Hartz IV and the Decline of German Unemployment: A Macroeconomic Evaluation[*]

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July 2018

This paper proposes a new approach to evaluate the macroeconomic effects of the Hartz IV reform in Germany, which reduced the generosity of long-term unemployment benefits. We propose a model with different unemployment durations, where the reform initiates both a partial effect and an equilibrium effect. The relative importance of these two effects and the size of the partial effect are estimated based on the IAB Job Vacancy Survey. Our novel methodology provides a solution for the existing disagreement in the macroeconomic literature on Hartz IV. We find that Hartz IV was a major driver for the decline of Germany's unemployment. In addition, we contribute to the literature on partial and equilibrium effects of unemployment benefit changes.

JEL classification: E24, E00, E60
Keywords: Unemployment benefits reform, search and matching, Hartz reforms

1. Introduction

The unemployment rate in Germany has been on a rising trend since the 1970s, reaching its maximum in 2005. Since then, it has dropped by roughly 50% (see Figure 1). At the beginning of this steep decline in 2005, Germany implemented a major reform of its unemployment benefit system. Before the reform, long-term unemployed received benefits proportional to their prior net earnings. These proportional long-term benefits were abolished in 2005 and replaced by a means-tested transfer (dubbed as "Hartz IV") that is independent of prior employment history.
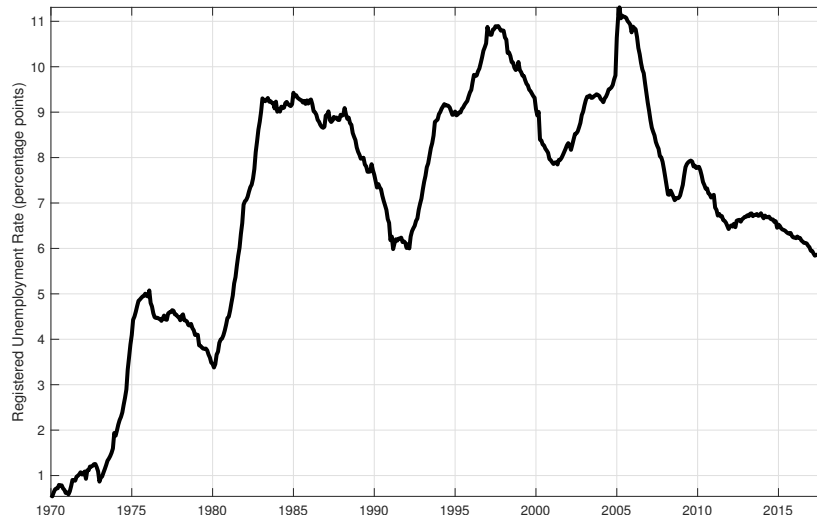

Figure 1: Registered Unemployment Rate in West Germany, 1970-2017. Note that a long time series is only available for West Germany.

While the effects of Hartz IV have been studied in the literature before, up to date no clear consensus has emerged on the quantitative importance of the reform for the decline of unemployment. Quite generally, one can distinguish between two approaches in existing studies. The first is to use microeconometric tools to analyse the reform impact on individuals by exploiting differences in their exposure to the reform. Microeconometric estimations can identify what we call the partial effect (PE) of the reform, i.e. the difference in the job-finding hazard of treated versus non-treated individuals. An example for this literature is a recent paper by Price (2018). He finds statistically significant and economically meaningful employment effects of the reform. If the reform induces further equilibrium effects (EE), e.g. because it affects firms' vacancy posting behaviour, macroeconomic tools are needed. Krause and Uhlig (2012), Krebs and Scheffel (2013), and Launov and Wälde (2013) all evaluate the reform using simulations of different variants of search (and matching) models of the labour market. However, their results differ substantially and range from a decline in unemployment of 0.1 percentage points (Launov and Wälde, 2013) to 2.8 percentage points (Krause and Uhlig, 2012). Different values for the decline of the replacement rate for long-term unemployed caused by the

Hartz IV reform are the key reason for these large discrepancies. In practice, it has turned out to be extremely difficult to assign a number to that variable suited for macro models (see Section 2 for details and a discussion). In fact, estimates of the fall of the replacement rate range from just 7% (Launov and Wälde, 2013) to nearly 70% (upper bound in Krause and Uhlig, 2012).

Against this background, our paper proposes a novel methodology to evaluate the reform through the lens of a macroeconomic model of the labour market that distinguishes between a partial and an equilibrium effect of the reform. Instead of directly assuming a certain reduction of the replacement rate, we empirically measure and then target the partial effect of the reform. In our model, workers have to search and firms have to post vacancies in order to get in contact with one another. Aggregate contacts follow a Cobb-Douglas constant returns function with searching workers and vacancies as inputs. New worker-firm contacts draw an idiosyncratic training cost shock. Only workers below a certain training cost threshold will be selected (see e.g. Chugh and Merkl, 2016; Kohlbrecher et al., 2016; Sedláček, 2014). When benefits for long-term unemployed workers are reduced, the value of unemployment for workers decreases and they are willing to accept lower wages.[1] This decrease in wages initiates two effects. First, firms post more vacancies and the contact rate of all unemployed workers increases. This represents the equilibrium effect. Second, because of lower wages, firms are willing to hire workers with larger idiosyncratic training costs. Thus, the selection rate increases. This increased hiring probability upon contact represents the partial effect in our model.

Our novel evaluation strategy consists of directly determining the partial effect of the reform by estimating the response of the selection rate in the data. For this purpose, we construct a time series for the selection rate using the IAB Job Vacancy Survey, which is a representative survey among up to 14,000 firms. To our knowledge, we are the first to i) construct an empirical measure of firms' selection rate (i.e. hiring standards) over time, ii) thereby provide empirical evidence on the importance of the selection margin, and iii) use this to evaluate a labour market reform. The selection rate increased from 46 percent before the Hartz IV reform (1992-2004) to 53 percent after the Hartz IV reform (from 2005-2015).

Furthermore, we use the time series behaviour of the selection rate and the job-finding rate to determine the relative importance of partial and equilibrium effects over the business cycle. In our model, this pins down the relative size of these two effects in response to unemployment benefit changes. Thus, our paper contributes to the debate on the size of microeconomic and macroeconomic effects of unemployment with respect to benefit changes, which goes far beyond the German case. While there are many papers that estimate the microeconomic effects of different unemployment benefit generosity (see Krueger and Meyer, 2002 for a survey or Card et al., 2015a,b for more recent examples) these may only capture part of the overall effect. This argument is stressed in Hagedorn et al. (2013) who estimate the macroeconomic elasticity based on policy discontinuities at state borders in the United States. Our empirical approach is very different and

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[1]See Figure D.4 in appendix D for descriptive empirical evidence based on the IAB Job Vacancy Survey. A substantial fraction of employers answers that Hartz IV has decreased workers' reservation wages.

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complementary to theirs. To our knowledge, we are the first to use time series of the selection rate to pin down the partial and equilibrium effects over the business cycle.[2]

Overall, our calibrated model suggests that the Hartz IV reform caused the German unemployment rate to drop by 2.6 percentage points. Partial and equilibrium effect each account for roughly half of the initial increase of the job-finding rate.[3] Therefore, aggregate policy statements that are only based on the partial effect would miss an important part of the story.

Compared to the previous macroeconomic literature on the effects of Hartz IV, our results are at the higher end of estimates. Two comments are in order. First of all, both the partial and the equilibrium effect of our model are soundly anchored in the data. Interestingly, although based on a very different methodology, our partial effects are highly comparable to the estimates found by Price (2018) based on microeconomic data.[4] Second, the decline of the replacement rate needed to generate the targeted partial effect in our model depends on the choice of the bargaining regime (individual Nash or collective bargaining). In both cases, however, the required decline is within plausible ranges. This demonstrates another important advantage of our approach. By directly targeting the partial effect in our model, our results are robust to different wage formation mechanisms (see Section 6.1).

Our model further allows us to perform various counterfactual exercises. During the three years after the reform, we obtain a quantitatively similar shift of the Beveridge curve as observed in the data from 2005 to 2007. This confirms that our model generates plausible results and that the Hartz IV reform was an important driver of the observed labour market dynamics.

The rest of the paper proceeds as follows. Section 2 briefly outlines the institutional background on Hartz IV and the consequences for the replacement rate of different population groups. Section 3 derives a suitable search and matching model with labour selection, which allows us to look at the data in a structural way. Section 4 explains our identification strategy for the partial and equilibrium effects and provides empirical results. Section 5 explains the calibration of the contact function and the selection mechanism. Section 6 shows the aggregate partial and equilibrium effects of Hartz IV and performs several counterfactual exercises. Section 7 concludes.

2. The Unemployment Benefit Reform

Prior to the Hartz IV reform, the German unemployment system consisted of three layers. Upon beginning a new unemployment spell, workers received short-term unemployment

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[2]The importance of taking into account equilibrium effects is also stressed by Cahuc and Le Barbanchon (2010) in the context of a different labour market policy.

[3]In subsequent periods, a compositional effect comes into play, as workers experience on average shorter unemployment duration associated with higher job-finding rates.

[4]Given the similar order of magnitude, we could also calibrate the partial effect based on Price (2018) in our macroeconomic model. The advantage of our approach is that the empirical measures we use directly correspond to our model.

benefits ("Arbeitslosengeld"), which amounted to 60-67% of the previous net earnings[5] and was usually paid for 12 months.[6] After the expiration of short-term benefits, the unemployed received long-term unemployment benefits ("Arbeitslosenhilfe"), which replaced 53-57% of the prior net earnings and could be awarded until retirement. If these transfers were not sufficiently high or if unemployed workers did not have a sufficiently long employment history, they obtained means tested social assistance ("Sozialhilfe"). As part of the reform, the proportional long-term unemployment benefits and social assistance were merged to "Arbeitslosengeld II" (ALG II), which is purely means tested based on household income and wealth. The standard rate in 2005 for a single household was 345 Euro.[7] Thus, the system was merged into two pillars, switching from a proportional to a means-tested system for the long-term unemployed. In addition, a second component of Hartz IV, which was implemented in 2006, contained a significant reduction of the maximum duration of short-term unemployment benefits for older workers, in particular those above 57. See Figure 2 for an illustration.[8]
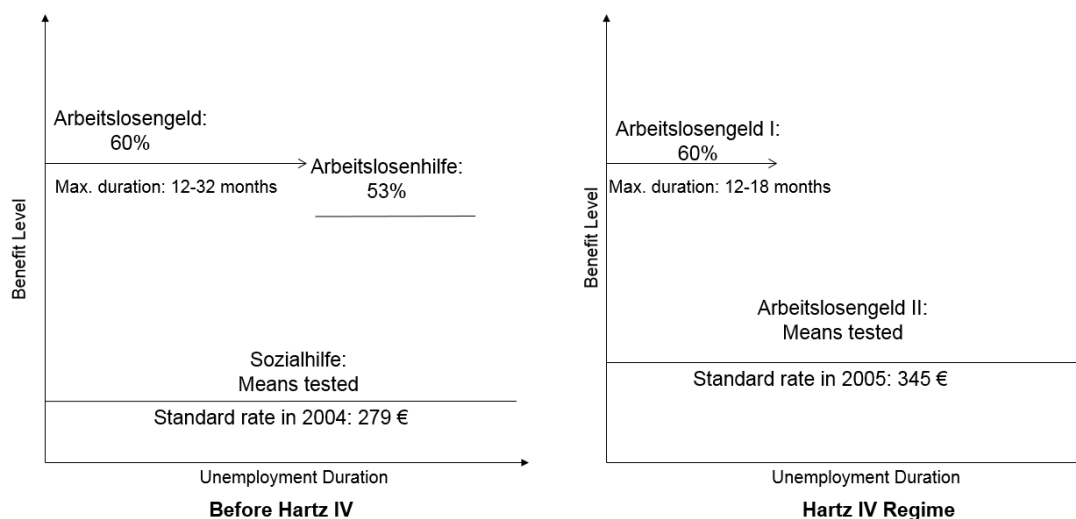

Figure 2: Illustration of the Hartz IV Reform for single households.

As a rule of thumb, the cut of benefits was larger for high income and high wealth households. The former faced a large drop because the new system switched from a system that was proportional to prior earnings to a fixed low-level transfer or because of ineligibility due to high spousal income. The latter faced a large drop because they, too, may have been ineligible for benefits before running down their wealth.

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[5]The higher rate was awarded to recipients with children.

