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New empirical findings about the interaction between Public Employment Agency and private search effort*

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Abstract

The Public Employment Agency (PEA) helps unemployed to find work and mediates PEA-registered job vacancies to job seekers via vacancy referrals. Using the spatial and temporal variation resulting from the regional roll-out of the Hartz 3 reform we are able to show that Hartz 3, which changed the counseling process of unemployed, decreased the fraction of unemployed that received vacancy referrals, increased the job-finding probability of unemployed without vacancy referrals, left the job-finding probability of unemployed with vacancy referrals unaffected, and increased average wages of newly hired, previously unemployed. Since the existing literature is not able to explain this set of findings, we develop a simple theoretical directed search model, which does. It does so by considering the interaction between the private market and the intermediation provided by the PEA.

Keywords: Public Employment Agency, natural experiment, job-finding probability, wages

JEL: J08, J3, J6

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1 Introduction

In most industrialized countries Public Employment Agencies (PEA) provide intermediation to help job seekers to obtain jobs and employers to fill vacancies. PEAs also counsel unemployed job seekers and enforce search requirements attached to unemployment benefit receipt.[1] Despite the mass of studies evaluating single labor market policies, we know very little about the interaction between the intermediation provided by the PEA and its effect on the private search effort of unemployed job seekers.

The pioneering theoretical work analyzing this interaction was developed by Pissarides (1979). According to Pissarides (1979) the intermediation by the PEA crowds out private search effort by unemployed job seekers. Fougère et al. (2009) uses a structural partial search equilibrium model to investigate Pissarides' hypothesis. Using French data to structurally estimate the model they find that more vacancy referrals crowd out private search effort but increase the job finding rate of unemployed, especially low-skilled workers. Merkl and Sauerbier (2023) calibrate a structural model in the spirit of Pissarides (1979) to fit the time-trends of the PEA vacancy share and PEA hiring share calculated from German micro data around the Hartz 3 reform. They show that the direct intermediation activities of the PEA did not contribute to the decline of unemployment in Germany in the late 2000s, only the higher degree of activation of unemployed. Van den Berg and Foerster (2024) work on a structural equilibrium model which in addition to the disincentive effects of PEA intermediation on workers' private search effort captures crowding out in the hiring process and changes in firms' vacancy posting behavior.

We are the first to investigate this question using a natural experiment, namely the spatial and temporal variation resulting from the regional roll-out of the Hartz 3 reform in Germany. Before the Hartz 3 reform case managers responsible for counseling unemployed job seekers were rewarded for matching unemployed job seekers with PEA-registered job vacancies via vacancy referrals. After the reform, case managers were rewarded for a high unemployment-to-employment (UE) transition rate irrespective of whether they helped unemployed job seekers to find a job with the help of a vacancy referral or demanded from them a higher search effort in the private market. Using the spatial and temporal variation resulting from the regional roll-out of Hartz 3 we find that this reform decreased the fraction of unemployed that received vacancy referrals and increased the overall UE-transition probability of unemployed job seekers. The latter effect is driven by unemployed job seekers without vacancy referrals. The UE-transition rate of job seekers with vacancy referrals is unaffected. And surprising, from a theoretical perspective, we find that Hartz 3 increased average wages of newly hired, previously unemployed workers.

The classical search and matching literature is not able to explain this set of findings. The

[1] Graversen and van Ours (2008), Crèpon et al. (2013), Ferracci et al. (2014) and Gautier et al. (2018) analyze the (equilibrium) effects of counseling unemployed job seekers and Belot et al. (2019) use a field experiment to show that providing tailored advice on alternative occupations improves labor market prospects. Schiprowski (2020) analyzes the effect of a meeting between an unemployed and her case manager using exogenous variation in unplanned absences among Swiss UI caseworkers. The effect of sanctions is among others studied by van den Berg et al. (2004), Abbring et al. (2005), Lalive et al. (2005), Svarer (2011), van den Berg and Vikström (2014), and van den Berg, Foerster and Uhlendorff (2019).

