regime III	0.9750	0.62	6,691	19,665			6,025,210	5,094,317
Regime VI	0.9750	0.62	6,691	19,665	6,684,280	5,651,561		