[6]The maximum duration of unemployment benefit receipt gradually increased by age for workers older than 45 years.

[7]Plus a limited reimbursement for rent.

[8]The Hartz IV refom was part of a broader reform agenda. For an overview of the Hartz reforms see Appendix A.

This institutional setting explains why it is difficult to quantify the decline of the replacement rate due to Hartz IV. Some groups faced a strong reduction of the replacement rate. A single median-income earner faced a drop of 69% according to the OECD Tax-Benefit Calculator (Seeleib-Kaiser, 2016). By contrast, some low-income households (without wealth) actually saw a slight increase of their replacement rate. It is very difficult to weigh these groups properly because the low-skilled workers are overrepresented in the pool of long-term unemployed and their benefits changed the least with the reform. On the other hand, many high-income workers who have on average short unemployment spells never touch the pool of long-term unemployed. Even if they do, they might not make a claim for benefits because they would not pass the means testing.[9] Finally, measuring the average decline of the replacement rate is further complicated by the cut in maximum entitlement duration for older workers.

It is therefore not surprising that the key reason for the diverging results in existing macroeconomic studies are different values for the decline of the replacement rate. Krebs and Scheffel (2013) use a decline of 20% for the replacement rate of long-term unemployed in their counterfactual simulation, in Krause and Uhlig (2012) the reduction is around 24% for low-skilled workers and around 67% for high-skilled workers. By contrast, Launov and Wälde (2013) use a decline of 7%. Given the mentioned difficulties in quantifying this drop, we use an outcome variable that is directly affected by a decline of the present value of unemployment (that might be caused both by a decline of the actual replacement rate or cut in entitlement duration), namely the share of workers that is selected by firms upon contact.

3. The Model

We use a version of the Diamond-Mortensen-Pissarides (DMP) model (e.g. Pissarides, 2000, Ch.1) in discrete time. The model is enriched in two dimensions: First, idiosyncratic training costs for new hires, and second a rich unemployment duration structure for unemployed workers with different contact efficiencies and fixed hiring costs. There is a continuum of workers on the unit interval who can either be employed or unemployed. Unemployed workers randomly search for jobs on a single labour market and receive unemployment compensation b^s during the first 12 months of any unemployment spell (i.e. short-term unemployment benefits) and b^l_t afterwards (i.e. long-term unemployment benefits). Long-term benefits have a time index, as these were changed by the reform. Employed workers can lose their job with constant probability ϕ. Unemployed workers are indexed by the letter d, where $d \in \{0, 1, \ldots, 12\}$ denotes the time left in months that a worker is still eligible for short-term unemployment benefits b^s. Therefore, a worker who has just lost a job receives the index 12, while a worker indexed by 0 is considered long-term unemployed. There is a fixed number of multi-worker firms on the unit interval indexed by i. Firms have to post vacancies in order to get in contact with workers and pay vacancy posting costs κ per vacancy. We assume free-entry of vacancies. Contacts

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[9]In this case they would not even by counted as unemployed if they did not register with the Federal Employment Agency.

between searching workers and firms are established via a standard Cobb-Douglas contact function. While all workers search on the same market, the contact efficiency of workers may depend on the duration of unemployment. In addition, workers vary in the amount of training they require for a specific vacancy. Technically, firms and workers draw a match-specific realisation ε from an idiosyncratic training costs distribution with density $f(\varepsilon)$ and cumulative density $F(\varepsilon)$. We assume a fixed training cost component tc^d that reflects that the average training required upon reemployment depends on the duration of the prior unemployment spell.[10] This is consistent with the idea that human capital depreciates during unemployment. Only contacts with sufficiently low training costs, $\varepsilon_{it} \leq \tilde{\varepsilon}_{it}^d$ will result in a hire, where $\tilde{\varepsilon}_{it}^d$ is firm i's hiring cutoff and $\eta_{it}^d = \eta(\tilde{\varepsilon}_{it}^d)$ is the firm's selection rate (i.e. the hiring probability for a given contact). Figure 3 illustrates the main features of the model.
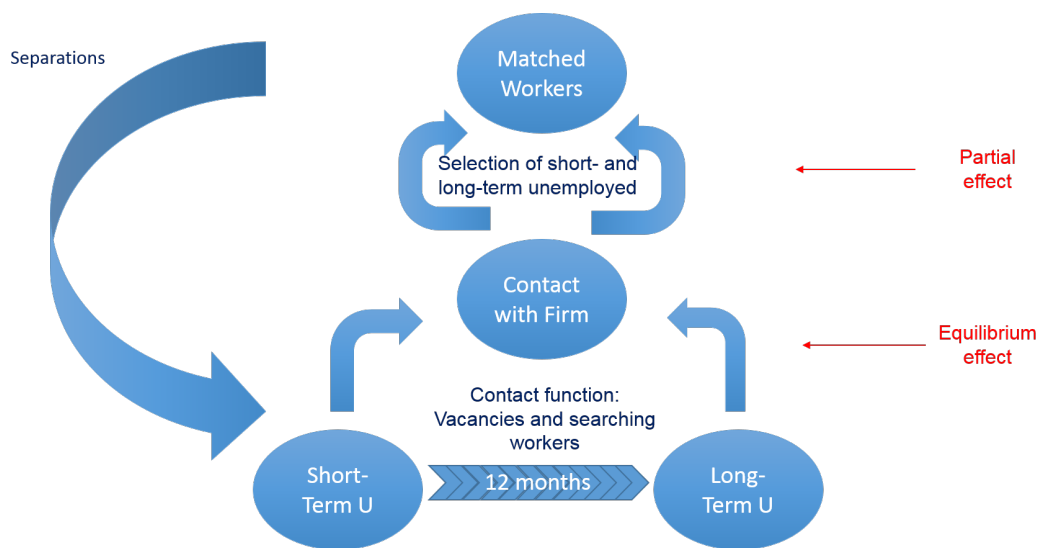

Figure 3: Graphical model description

Our model is similar to that in Kohlbrecher et al. (2016), to the stochastic job matching model (Pissarides, 2000, chapter 6) or many of the endogenous separation models (e.g. Krause and Lubik, 2007). Chugh and Merkl (2016), Lechthaler et al. (2010), and Sedláček (2014) are further examples of labour selection models. Except for different unemployment durations, which are essential for the reform, we do not model further heterogeneities in our theoretical framework (e.g. permanent skill differentials or wealth differentials among unemployed workers). The reason is that the IAB Job Vacancy Survey does not provide any guidance on the selection rate in these dimensions. Thereby, the results across groups would be driven by modelling and parametrisation choices instead of being disciplined by the data.

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[10]We assume that the distribution of the idiosyncratic training cost distribution is the same for all worker types. Equivalently, we could let the mean of the distribution shift with duration of unemployment.

3.1. Firm's Problem

Firms produce with a constant returns technology with labour as the only input. They post vacancies at a fixed cost κ per vacancy. Search is random (i.e. undirected). The probability for a firm of hiring an unemployed worker indexed by duration d depends on three factors: the share of unemployed workers indexed by d among all the searching workers s_t^d, their respective search efficiency which translates into different contact probabilities for firms q_t^d, and the firm's selection rate, $\eta_{it}^d = \eta\left(\tilde{\varepsilon}_{it}^d\right)$, which depends on the firm's hiring cutoff $\tilde{\varepsilon}_{it}^d$.

The firm discounts the future with discount factor δ and chooses employment n_{it}, vacancies v_{it} and its hiring cutoffs $\tilde{\varepsilon}_{it}^d$ for all $d \in \{0, 1, \ldots, 12\}$ to maximise the following intertemporal profit function:

$$E_0 \left\{ \sum_{t=0}^{\infty} \delta^t \left[a_t n_{it} - w_{it}^I(1-\phi)n_{i,t-1} - \kappa v_{it} - v_{it} \sum_{d=0}^{12} s_t^d q_t^d \eta_{it}^d (\bar{w}_{it}^d + \bar{H}_{it}^d + tc^d) \right] \right\}, \quad (1)$$

subject to the evolution of the firm's employment stock and the firm's selection rate for workers with duration index d in every period:

$$n_{it} = (1-\phi)n_{i,t-1} + v_{it} \sum_{d=0}^{12} s_t^d q_t^d \eta_{it}^d, \quad (2)$$

$$\eta_{it}^d = \int_{-\infty}^{\tilde{\varepsilon}_{it}^d} f(\varepsilon)d\varepsilon \quad \forall d. \quad (3)$$

Here and in the following a_t stands for aggregate productivity, n_{it} firm-specific employment, tc^d are fixed training costs, w_{it}^I is the wage for incumbent workers (who do not require any training), and $\bar{w}_{it}^d$ and $\bar{H}_{it}^d$ denote firm i's expectation of the wage and the idiosyncratic training costs realisation conditional on hiring.[11]

Let π_{it}^d and π_{it}^I denote the firm's discounted profit at time t for a newly hired worker with remaining eligibility for short-term unemployment benefits d and for an incumbent worker (indexed by I):

$$\pi_{it}^d(\varepsilon_{it}) = a_t - w_{it}^d(\varepsilon_{it}) - \varepsilon_{it} - tc^d + \delta(1-\phi)E_t\pi_{i,t+1}^I, \quad (4)$$

$$\pi_{it}^I = a_t - w_{it}^I + \delta(1-\phi)E_t\pi_{i,t+1}^I. \quad (5)$$

Taking first order conditions of equation (1) with respect to firm-specific employment n_{it}, vacancies v_{it}, and the hiring cutoffs $\tilde{\varepsilon}_{it}^d$ and rearranging yields the following optimality conditions for the firm:

$$\tilde{\varepsilon}_{it}^d = a_t - \tilde{w}_{it}^d - tc^d + \delta(1-\phi)E_t\pi_{i,t+1}^I \quad \forall d \quad (6)$$

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[11]More specifically, $\bar{w}_{it}^d = \frac{\int_{-\infty}^{\tilde{\varepsilon}_{it}^d} w_{it}^d(\varepsilon)f(\varepsilon)d\varepsilon}{\eta_{it}^d}$ and $\bar{H}_{it}^d = \frac{\int_{-\infty}^{\tilde{\varepsilon}_{it}^d} \varepsilon f(\varepsilon)d\varepsilon}{\eta_{it}^d}$.

and

$$\kappa = \sum_{d=0}^{12} s_t^d q_t^d \eta_{it}^d \bar{\pi}_{it}^d. \tag{7}$$

Note that all variables with a "tilde" sign are evaluated at the cutoff training costs $\tilde{\varepsilon}_{it}^d$ while variables with a "bar" correspond to the expectation of the respective variable conditional on hiring (i.e. the evaluation of the variable at the conditional mean of idiosyncratic training costs and/or wages).

As firms are ex-ante identical, they all choose the same hiring cutoff and hence selection probability. We can therefore write:

$$\tilde{\varepsilon}_t^d = a_t - \tilde{w}_t^d - tc^d + \delta(1-\phi)E_t\pi_{t+1}^I \quad \forall d, \tag{8}$$

and

$$\kappa = \sum_{d=0}^{12} s_t^d q_t^d \eta_t^d \bar{\pi}_t^d. \tag{9}$$

with

$$\pi_t^d(\varepsilon_t) = a_t - w_t^d(\varepsilon_t) - \varepsilon_t - tc^d + \delta(1-\phi)E_t\pi_{t+1}^I, \tag{10}$$

and

$$\pi_t^I = a_t - w_t^I + \delta(1-\phi)E_t\pi_{t+1}^I. \tag{11}$$

Finally, the economy-wide selection rate for workers with duration index d is

$$\eta_t^d = \int_{-\infty}^{\tilde{\varepsilon}_t^d} f(\varepsilon)d\varepsilon \quad \forall d, \tag{12}$$

and the conditional mean (and expectation) of idiosyncratic training costs is

$$\bar{H}_t^d = \frac{\int_{-\infty}^{\tilde{\varepsilon}_t^d} \varepsilon f(\varepsilon)d\varepsilon}{\eta_t^d} \quad \forall d. \tag{13}$$

3.2. Worker's Problem

Workers have linear utility over consumption and discount the future with discount factor δ. Once separated from a job, a worker is entitled to 12 months of short-term unemployment benefits b^s and long-term unemployment benefits b_t^l afterwards, with $b^s > b_t^l$.

The value of unemployment therefore depends on the remaining months a worker is eligible for short-term unemployment benefits. For a short-term unemployed (i.e. $d \in \{1, \ldots, 12\}$) the value of unemployment is given by:

$$U_t^d = b^s + \delta E_t \left[p_{t+1}^{d-1} \eta_{t+1}^{d-1} \bar{V}_{t+1}^{d-1} + (1 - p_{t+1}^{d-1}\eta_{t+1}^{d-1})U_{t+1}^{d-1} \right]. \tag{14}$$

In the current period, the short-term unemployed receives benefits b^s. In the next period, she either finds a job or remains unemployed. In the latter case the time left in short-

term unemployment d is reduced by a month. The probability of finding employment in the next period will depend on the next period's contact probability and selection rate, which both depend on unemployment duration at that point.

After 12 months of unemployment the worker receives the lower long-term unemployment benefits b_t^l indefinitely or until she finds a job:

$$U_t^0 = b_t^l + \delta E_t \left[p_{t+1}^0 \eta_{t+1}^0 \bar{V}_{t+1}^0 + (1 - p_{t+1}^0 \eta_{t+1}^0) U_{t+1}^0 \right]. \tag{15}$$

The value of work for an entrant depends through the wage on the remaining months she is eligible for short-term benefits and on the realisation of the idiosyncratic training cost:

$$V_t^d(\varepsilon_t) = w_t^d(\varepsilon_t) + \delta E_t \left[(1 - \phi) V_{t+1}^I + \phi U_{t+1}^I \right] \quad \forall d. \tag{16}$$

Following our previous notation, $\bar{V}_t^d$ corresponds to the evaluation of $V_t^d(\varepsilon_t)$ at the conditional expectation of ε_t. We allow for the possibility of immediate rehiring. The resulting value of work for an incumbent worker I is:

$$V_t^I = w_t^I + \delta E_t \left[(1 - \phi) V_{t+1}^I + \phi U_{t+1}^I \right], \tag{17}$$

where U_t^I denotes the outside option for an incumbent worker, in case that wage negotiations fail or she is exogenously separated from her job:

$$U_t^I = p_t^{12} \eta_t^{12} \bar{V}_t^{12} + (1 - p_t^{12} \eta_t^{12}) U_t^{12}. \tag{18}$$

3.3. Contacts

Contacts between searching workers and firms are established via a Cobb-Douglas, constant returns to scale (CRS) contact function

$$c_t^d = \mu_t^d v_t^\gamma u s_t^{1-\gamma} \quad \forall d, \tag{19}$$

where us_t are the number of searching workers at the beginning of period t, v_t is the vacancy stock, c_t^d is the number of contacts in period t made with unemployed with duration d, and μ_t^d is the contact efficiency that depends on the duration of unemployment. The contact probability for a worker and for a firm are therefore:

$$p_t^d (\theta_t) = \mu_t^d \theta_t^\gamma \quad \forall d, \tag{20}$$

and

$$q_t^d (\theta_t) = \mu_t^d \theta_t^{\gamma-1}, \tag{21}$$

with

$$\theta_t = \frac{v_t}{us_t}. \tag{22}$$

3.4. Unemployment Dynamics

As the total labour force is normalised to one, the total number of unemployment (and also the unemployment rate) in period t after matching has taken place is the sum over all unemployment states ($d \in \{0, ..., 12\}$):

$$u_t = \sum_{d=0}^{12} u_t^d. \tag{23}$$

Employment in period t is thus given by

$$u_t = 1 - n_t. \tag{24}$$

The number of unemployed with 12 remaining months of short-term benefits is given by the workers that have been separated at the end of last period and were not immediately rehired:

$$u_t^{12} = \phi(1 - p_t^{12}\eta_t^{12})n_{t-1}. \tag{25}$$

The law of motion for unemployment with remaining eligibility of short-term unemployment benefits $d \in \{1, \ldots, 11\}$ is:

$$u_t^d = (1 - p_t^d\eta_t^d)u_{t-1}^{d+1}, \tag{26}$$

and the pool of long-term unemployed consists of the unemployed whose short-term benefit eligibility has just expired as well as previous period's long-term unemployed that have not been matched:

$$u_t^0 = (1 - p_t^0\eta_t^0)(u_{t-1}^1 + u_{t-1}^0). \tag{27}$$

We can now define the number of searching workers at the beginning of period t (before matching has taken place):

$$us_t = \phi n_{t-1} + u_{t-1}. \tag{28}$$

The share of searching workers with remaining short-term unemployment eligibility of d months among all searchers is therefore:

$$s_t^{12} = \frac{\phi n_{t-1}}{us_t}, \tag{29}$$

for newly separated workers,

$$s_t^d = \frac{u_{t-1}^{d+1}}{us_t}, \tag{30}$$

for $d \in \{1, \ldots, 11\}$ and

$$s_t^0 = \frac{u_{t-1}^1 + u_{t-1}^0}{us_t} \tag{31}$$

for long-term unemployed.

3.5. Wages

In the main part of the paper, we assume individual Nash bargaining for both new and existing matches. Workers and firms bargain over the joint surplus of a match, where workers' bargaining power is α and firms' bargaining power is $(1-\alpha)$. The Nash bargained wages therefore solve the following problems:

$$w_t^d(\varepsilon_t) \in \arg\max \left(V_t^d(\varepsilon_t) - U_t^d \right)^\alpha \left(\pi_t^d(\varepsilon_t) \right)^{1-\alpha} \quad \forall d \qquad (32)$$

for newly hired workers with prior duration index d and

$$w_t^I \in \arg\max \left(V_t^I - U_t^I \right)^\alpha \left(\pi_t^I \right)^{1-\alpha} \qquad (33)$$

for an incumbent worker. Note that the individually bargained wage will depend on the idiosyncratic training cost component as the latter enters firms' profits $\pi_t^d(\varepsilon)$.[12] In Appendix C.1 we show results for the polar opposite case when wages are bargained collectively.

3.6. Labour Market Equilibrium

Given initial values for all states of unemployment u_{t-1}^d with $d \in \{0, ..., 12\}$ and employment n_{t-1} as well as processes for productivity and long-term unemployment benefits $\{a_t, b_t^l\}_{t=0}^{+\infty}$, the labour market equilibrium is a sequence of allocations $\left\{ n_t, u_t, us_t, v_t, \theta_t, u_t^d, s_t^d, p_t^d, q_t^d, \tilde{\varepsilon}_t^d, \eta_t^d, \bar{H}_t^d, \pi_t^I, \bar{\pi}_t^d, V_t^I, \bar{V}_t^d, \tilde{V}_t^d, U_t^I, U_t^d, w_t^I, \bar{w}_t^d, \tilde{w}_t^d \right\}_{t=0}^{+\infty}$ for all durations $d \in \{0, ..., 12\}$ that satisfy the following equations: the definition of employment (24), unemployment (23) and searching workers (28), the free-entry condition for vacancies (9), market tightness (22), unemployment (25) - (27), the shares of searching workers (29) - (31), the contact rates for workers (20) and firms (21), the hiring cutoffs (8), selection rates (12), conditional expectation of idiosyncratic hiring costs (13), the definition of profits for entrants (10) and incumbents (11), the value of a job for entrants (16) and incumbents (17), the value of unemployment (14), (15), and (18), and the definition of wages (32) and (33), where wages, the value of work for entrant workers as well as firms' profits for new hires are evaluated either at the cutoff and/or the conditional expectation of idiosyncratic training costs.

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[12]Due to the training costs in the first period, the wage for entrants is smaller than the wage for incumbents in our bargaining setup. However, the net present value of the match for workers and firms at the time of hiring is equivalent to a wage contract where the training costs in the wage are spread over the entire employment spell. Results are available on request.

4. Empirical Strategy

The German Hartz IV reform reduced the replacement rate for long-term unemployed. Less generous unemployment benefits decrease workers' fallback option in our model. The closer unemployed workers get to the expiration of short-term benefits, the lower will be the value of unemployment and the lower will be their reservation wage. This leads to lower bargained wages. One of the key differences of our model relative to the plain vanilla search and matching model (e.g. Pissarides, 2000, Ch.1) is that matching has two components and that two effects are initiated due to a decline in benefits. First, workers and firms have to get in contact with one another, where p_t denotes workers' contact rate. Lower unemployment benefits lead to more vacancy posting by all firms due to higher expected profits. In equilibrium, this leads to a higher tightness in the market and thus a higher contact rate for workers. We call this mechanism the equilibrium effect. Second, upon contact a certain fraction of workers is selected at the firm level, where η_t denotes the selection rate. With lower unemployment benefits and hence lower wages, firms are willing to select workers with higher idiosyncratic training costs at the margin. Thus, the selection rate increases. As this effect takes place at the worker-firm level, we call this mechanism the partial effect.

As the aggregate contact and selection rate are roughly multiplicative in our model ($jfr_t \approx p_t\eta_t$),[13] in terms of log-deviations (denoted with hats), we can express the job-finding rate as the sum of the contact rate and the selection rate:

$$j\hat{f}r_t \approx \hat{p}_t + \hat{\eta}_t, \tag{34}$$

where $\hat{p}_t$ corresponds to the equilibrium effect and $\hat{\eta}$ reflects the partial effect.[14]

This section proceeds in four steps. We will first describe the construction of an empirical measure of the selection rate. We will then demonstrate how the combination of model and data informs us about the partial and equilibrium effect of a benefit reform. In steps three and four, we will describe the empirical implementation for PE and EE.

4.1. Measuring Selection

A core innovation of our paper is the construction of an empirical time series for the selection rate. As our choice of measurement is informed by the model, it is useful in a first step to think about the role of selection from the model's point of view. The selection rate corresponds to the share of workers that is hired upon meeting a firm or, put differently, the probability that a worker that gets in contact with a firm, is hired.

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[13]Note that this connection holds with equality for each duration group $jfr_t^d = p_t^d\eta_t^d$. In aggregate, it only holds with equality on impact when the shares of unemployed workers in different duration groups are equal to the steady state shares. During the adjustment dynamics, composition effects start playing a role. See discussion in Section 6.

[14]For the sake of simplicity, we will refer to the increase of the selection rate as the partial effect. This is slightly inaccurate wording, as there is a small, negative feedback effect from tightness on the selection rate. We will therefore control for tightness in our regressions and target the selection rate increase in partial equilibrium by holding tightness fixed.

Therefore, the selection rate corresponds to the inverse of the average number of contacts a firm makes until it realises a hire. Figure 4 shows the response of the total number of contacts in the model economy and the number of contacts for the last hire in response to a negative benefit shock in a model simulation.[15] The total number of contacts first goes up after the decline of benefits because workers' contact rate increases due to more vacancy posting (the equilibrium effect). In the medium run, it converges to a new steady state below the initial level because the pool of unemployed has declined over time. Very importantly, the number of contacts per hire, which equals the inverse of the selection rate, has completely different dynamics. It drops on impact and stays at a permanently lower level. For example, when a multi-worker firm has a selection probability of 50%, it makes on average two contacts per hire. When the firm selects only 33% of workers, it requires on average three contacts until hiring. As firms select a larger fraction of contacts when benefits - and hence workers' outside option - fall, the number of contacts per hire goes down. Note that if the selection rate was constant, as standard in many search and matching models, the number of matches and the number of contacts in the economy would rise in equal proportion and the number of contacts per hire would not change. With an increased selection rate, however, hires increase more than proportionally which is reflected in a lower number of contacts per hire.
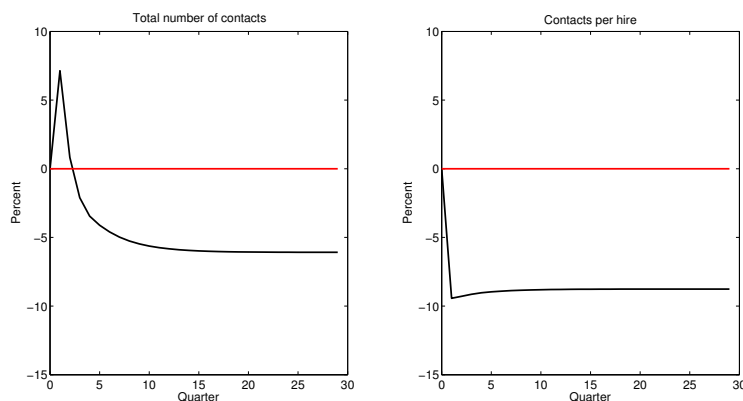

Figure 4: Response of the total number of contacts and contacts per hire in response to a reduction of the replacement rate for long-term unemployed in the baseline calibration.

Based on these insights, we are the first to construct a time series for selection over the business cycle. For this purpose, we use the IAB Job Vacancy Survey which is an annual representative survey of up to 14,000 German establishments.[16] Firms are asked about the number of suitable applicants for their last realised hire. The question is well in line

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[15]Note that the IRFs are based on the calibration as described below. At this stage, we show them for illustration purposes and only discuss the qualitative response.

[16]For more information on the IAB Job Vacancy Survey, see Appendix B.1.

with our model. Given that firms are asked about the number of *suitable* applicants,[17] firms must have screened these candidates in some way (e.g. by checking the application package or by inviting the applicant for an interview). The number of suitable applicants therefore is a natural proxy for the number of contacts a firm has made for the last hire. Thus, we can calculate the average probability of a worker (who got in contact with a firm) to be selected as the inverse of the number of suitable applicants for the last hire. Note that the IAB Job Vacancy Survey is a repeated cross-section. Thus, we can only run regressions at aggregated levels. Using representative survey weights for the last hire, we therefore construct annual selection rate time series on the national (West Germany), state and industry level from 1992 to 2015.[18]

Figure 5 shows the movement of the job-finding rate, selection rate and market tightness from 1992 to 2015. We normalised all three time series to an average of 1 to improve the visibility of relative movements. As predicted by theory, all three time series are procyclical, i.e. they comove positively with the business cycle. It can be seen that market tightness shows much larger fluctuations than the job-finding rate and the selection rate. This is well in line with our model. Kohlbrecher et al. (2016) show that the selection rate comoves procyclically (but less than proportionally) with market tightness over the business cycle in a selection model.

4.2. Linking the Model to the Data

How are these time series helpful for our identification? Ideally, we would be able to identify the reaction of the job-finding rate with respect to benefit changes directly, namely $\partial \hat{jfr}_t / \partial \hat{b}$. Besides the usual econometric issues, this is particularly complicated for the Hartz IV reform. First, several other labour market reforms (namely, Hartz I to III) were implemented in 2003 and 2004 briefly before the Hartz IV reform. These may have affected the job-finding rate through increases in contact efficiency (see e.g. Launov and Wälde, 2016). Second, there is a severe structural break in the data in 2005 when unemployment was redefined in Germany as a direct consequence of the reform. In fact, the definition of unemployment nowadays includes a wider group of people, namely workers who had formerly received social assistance and had not been counted as unemployed under the old system. As the adjustment to the new definition took place over several months, it is very hard to cleanly control for the change in measurement during that time. Finally, it is important to note that unemployment in Germany is based on registration with the Federal Employment Office and not self-reported job search. Unemployed workers not eligible for long-term benefits after the reform may have decided not to register while still searching. Therefore, it would be very misleading to evaluate the reform based on transitions from unemployment to employment as the pool of measured unemployment before and after the reform is not easily comparable (this point is also stressed by Carrillo-Tudela et al., 2018, see Section 6.3).

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[17]In the most recent waves of the survey, firms are also asked about the overall number of applicants. This number is on average substantially higher.

[18]We restrict the analysis to West Germany because of the special conditions in East Germany during the transformation period in the 1990s.
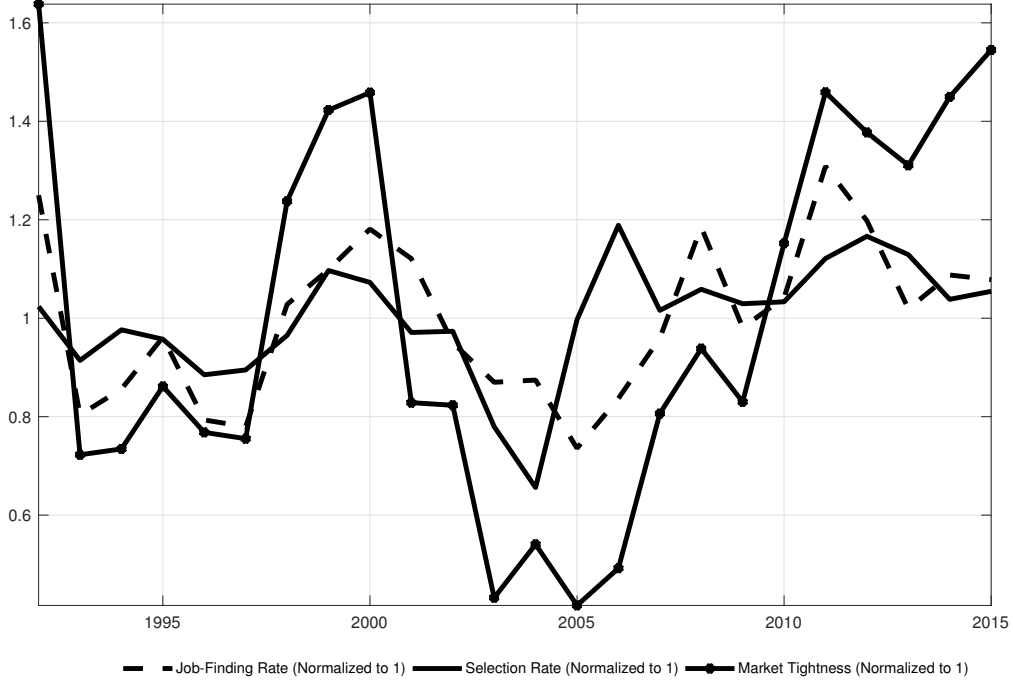
Figure 5: German labour Market Dynamics, 1992-2015.

To circumvent this problem, we apply a novel empirical strategy that combines insights from our theoretical model with our unique time series data. We start with the observation that we can decompose the reaction of the job-finding rate to benefit changes as follows:

$$\frac{\partial \hat{jfr}_t}{\partial \hat{b}} \approx \frac{\partial \hat{p}_t}{\partial \hat{b}} + \frac{\partial \hat{\eta}_t}{\partial \hat{b}}. \tag{35}$$

Unfortunately, we cannot provide any estimates for $\partial \hat{p}_t / \partial \hat{b}$ because there is no direct and independent measure for the contact rate. Our identification therefore consists of two steps. First, we will directly estimate the partial effect $(\partial \hat{\eta}_t / \partial \hat{b})$ based on our time series of selection. As we will argue in Section 4.3, our measure is neither affected by the structural measurement break nor by changes of the contact efficiency. In addition, our time series for labour selection corresponds directly to the mechanism in our model. Based on this measure, we estimate a sharp increase of the selection rate at the time of the Hartz IV reform.

Second, we use an indirect inference method to estimate the equilibrium effect. With an estimate of the partial effect with respect to benefits $(\partial \hat{\eta}_t / \partial \hat{b})$, all we need to know is how important the response of the contact rate is relatively to the response of the selection rate to a shock. Through the lens of our model, the relative contribution of the contact rate and the selection rate to the transmission of aggregate shocks (in our case,

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an aggregate productivity shock) and benefit changes is equivalent.[19] We can therefore use the business cycle behaviour of the job-finding rate and the selection rate to infer the equilibrium effect. To be more precise, we will use the following decomposition:

$$\frac{\partial \hat{jfr}_t}{\partial \hat{\theta}_t} \approx \frac{\partial \hat{p}_t}{\partial \hat{\theta}_t} + \frac{\partial \hat{\eta}_t}{\partial \hat{\theta}_t}. \tag{36}$$

The job-finding rate over the business cycle is a function of market tightness and it can be decomposed into the comovement of the contact rate and the selection with respect to market tightness. Thus, in order to identify the relative importance of the partial effect and the equilibrium effect over the business cycle, we estimate the elasticity of the job-finding rate with respect to market tightness and the elasticity of the selection rate with respect to market tightness.

4.3. Determining the Partial Effect

Our new time series for the selection rate allows us to estimate the partial effect for the Hartz IV reform. Visual inspection of Figure 5 shows that the selection rate - in line with our model prediction - increased substantially in 2005 when the Hartz IV reform was implemented. We have argued before that it is very difficult to estimate the effects of Hartz IV based on the time-series data on unemployment and the job-finding rate. In the following, we provide several arguments why these caveats do not apply to the selection rate. First, the selection rate is derived from the IAB Job Vacancy Survey and is therefore not affected by the change of the unemployment definition or registration incentives in the administrative data. In addition, the selection rate is not directly affected by labour market reforms that improve matching efficiency. Launov and Wälde (2016), for example, argue that the reform of the Federal Employment Agency (Hartz III reform in 2004) has increased the matching efficiency in Germany substantially and was therefore a key contributor for the decline of unemployment in Germany. In our model, however, improved matching efficiency does not directly impact the selection rate, as selection takes place after contacts between workers and firms have been established. While there is an indirect effect though bargained wages, it is negative and small (see Figure C.2 in the Appendix). In this case, we obtain a lower bound when we estimate the partial effect. One might also object that the selection rate could be affected by changes in workers' search behaviour caused by the reform. A common perception is that under the new and stricter benefit regime workers are required to document search effort, e.g. in forms of written applications. Two scenarios are possible: Either, these forced applications are not meaningful and do not make it into the pool of suitable applicants. In this case the selection rate would be unaffected. Or the number of suitable applicants increases which would lower the measured selection rate. Again, if we find an increase of the selection rate in response to the reform, it is downward biased. Finally, it is worthwhile pointing out that the reform introduced a permanent change in policy. For all these reasons, we

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[19]This can be shown numerically and also analytically in a simplified version of the model. Results are available on request.

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believe that it is a valid strategy to estimate the reform effect with a simple shift dummy. Of course, while the selection rate is not immediately affected by changes in tightness (equilibrium effect), there is a small feedback effect through the influence of contact rates on wages. We take this into account in our estimation.

In order to obtain the partial effect of Hartz IV on the selection rate, we run versions of the following regression

$$\ln \eta_t = \beta_0 + \beta_1 D_t^{Hartz\ IV} + \beta_2 \ln \theta_t + \beta_3 X_t + \nu_t. \tag{37}$$

The dependent variable $\ln \eta_t$ is the logarithm of the selection rate, which is regressed on a shift dummy that takes the value of one from 2005 onward ($D_t^{Hartz\ IV}$) to measure the differences in the selection rate before and after Hartz IV. We control for potential feedback effects of market tightness θ_t on the selection rate.[20] Furthermore, X_t denotes controls which we add in robustness checks, and ν_t is the error term.

Due to data availability, we perform the baseline estimation on an annual basis for the sample range 1992 to 2015. In a robustness check, we also perform a fixed-effects panel estimation on West German state and industry level, which yields very similar results.

Table 1 shows that conditional on tightness the aggregate selection rate has increased by 13% after the reform.[21] The estimated coefficient is statistically significant at the 1% level. Of course, our estimation does not allow us to causally link this effect to the reform. In the above discussion, we have already ruled out several alternative explanations. In addition, a number of robustness checks support our claim that the observed increase of the selection rate is indeed linked to the benefit reform. In column 2 and 3 of Table 1, we show that the results are very similar if we disaggregate by state and industry and use a panel fixed-effects estimator. Moreover, our results are robust if we control for the share of vacancies for low-qualification jobs and the share of long-term unemployed in the pool of unemployment (see columns 4 and 5 in Table 1).[22]

Could the increase in the selection rate capture some general trend in the economy unrelated to the labour market reform? In order to illustrate that our Hartz IV-dummy effect is no coincidence, we perform several regressions with placebo shift-dummies in the years before and after the reform. Figure 6 clearly supports our view that the jump of the selection rate took place in 2005, the year of the reform. Shift-dummies starting in all other years but 2005 and 2006 are not statistically different from zero. In addition, it is not surprising that the dummy coefficient in 2006 is still significant as the second reform step of Hartz IV (the cut in the entitlement duration) was implemented in February 2006 and hence captures part of the reform effect. In addition, this exercise shows that the increase of the selection rate cannot be attributed to earlier Hartz reforms (I to III) or the wage moderation starting in the early 2000s.

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[20]As the policy change is permanent, effects of future profits are directly reflected in the current level of tightness.

[21]If we control for gdp growth instead of market tightness, the selection rate increases by slightly more (14.4%).

[22]It could be the case that the pool of the unemployed or the types of vacancies posted change due to the reform and over the business cycle.
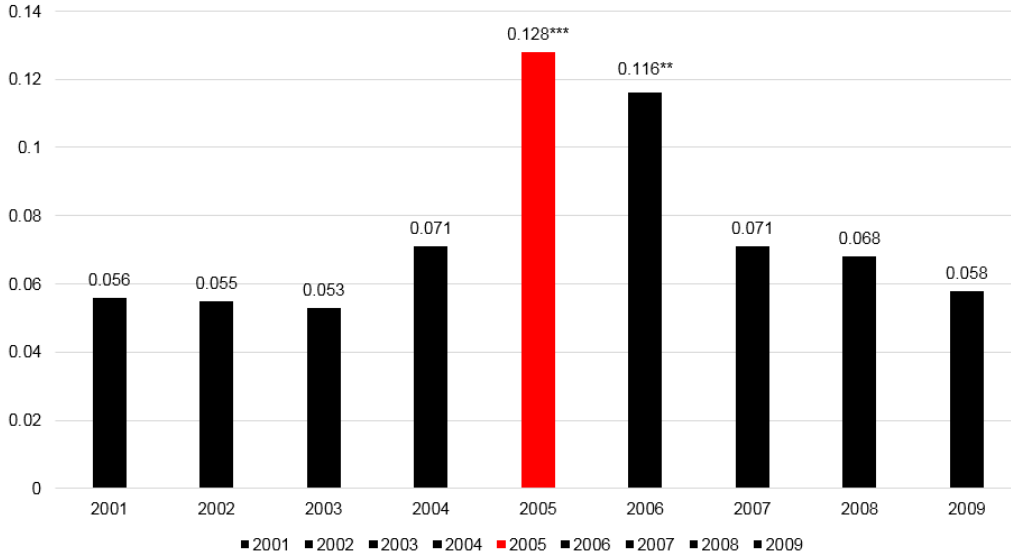
Figure 6: Alternative shift-dummies starting in each respective year

Figure D.3 in Appendix D shows further that the increase of the selection rate between 2004 and 2005 was largest for workers in the middle of the skill distribution. This is in line with our expectation. Compared to workers in the middle of the skill distribution, low-skilled workers faced a moderate decline of the replacement rate due to the Hartz IV reform (see Section 2), while high-skilled workers usually face short unemployment spells and therefore a lower risk of becoming long-term unemployed. Thus, medium-skilled workers were hit hardest by the Hartz IV reform and thereby reacted most in terms of the selection rate. While we agree that it would be desirable to study the cross-sectional response of the selection rate in more detail, we are limited by information provided in the data. Information on skills is for example not available for a longer time-series.

Finally, although we cannot establish a causal relationship, the quantitative order of magnitude of our estimates is very close to Price's (2018) causal results. In our context, using the selection rate to measure the partial effect is preferable as it directly corresponds to the mechanism described in our model. Furthermore, our framework allows us to make statements on the relative importance of partial versus equilibrium effects.

Table 1: Estimates of the Partial Effect, Results for West Germany, 1992-2015.

	Dependent variable:				
			log(selection rate)		
	OLS	*Fixed effects panel linear*		*OLS*	
	Aggregate West Germany	State Level	Industry Level	Aggr.: Low Qualification	Aggr.: Long-term U
	(1)	(2)	(3)	(4)	(5)
Hartz IV Dummy	0.13***	0.10***	0.12***	0.17***	0.14**
	(0.04)	(0.03)	(0.03)	(0.04)	(0.06)
log(market tightness)	0.15***	0.10***	0.08***	0.11***	0.14***
	(0.05)	(0.01)	(0.02)	(0.04)	(0.05)
log(low_qualification)				0.39**	
				(0.17)	
log(share_long-term u)					0.18**
					(0.07)
Constant	−0.56***			0.18	−0.41***
	(0.09)			(0.37)	(0.12)
Observations	24	120	192	24	18
R^2	0.54	0.22	0.18	0.72	0.53
Adjusted R^2	0.50	0.18	0.14	0.67	0.43
Residual Std. Error	0.09 (df = 21)			0.07 (df = 20)	0.11 (df = 14)
F Statistic	12.50*** (df = 2; 21)	16.25*** (df = 2; 113)	20.57*** (df = 2; 182)	16.83*** (df = 3; 20)	5.32** (df = 3; 14)

Note: Aggregate estimation by OLS with Newey-West standard errors; Panel estimation with fixed effects (state and industry fixed effects respectively) and standard errors clustered at group level. Due to data availability, the regression for long-term unemployed covers the shorter time span 1998 - 2015. *p<0.1; **p<0.05; ***p<0.01

4.4. Determining the Importance of PE and EE

The estimated partial effect of Section 4.3 will be imposed in our calibration. In different words, in our simulation exercise, we will reduce the unemployment benefits by the amount necessary to obtain a 13% increase of the aggregate selection rate, while keeping contact rates constant.[23]

Now, given an estimate for the partial effect, we need to determine the relative importance of partial and equilibrium effect. Therefore, we estimate the elasticity of the job-finding rate and the selection rate with respect to market tightness

$$\ln Y_t = \beta_0 + \beta_1 D_t^{Hartz\ IV} + \beta_2 \ln \theta_t + \nu_t, \tag{38}$$

where the dependent variable $\ln Y_t$ is either the logarithm of the job-finding rate (based on administrative data) or the logarithm of the selection rate.

The estimated elasticities are equal to 0.31 for the job-finding rate, and 0.15 for the selection rate (see Table 2). To our knowledge, we are the first to estimate the elasticity of the selection rate from time series data and thereby to quantify the contribution of the selection margin for the behaviour of the job-finding rate over the business cycle.

Two things are worth pointing out in this context. First, the estimated elasticity of the job-finding rate with respect to market tightness is well in line with other matching function estimations for Germany such as Hertweck and Sigrist (2013) (based on data from the German Socio-Economic Panel) and Kohlbrecher et al. (2016) (based on detailed administrative data). Second, the elasticity of the selection rate with respect to market tightness is smaller than the elasticity of the job-finding rate.[24] Thus, the dynamics of the job-finding rate is both driven by contact and selection. To be more precise, about one half of the dynamics of the job-finding rate is driven by the selection rate and about one half is driven by the contact rate. The partial effect and the equilibrium effects are of roughly similar size.[25] The estimated elasticities of the job-finding rate and the selection rate will be important targets in our calibration below and discipline the relative size of the equilibrium effect.

Finally, the estimated elasticity of the selection rate helps to discipline our calibration in another dimension. The relationship between the change in benefits and the resulting response of the selection rate in our model will to a large extent depend on our assumptions about the distribution of idiosyncratic training costs. Kohlbrecher et al. (2016) show in the context of a similar model structure that the elasticity of the selection rate over the business cycle - which we have estimated - is a function of the distribution of training costs (or more general idiosyncratic productivity) at the hiring cutoff point. They derive the following analytical steady state equation, which is also a good approximation for

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[23]We could also target the increase of the selection rate in the full model. However, as we condition on tightness in the estimation, we do the same in our calibration. In addition, the feedback effect lowers the response of the selection rate. We therefore choose the more conservative strategy.

[24]If the inverse was true, the contact rate would have to be countercyclical. This would stand in contradiction to standard contact functions.

[25]Kohlbrecher et al. (2016) determine the relative importance of the two effects based on microeconomic administrative residual wage data. Their exercise yields similar results in this regard.

Table 2: Regression results for West Germany, 1992-2015.

	Dependent variable:	
	log(selection rate)	log(job-finding rate)
	(1)	(2)
Hartz IV Dummy	0.13***	0.02
	(0.04)	(0.05)
log(market_tightness)	0.15***	0.31***
	(0.05)	(0.07)
Constant	−0.56***	−2.54***
	(0.09)	(0.07)
Observations	24	24
R^2	0.54	0.53
Adjusted R^2	0.50	0.49
Residual Std. Error (df = 21)	0.09	0.13
F Statistic (df = 2; 21)	12.50***	12.05***

*Note: Estimation by OLS with Newey-West standard errors; *$p<0.1$; **$p<0.05$; ***$p<0.01$*

dynamic fluctuations:[26]

$$\frac{\partial \ln \eta}{\partial \ln \theta} = \frac{f(\tilde{\varepsilon})}{\eta} \left(\tilde{\varepsilon} - \frac{\int_{-\infty}^{\tilde{\varepsilon}} \varepsilon f(\varepsilon) \, d\varepsilon}{\eta} \right). \tag{39}$$

Thus, for a given underlying distributional shape of the idiosyncratic training costs and a given cutoff point,[27] the estimated elasticity of the selection rate with respect to market tightness $(\partial \ln \eta_t / \partial \ln \theta_t)$ pins down the dispersion of the underlying idiosyncratic distribution. This insight will be used in the calibration below.

5. Calibration

We calibrate the model to West-German data from 1992 to 2015.[28] We choose a monthly frequency with a discount factor of $0.99^{\frac{1}{3}}$ and normalise aggregate productivity to 1. Furthermore, we assume that firms and households have equal bargaining power (i.e. $\alpha = 0.5$). The short-term unemployed in Germany receive unemployment benefits that amount to 60% or 67% of the last net wage, the long-term unemployed received 53% or 57% prior to the Hartz IV reform. As the unemployed may also enjoy some home production or utility from leisure, we choose the upper bound of the legal replacement rates for our calibration. We set the replacement rates to 67% and 57% of the steady state incumbent wage in our model. We set the monthly separation rate to 2% to target a steady state unemployment rate of 10.9% (prior to Hartz IV).[29] We target a steady state market tightness of 0.25, which pins down the value of the vacancy posting costs.

The rest of the parameters are pinned down by six additional targets that we can measure in the data: The exit rates out of short-term and long-term unemployment, the aggregate selection rate, the relative contact rates of long-term versus short-term unemployed, as well as the elasticity of both the selection rate and the job-finding rate with respect to market tightness.

Using the data provided by Klinger and Rothe (2012), the pre-reform exit rates out of unemployment are 16% and 6.5% for short-term and long-term unemployed. In our model, this could be driven by both lower contact rates and lower selection rates over time. How can we differentiate between the two? We observe the average pre-reform selection rate form the Job Vacancy Survey, which is 46%, and take that as given. Unfortunately, we cannot differentiate selection rates for long-term and short-term unemployed with our

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[26]Kohlbrecher et al. (2016) show that this equation holds for a broad class of selection models, such as idiosyncratic training costs, permanent idiosyncratic productivity shocks, and endogenous separation models in which the shock also hits in the first period.

[27]Remember that the selection rate is $\eta_t^d = \int_{-\infty}^{\tilde{\varepsilon}_t^d} f(\varepsilon) d\varepsilon$. The IAB Job Vacancy Survey provides a target for the selection rate and thereby pins down the cutoff point for a given distributional form.

[28]We restrict our analysis to West Germany, as we do not want our regressions to be distorted by labour market transition effects in East Germany at the beginning and middle of the 1990s. Note, however, that we obtain a similar partial Hartz IV effect when we estimate the effects for Germany as a whole.

[29]This corresponds to the unemployment rate in January 2005.

Table 3: Parameters and Targets for Calibration.

Parameter/Target	Value	Source
Aggr. productivity	1	Normalisation
Discount factor	$0.99^{\frac{1}{3}}$	Standard value
Short-term replacement rate	0.67	Legal replacement rate
Long-term replacement rate (pre-reform)	0.57	Legal replacement rate
Bargaining power	0.5	Standard value
Separation rate	0.02	Unemployment rate of 10.9%
Short-term job-finding rate	0.16	Klinger and Rothe (2012)
Long-term job-finding rate	0.07	Klinger and Rothe (2012)
Relative contact rate of long-term unemp.	0.45	PASS survey
Market tightness	0.25	IEB and Job Vacancy Survey
Selection rate	0.46	Job Vacancy Survey
$\partial \ln \eta / \partial \ln \theta$	0.15	IEB and Job Vacancy Survey
$\partial \ln jfr / \partial \ln \theta$	0.31	IEB and Job Vacancy Survey

firm dataset. We therefore use information contained in the IAB PASS survey.[30] In this survey, respondents are asked whether they have had a job interview during the last four weeks. We compute the contact rate as the share of respondents who answer this question affirmatively. It turns out that the contact rate for ALG II recipients (i.e. long-term unemployed) is 45% of the contact rate for ALG I recipients (i.e. short-term unemployed). We accordingly set the relative contact efficiency of the long-term unemployed to 45%. Together with the targeted aggregate selection rate and the exit rates for long- and short-term unemployed this pins down all the contact, selection, and job-finding rates in the economy. Note that while we assume that all short-term unemployed face the same contact, selection, and job-finding rate,[31] our calibration implies that the fixed training costs component increases every month with the duration of unemployment.[32]

We assume that idiosyncratic productivity follows a lognormal distribution. As shown by Kohlbrecher et al. (2016), in a selection model the elasticity of the selection rate with respect to market tightness is determined by the shape of the idiosyncratic productivity distribution at the cutoff point. Given the distribution, the cutoff point is in turn determined by the selection rate, which we have already targeted. We can therefore pin down the parameters of the distribution by targeting the elasticity of the selection rate with respect to market tightness, which is 0.15 in our data.[33] The elasticity of the contact rate

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[30]For a description of the IAB PASS survey, see Appendix B.

[31]While we observe different job-finding rates per month of short-term unemployment duration in the data, we cannot compute the corresponding contact rates.

[32]As the reservation wage falls with duration of unemployment, average training costs have to increase if we want to keep the steady state job-finding rates fixed.

[33]The resulting scale parameter of the distribution is 3.8. Note that we fix the location parameter of the distribution at 0 and instead allow the fixed training costs component to adjust. This allows us to

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with respect to market tightness (i.e. the weight on vacancies in the contact function) is finally set to target the overall elasticity of the job-finding rate with respect to market tightness, which is 0.31 in the data. The resulting weight on vacancies in the contact function is 0.14. Thus, the selection mechanism accounts for about half of the elasticity of the job-finding rate with respect to market tightness in our model.

6. The Effects of Hartz IV

This section proceeds in three steps. First, we show the partial effects in our model. Although we target the aggregate PE in our estimation, we can make statements on the response of the selection rate for each unemployment duration group. Second, we switch on equilibrium effects and analyse how aggregate unemployment and vacancies changed due to Hartz IV. Third, we put our quantitative results in perspective to other papers on the German Hartz reforms.

6.1. Partial Effects

Our empirical estimation in Section 4.3 has shown that the reform resulted in a 13% increase of the selection rate (controlling for aggregate market tightness). We therefore target the same increase of the average selection rate in the quantitative model, while keeping equilibrium effects switched off (i.e. a constant contact rate).

For this purpose, we require a decline of unemployment benefits for long-term unemployed of 11.3%. Under collective bargaining the required drop is 24% (see Appendix C.1). For a given drop of workers' reservation wages initiated by the fall of the replacement rate, firms are willing to extend hiring by more when wages are bargained individually. The reason is that part of the increase in training costs for the marginal worker is directly offset by her wage. Conversely, if wages are bargained collectively, the increase in training costs for the marginal worker is only indirectly reflected in her wage, i.e. through its effect on average training costs. We therefore require a larger fall of the replacement rate to achieve the same response of the selection rate under collective bargaining. Nonetheless, both values are within the range used by Launov and Wälde (2013), Krause and Uhlig (2012), and Krebs and Scheffel (2013).

These results stress another important aspect of our evaluation strategy. The choice of the bargaining regime is crucial for the reaction of the macroeconomy to a given replacement rate shock. By directly targeting the selection rate (i.e. the partial effect), our results are robust to the specific choice of the bargaining regime.

Figure 7 shows the impulse responses of the selection rate in reaction to this permanent decline of the replacement rate for long-term unemployed. The selection rate immediately increases on impact for all groups of searching workers due to a lower outside option. However, the effect is larger, the closer the unemployed get to the expiration of the more generous short-term benefits. For workers who have just been separated from a job (upper right panel in Figure 7), the reduction of long-term unemployment benefits affects

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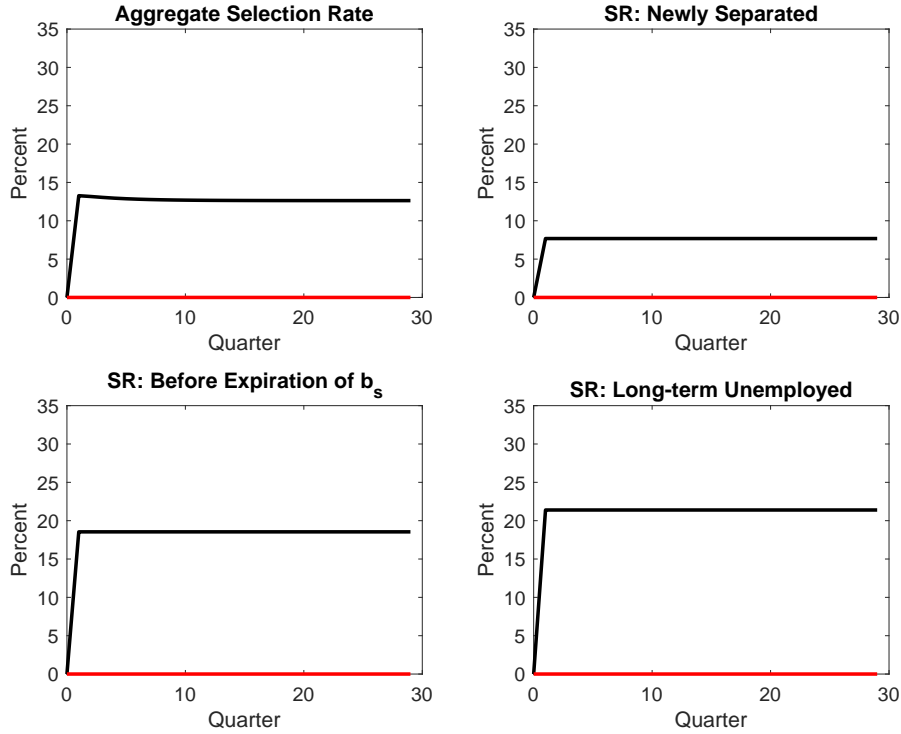vary the mean of the training costs for different groups while preserving the shape of the distribution.

Figure 7: Selection rate (SR): impulse responses to a 11.3% decline in long-term unemployment benefits.

their present value of unemployment by the least because they will only feel the reduction if they are not matched within the next twelve months. Still, their outside option falls, which increases the joint surplus of a match. The selection rate for workers who still have a full year of short-term benefits increases by around 8%. For workers who switch to the long-term benefit scheme in the next period, the reduction in long-term benefits has a larger effect on their outside option. Their selection rate increases by 19%. This is in line with Price (2018) who finds that unemployed workers' job-finding rates increase sharply before the expiration of benefits. Finally, the impact is largest for the long-term unemployed who are immediately affected by the reduction of long-term benefits. Their selection rate increases by 21%.[34] Figure 8 shows the impact responses of the selection rate in response to a decline in long-term unemployment benefits for all duration groups of our model. The x-axis indicates the time remaining until short-term benefits expire. We see that the response increases gradually with the expiration of short-term benefits coming nearer and kinks at the expiration threshold.

How do our results compare to other recent microeconometric studies of the Hartz IV

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[34]While the individual selection rates all adjust on impact, the aggregate rate, which is a weighted average, slightly overshoots at the beginning. The reason is a composition effect. Initially, there are more long-term unemployed for whom the effect is largest. However, the difference between the initial response and the steady state response is small (around 1 pp).
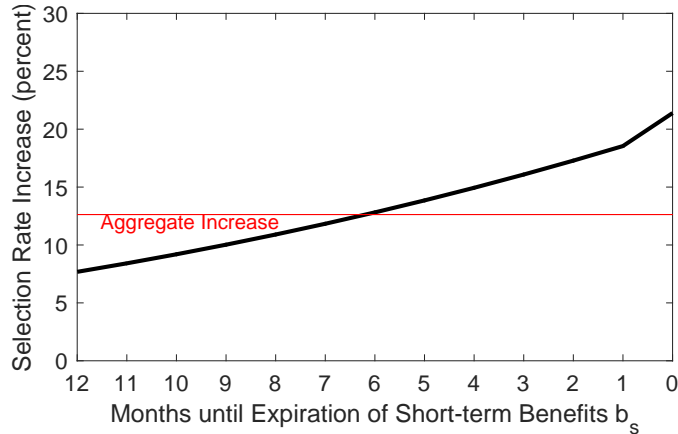
Figure 8: Impact responses of selection rate to a decline of long-term unemployment benefits by remaining months of short-term benefit entitlement.

reform? Price (2018) uses the German administrative data to estimate the causal effects of Hartz IV from the worker side. He finds that the probability of being reemployed within 12 months of beginning a claim increases by 4.7 percentage points. We find an increase of the reemployment hazard of 3.1 percentage points, which is smaller but close to Price's (2018) results. Furthermore, the magnitudes of the wage effects in our model are quite comparable. In our model, the average wage over the employment spell for a reemployed worker who exhausted short-term benefits falls by 3% due to Hartz IV. Price (2018) finds that those workers accept 4% - 8% lower wages on reemployment after the reform and conditional on jobless duration.[35] Note that the wage effect is much smaller if we average over all unemployment durations. In this case the average reemployment wage drops by only 1.2%.[36] As wage effects are crucial for the transmission of the benefit shock in our model, it is reassuring that these are well in line with empirical estimates. This is particularly important in light of the debate in the empirical literature as to whether benefits actually influence reemployment wages once controlling for unemployment duration. Schmieder et al. (2016), for example, find for the pre-Hartz period in Germany that the effect of benefit duration on wages is at best very small. However, they study a different time period and identify their effects based on age related differences in the maximum duration of short-term benefits. In the pre-Hartz period, however, upon exhaustion of short-term benefits, workers still received relatively generous long-term benefits. The Hartz IV reform, however, meant that entering long-term unemployment became a lot more painful which might explain why Price (2018) finds larger effects on wages for those workers close to the expiration of short-term benefits. Finally, it is

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[35]We cannot make this distinction in our model as there is a one to one relationship between duration and benefit eligibility.

[36]Note that these result all rule out equilibrium effects, as we fixed tightness at its pre-reform level. Allowing for tightness to adjust, average reemployment wages (again measured as average wages over the employment spell) drop by only 0.7%.

important to stress that the similarity in results between our study and Price (2018) is quite remarkable, given that we derive our partial effects based on completely different methodologies and data sources: the administrative worker data (in the case of Price (2018)) and firm survey data (this study).

6.2. Equilibrium Effects

We now present results for the full model, i.e. we allow market tightness to adjust. Keep in mind that we have disciplined the relative magnitude of the equilibrium effect by our estimations in Section 4.4. As firms' expected surplus rises, they post more vacancies. More vacancies increase the market tightness and thereby increase the probability of workers to get in contact with a firm (through the contact function). This is illustrated in the lower left panel of Figure 9. The contact rate for unemployed workers rises by 10% on impact.[37] The overall job-finding rate, which is the product of both the contact and the selection rates, increases by 22% on impact (lower right panel of Figure 9). Therefore, about half of the initial response of the job-finding rate is due to the equilibrium effect. Note that the response of the selection rate (12% increase on impact, 11% higher in the new steady state) is a bit smaller in the full model compared to the model with the equilibrium effect switched off. The reason is a small negative feedback effect from increased contact rates on the wage level and hence the selection rate. Overall, the unemployment rate falls by 24%. This corresponds to a decrease of the unemployment rate by 2.6 percentage points in our calibration. Hence, the Hartz IV reform can account for more than 40 percent of the decline in German unemployment since 2005.

When the economy adjusts to a new steady state, the composition of the pool of unemployed changes. This can be seen in the adjustment dynamics of the contact and job-finding rate, which increase quite sluggishly.[38] The aggregate contact and job-finding rates are a weighted average for all duration groups. Due to the reform, the duration of unemployment is shortened. The share of the searching workers with long unemployment duration declines over time. The share of long-term unemployed, who have much lower contact rates, is 10 percentage points lower in the new steady state.[39] When we control for the composition effect,[40] the unemployment rate falls by 19% or 2.1 percentage points (instead of 2.6 percentage points). The increase of the selection rate (partial effect) and the contact rate (equilibrium effect) each account for roughly half of this decline.

Finally, it is interesting to study the trajectory of the Beveridge curve in the data and in the model. Figure 10 shows the simulated Beveridge Curve in response to the decline of the replacement rate for long-term unemployed workers in our model. Vacancies increase, overshoot and end up at a level above the initial steady state. Unemployment sequentially declines to a lower long-run level. We contrast our simulation results with

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[37]As all workers search on the same labour market, the relative response of the contact rate to the reform is the same for short and long-term unemployed.

[38]The new steady state is only reached after 7 years.

[39]In principle, the composition effect could also be driven by selection. However, in our calibration, most of the differences in job-finding rates between long- and short-term unemployed are accounted for by lower contact efficiencies, which was guided by the PASS survey.

[40]We assume counterfactually that the shares of each unemployment duration group stay constant.
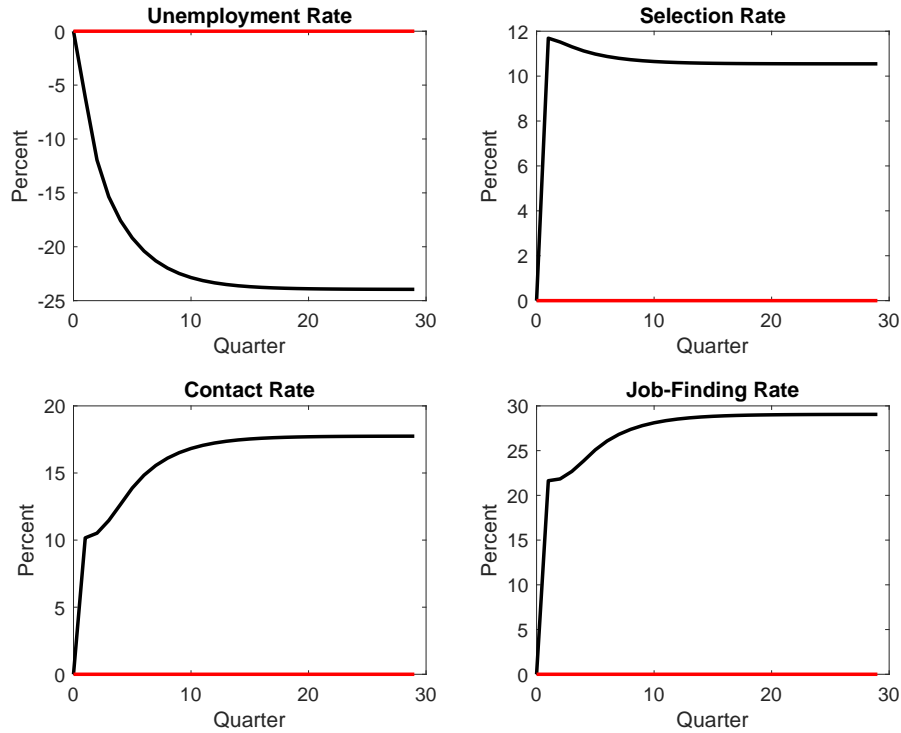
Figure 9: Impulse responses to a decline in long-term unemployment benefits.

the actual movement of the Beveridge Curve from the first quarter of 2005 to the fourth quarter of 2007 (Figure 11). Note that the increase in unemployment due to the redefinition can be seen visually in this figure. Similar to the simulation, vacancies increase, overshoot somewhat and end up at a higher level.[41] Unemployment sequentially declines to a permanently lower level in the data. The movements are not only qualitatively comparable, but the quantitative reactions (as percent deviations) are also similar.

While the comparison of our simulation and the data is purely descriptive, given the similarities between the two, the exercise provides suggestive evidence for the importance of the Hartz IV reform for German labour market dynamics in the years after the reform. Overall, our work points to an important role of the reform of the benefit system for the decline of German unemployment. Other reforms (such as Hartz III) may also have contributed (e.g. Launov and Wälde, 2016). However, our methodology does not allow us to quantify these contributions.

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[41]The overshooting behaviour takes place later in the data and is somewhat less pronounced. Vacancies are a purely forward-looking variable in our model, while there may by reasons why they are more persistent in the data.
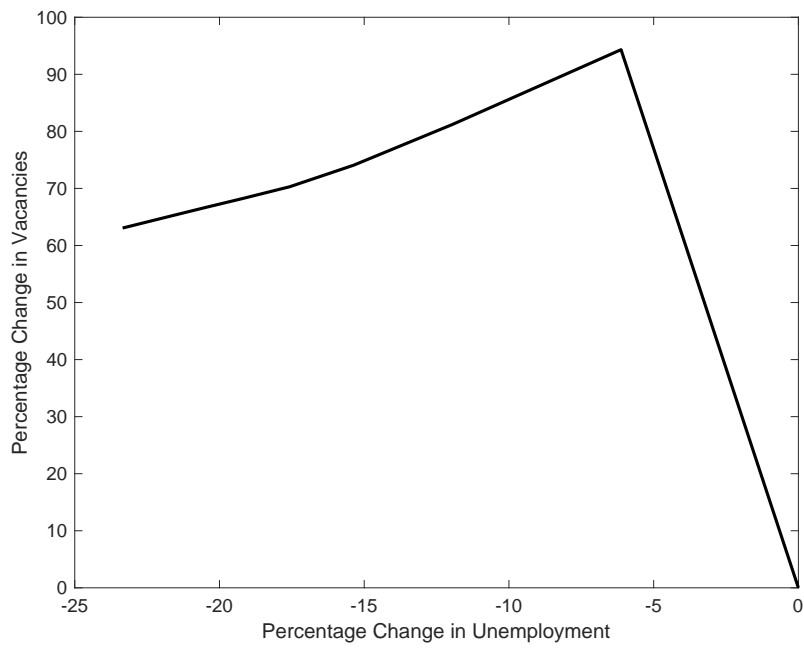
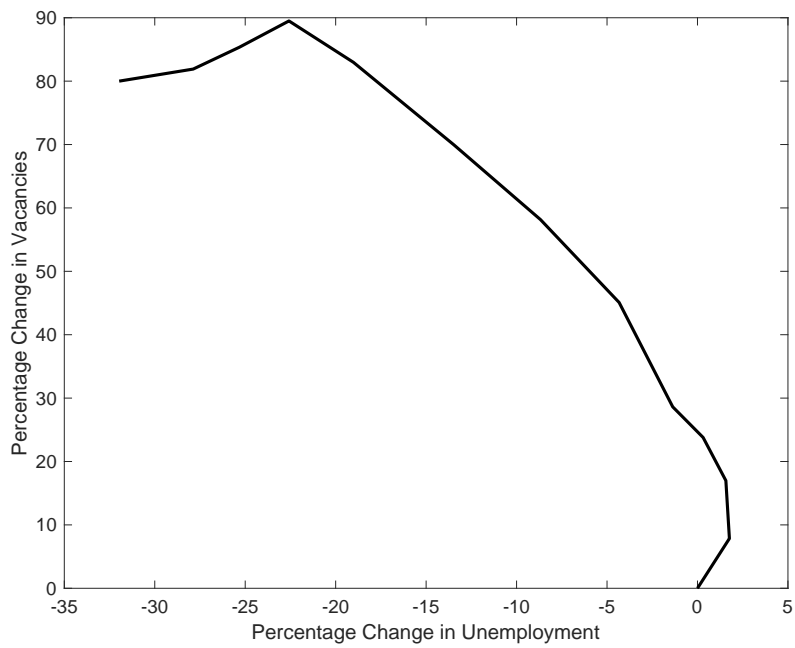Figure 10: Beveridge curve generated by the model during first three years after the shock.

Figure 11: West German Beveridge curve from 2005-2007.

6.3. Broader Perspective

How do our results compare to changes of labour market stocks and flows around the time of the Hartz reforms? Although the labour market data is somewhat difficult to interpret due to a major structural break of the unemployment definition in 2005 (and thereby also the job-finding rate), a comparison to recent empirical studies delivers interesting patterns.

In recent papers, Carrillo-Tudela et al. (2018) and Rothe and Wälde (2017) document that relatively few unemployed workers directly transitioned to regular (full-time) employment after Hartz IV. Indeed, Carrillo-Tudela et al. (2018) show that flows into non-participation account for a large part of the outflows from unemployment in the aftermath of the Hartz IV reform but that labour force participation actually increased. Apparently, the reform induced many unemployed to deregister with the Federal Employment Office, but then - out of non-participation - to take up jobs often in the form of part-time employment[42] or mini-jobs. The latter then often served as stepping stones into contributing employment. Besides the known measurement issues with the unemployment rate in 2005, these dynamics provide an additional argument why it would be very misleading to focus on direct unemployment to employment transitions when assessing the Hartz IV reform.

Interestingly, these results contrast with the findings by Price (2018). He documents that the net-employment effects from his causal identification - which are comparable in magnitude to our partial effects - are driven by full-time employment. Still, against the background Carrillo-Tudela et al.'s (2018) and Rothe and Wälde's (2017) work, it may be the case that labour market transitions took place in a more complex and sluggish way than in our simulated model (e.g. via non-participation and irregular types of unemployment, which served as stepping stones). To the extent that stepping stones played an important role, our model overestimates the speed at which the equilibrium effect generates full-time jobs. To our knowledge, there exists no macroeconomic labour market framework which allows modelling stepping stone effects. Finally, understanding better the dynamics of participation decisions and their interaction with the benefit reform would certainly be desirable. However, besides the usual challenges of modelling participation decisions in quantitative models, the work by Carrillo-Tudela et al. (2018) shows that the German case is even more challenging as incentives to be registered as unemployed might be completely unrelated to search behaviour. Against this background, we have proposed a novel approach how to measure the partial effect of Hartz IV with a data source (IAB Job Vacancy Survey) that is completely unrelated to the definition of registered unemployment. Our new selection measure is robust to changed definitions of labour market states (related to unemployment registration) and resulting spurious labour market flows.

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[42]The rise in part-time employment around the time of the Hartz reforms is also documented in a recent paper by Burda and Seele (2016).

7. Conclusion

This paper proposes a novel approach how to evaluate the reform of the German unemployment benefits system in 2005. In contrast to existing literature, our strategy does not hinge on an external source for the quantitative decline of the replacement rate for long-term unemployed, for which the literature provides a wide range of estimates. Instead, we use information on firms' hiring behaviour from the IAB Job Vacancy Survey and show that their selection rates increased following the Hartz IV reform. In addition, we estimate the relative importance of partial and equilibrium effects over the business cycle and impose it on our model. Our simulation shows that the reform had important equilibrium effects. Our simulated model can match important facts, such as the inward shift of the Beveridge Curve after the reform and the larger increase of the job-finding rate for unemployed with longer unemployment durations. Overall, our results show that 2.6 percentage points of the decline in unemployment since 2005 can be attributed to the Hartz IV reforms. It was thus a major driver of the decline of unemployment in Germany.

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A. Details on the Hartz Reforms

In response to rising unemployment in the early 2000s, the Hartz commission developed recommendations for the German labour market. These proposals were implemented gradually between 2003 (Hartz I and Hartz II) and 2005 (Hartz IV). According to Jacobi and Kluve (2006), the Hartz reforms had three main goals: (1) increasing the effectiveness and efficiency of labour market services, (2) activating the unemployed and (3) boosting labour demand by deregulating labour markets. Under the concept of *"demanding and supporting" (Fordern und Fördern)*, these four reforms radically restructured the German labour market:

Hartz I (in action since 01/01/2003): This reform facilitated the employment of temporary workers. Additionally, vouchers for on-the-job training were introduced.

Hartz II (in action since 01/01/2003): Introduction of new types of marginal employment with low income such as *Minijobs* (up to 450 euros per month, exempted from the income tax) and *Midijobs* (income up to 850 euros per month, reduced social security contributions). Furthermore subsidies for business start ups of unemployed were introduced.

Hartz III (in action since 01/01/2004): The core element of Hartz III was the restructuring of the Federal Employment Agency. The Federal Employment Agency was divided into a headquarter, regional directorates and local job center. Those local job center are now managed via a target agreement. Since Hartz III, all claims of an unemployed person are processed by the same case worker (support from a single source) and an upper limit on the number of cases handled was introduced. Furthermore, a special focus was put on long-term unemployed and unemployed who are older than fifty years. In addition, market elements for private placement services and providers of training measures were introduced.

Hartz IV (in action since 01/01/2005): The last step was the most widely discussed reform since it caused a substantial cut in unemployment benefits for several groups. Unemployment benefits proportional to previous earnings were limited to up to one year, with exceptions for unemployed workers over 45 years old (*Arbeitslosengeld I*). After one year, unemployed shift to the much lower fixed unemployment benefits *Arbeitslosengeld (ALG) II*. Hence, the unemployment assistance which amounted to 53 % of previous net earnings (57% with children) and social assistance was abolished and replaced by *ALG II* which is independent of previous earnings. Eligibility for ALG II depends on savings and the partner's income. In addition, a sanctioning system was introduced which allowed cuts in the fixed unemployment benefits if the unemployed person breaks an agreement with the Public Employment Agency (e.g. in terms of writing applications, reachability, responsible economic behaviour).

In addition, the Hartz IV law also includes a reduction of the maximum entitlement duration of short-term unemployment benefits for workers older than 45 years by up to 14 months. This reform step became effective on February 1, 2006.

For a more detailed description of the Hartz reforms, see Jacobi and Kluve (2006) or Launov and Wälde (2016).

B. Data

We use annual data on the number of suitable applicants for the most recent hire in the last 12 months and the number of total vacancies of the IAB Job Vacancy Survey. Information on the IAB Job Vacancy Survey can be found in Moczall et al. (2015). Note that since the IAB Job Vacancy survey corresponds to the third quarter of a year, we consistently use third quarter data in our estimations. In addition, data on unemployment and transitions from unemployment into employment (matches) were taken from register data of the federal labour office, the "Integrated Labour Market Biographies (IEB)" (vom Berge et al., 2013).[43] Data for calculating the contact rate for short-term and long-term unemployed stems from the IAB PASS Survey. Furthermore, we take values on the job-finding rates for ALGI (short-term unemployed) and ALGII recipients (long-term unemployed) from (Klinger and Rothe, 2012). They calculated these job-finding rates based on German administrative data. We use the average job-finding rate by duration of unemployment for the time span 1998-2004.[44]

B.1. Details on the IAB Job Vacancy Survey

The Job Vacancy Survey was first carried out in 1989 in West Germany and was extended to East Germany in 1992. It is conducted via a written questionnaire every fourth quarter of the year. Yearly, a stratified random sample of establishments is drawn according to industries, regions as well as size classes. The number of establishments participating ranges from 4,000 in the first years to about 14,000 in the recent years. The data set includes weights to extrapolate the data for the whole economy. Weights for the most recent case of hiring ensure representativeness for all hires.

As the number of suitable applicants for Germany is available from 1992 onwards, we restrict our sample range from 1992 to 2015. Since the aggregate sample range is quite short to conduct time series analysis, we calculate the time series at the federal state and industry level. We aggregate the inverse of the number of suitable applicants by taking mean values. Following Klinger and Rothe (2012, p.17), we add the city state Bremen to the neighbouring state Lower Saxony to avoid spatial correlation. The Job Vacancy Survey contains too few observations for small federal states in order to be representative. Therefore, we restrict our sample to federal states with at least 6 million inhabitants.[45]

B.2. Details on the IAB PASS Survey

Furthermore, we use data of the IAB Panel Study Labour Market and Social Security (PASS)[46] to calculate the relative contact rates of long- and short-term unemployed

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[43]Status quo of the data as of January 2016.

[44]This corresponds to the available pre-Hartz period.

[45]As of December 2014. Hence, we include Baden-Wuerttemberg, Bavaria, North-Rhine Westphalia, Lower Saxony plus Bremen and Hessen.

[46]Data access was provided via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB), project no. 101752

workers. This annual Panel Survey was first carried out in 2007 and consists currently of ten waves. Each wave consists of approximately 10,000 households. Its focus lies on the circumstances and characteristics of recipients of Unemployment Benefit II (ALGII). Interview units are both households as well as individuals (15,000 each year). The Panel consists of two equally large subsamples, (a) recipients of unemployment benefits II (ALGII) and (b) a sample of general German population in which low-income households are overrepresented.[47] In addition, the PASS survey includes several questions on the job search behaviour of unemployed workers. These questions regard job search channels, the number of applications as well as the number of job search interviews attended. We measure the contact rate in our model by calculating the share of unemployed workers who attended at least one job interview in the past four weeks. Furthermore, we split unemployed workers by short-term unemployed (ALGI recipients) and long-term unemployed (ALGII recipients). The number of unemployed workers in our sample is 1,806 for ALGI recipients and 23,103 for ALGII recipients. For a detailed description of the IAB PASS survey, see Trappmann et al. (2013).

C. Robustness

C.1. Collective Bargaining

In the main part of the paper we assume that all wages are determined by individual Nash bargaining. However, a significant share of German wages are still set under collective bargaining arrangements. In 2010, 53% of all West German employees in the private sector were covered by collective bargaining (see e.g. Hirsch et al., 2014). We therefore present results for the polar opposite case, i.e. wages are bargained collectively. We assume that all workers within a duration group earn the same wage but still allow for differences between groups. We assume that the union represents the average worker that is hired in every group. The union wage is then again determined by Nash bargaining. We apply the exact same calibration strategy as in the main part of the paper (i.e. we keep the same targets). The only major difference between the collective and the individual Nash bargaining case is that the reduction of the replacement rate that is required for the targeted increase of the selection rate is higher under collective bargaining. More precisely, we require a 24% drop of long-term unemployment benefits to achieve a 13% increase of the selection rate in partial equilibrium (i.e. keeping tightness fixed). While this is more than double the amount required under individual Nash bargaining, it is similar to the reduction used by Krebs and Scheffel (2013) and Krause and Uhlig (2012) (for low-skilled workers). Figure C.1 shows that otherwise the model reaction is virtually unchanged.

C.2. Matching Efficiency Shock

Figure C.2 shows the response of the selection rate to a positive shock to the matching efficiency. A one percent increase of matching efficiency leads to a drop of the selection

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[47]For details, see `http://www.iab.de/en/befragungen/iab-haushaltspanel-pass.aspx`.
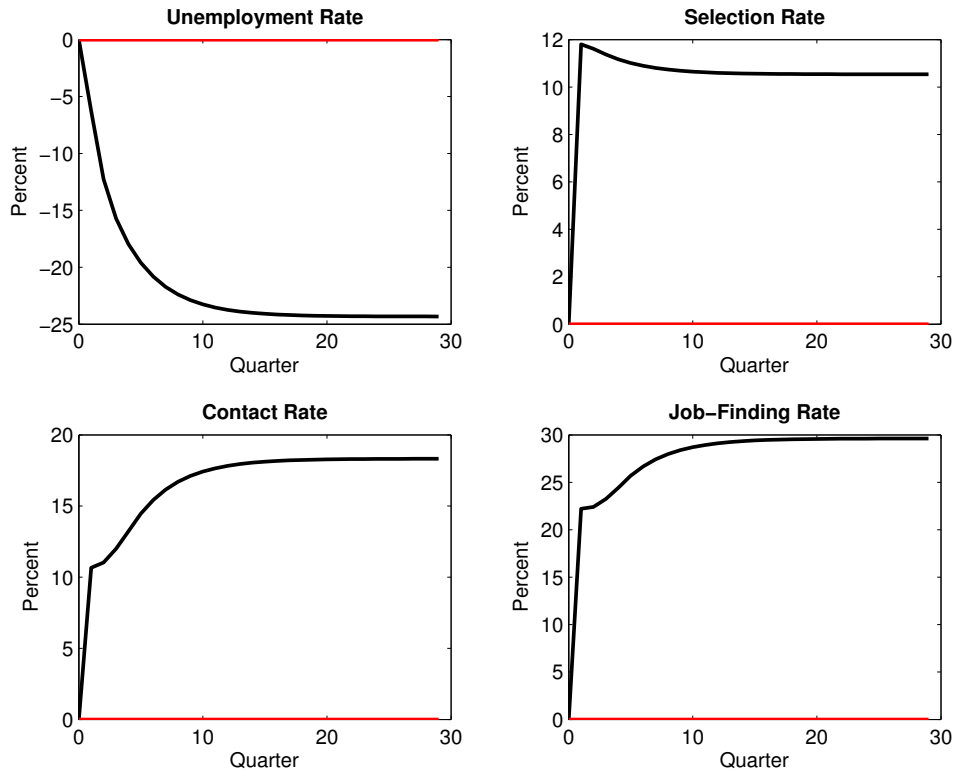
Figure C.1: Impulse Responses to a 24% drop of long-term unemployment benefits under collective bargaining.

rate of around 0.1%. Thus, the effect is extremely small and - if any - would bias our results downward.
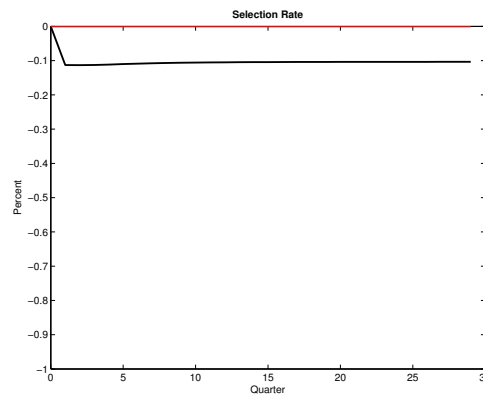

Figure C.2: Response of the selection rate to a 1% positive shock to the matching efficiency.

D. Further Evidence

In addition, a closer look at the change of the selection rate by skill group from 2004 to 2005[48] reveals that the increase in the selection rate was highest for workers with a vocational degree. This is exactly what we would expect: While medium-skilled workers suffered on average a larger drop in the replacement rate due to higher wages compared to low-skilled workers, they also faced a higher risk of unemployment compared to high-skill workers.[49]

Figure D.4 shows evidence from a special survey on Hartz IV of the IAB Job Vacancy survey in which establishments were asked about their perception on changes in applicants' reservation wages and their willingness to accept special working conditions due to the Hartz IV reform. The results indicate that on average, establishments perceived that reservation wages of unemployed applicants had dropped and that their willingness to accept special working conditions had increased.

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[48] Unfortunately, the IAB job vacancy survey provides information on the last realised hire by skill group only from 2004 onward.

[49] Unskilled workers may even have benefited from the Hartz IV reform because the standard rate for social assistance ("Sozialhilfe") was even lower than the standard rate for "Hartz IV". On the other hand, high-skilled workers with a college degree face only a very small probability to fall into the pool of long-term unemployed in the first place.
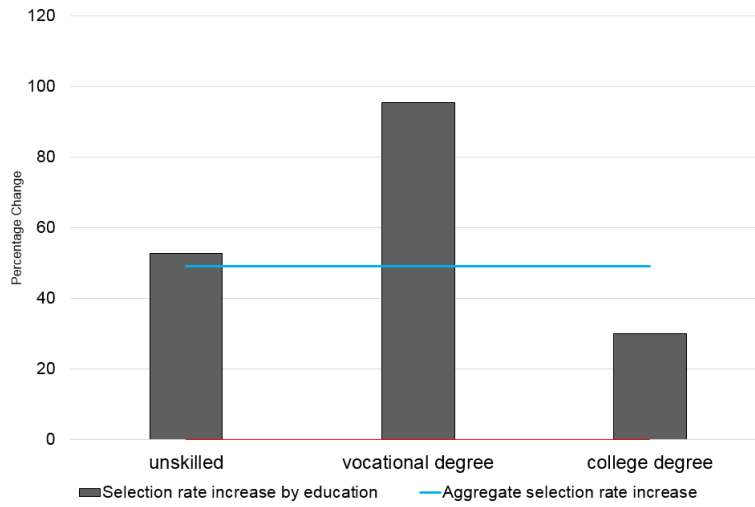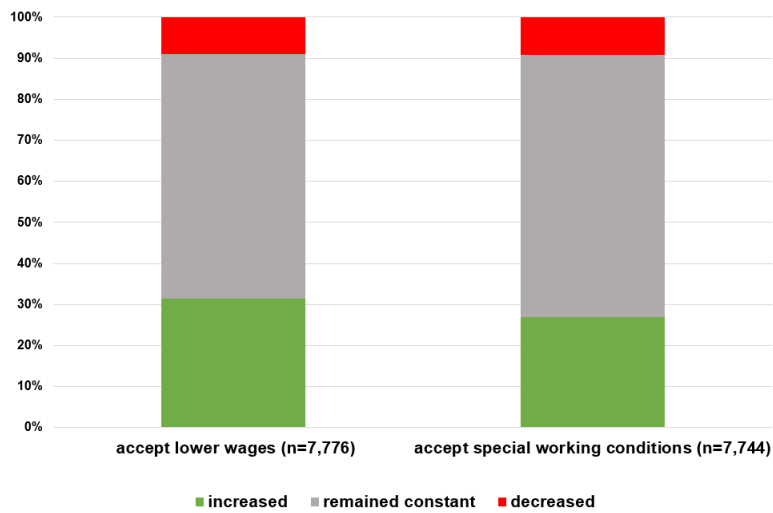
Figure D.3: Increase of selection rate by skill group, 2004-2005

Source: IAB Job Vacancy Survey (Special survey on Hartz IV 2005/2006).

Figure D.4: The willingness of unemployed applicants to ... (% of establishments who gave the respective answer.)