Diamond-Mortensen-Pissarides (DMP) random search and matching model has one black-box matching function - see e.g. Pissarides (2000). A decrease in matching efficiency - as one would model the decrease in the probability to receive a vacancy referral in the DMP-framework - would result in a decrease in the overall UE-transition probability. The observed increase in the overall UE-transition probability could only be explained within the DMP-framework, if the negative effect of the lower matching efficiency is outweighed by a simultaneous increase in the search intensity of unemployed job seekers demanded by case managers. However, the classical DMP-model would predict that an increase in the job finding rate of unemployed job seekers triggered by an increase in the job seekers search intensity lowers wages. The reason is that a higher search intensity of job seekers increases firms' chances of finding an alternative worker and thus improves their bargaining position. Directed search models with one common search market would also predict that an increase in the job-finding probability goes along with lower wages.[2]

The fact that the UE-transition rate affected unemployed with and without vacancy referrals differently suggests the use of a model with different search channels like the one by Pissarides (1979). The model by Pissarides (1979) predicts that lower costs of searching in the private market increase private search effort. Given that Hartz 3 incentivized case managers to demand a higher search effort from unemployed by threatening with sanctions in case they did not search enough, Hartz 3 reduced unemployed job seekers' opportunity costs of searching privately. Thus, the model by Pissarides (1979) is nicely able to explain why job seekers without vacancy referrals have a higher job-finding probability after the Hartz 3 reform. The result that the job-finding probability of unemployed with vacancy referrals remained unchanged can be explained by the observation that Hartz 3 decreased mediation via vacancy referrals, which counteracted the positive effect of the higher private search effort.

Pissarides (1979) is silent on the effect a reduction in the PEA activity and a decrease in job seekers' cost of searching in the private market has on wages. The reason is that for simplicity he assumes an exogenous wage and that the wage is the same irrespective of the search channel used.[3] Also Fougère et al. (2009) assume exogenous, search-channel-specific wage-offer distributions in their structural partial search equilibrium model.

To fill this gap we develop a simple theoretical directed search model by adopting the model by Pissarides as closely as possible.[4] Like him we assume that all unemployed are registered at the PEA, that searching in the decentralized market is costly for workers, and that firms can choose between two alternative methods of finding a worker: via the private market and via vacancy referrals of the PEA. There are two major differences between his and our model. First, workers are homogeneous in

[2] For an overview over directed search models see Wright et al. (2021).

[3] He is also not sure whether his finding, that inducing job seekers to search more in the private market increases the overall UE-transition rate, carries over to a framework with endogenous wages (see Pissarides, 1979, p. 827).

[4] A directed search framework (instead of a random search framework) best fits with this purpose. Some major implications of our model cannot be obtained from random search models. In addition, the following empirical observations support directed search approaches. Van Ours and Ridder (1992) show that firms with vacancies typically collect a pool of applicants before deciding on whom to hire and Wolthoff (2018) shows that for a given vacancy, almost 5 interviews are conducted. Gautier et al. (2016) and Belot, Kircher, and Muller (2019) provide evidence that unemployed workers apply simultaneously to multiple jobs.

Pissarides (1979), while the key ingredient of our model is that workers differ in expected suitability for the job, which is their private information. Second, Pissarides (1979) considers a random search model and assumes an exogenous and identical wage in both markets. In contrast, we show that firms in the private market choose to post higher wages than firms registered with the PEA.

The existence of lower wages in the PEA compared to the private market is at first sight surprising, because if wages are lower in the PEA we would expect that all firms would register their vacancy with the PEA and try to be matched via vacancy referrals instead of hiring through the private market. Our model explains the coexistence of the PEA market and the private market via adverse selection. Firms can decide between two wage strategies, one where they offer higher wages, which are attractive only for more suitable workers despite the extra cost of searching in the private market, and one where they offer unemployed their reservation wage and rely on vacancy referrals to receive applicants. Vacancy referrals by the PEA ensure a positive matching probability for registered vacancies even if they offer low wages. In the private market, however, vacancies need to offer higher wages, which are competitive and able to attract suitable applications despite the extra cost. Consequently, job seekers with a higher probability to be suitable are more likely to apply through the private market. Thus, firms, which are willing to pay high wages, benefit from the positive selection of suitable applicants in the private market and the implied higher matching probability.

The mechanism, which according to our theory leads to the difference in wages, is based on the hypothesis that job seekers coming from the PEA and the private market differ in their expected suitability for a job. More precisely, this suitability hypothesis holds if the fraction of suitable applicants among all applicants coming via the private market is higher than the respective fraction of suitable applicants coming via the PEA. Using information from the German Job Vacancy Survey on the number of applicants and the number of suitable applicants a vacancy receives from the PEA and the private market we can show that this suitability hypothesis indeed holds.

Our results can also help to improve the understanding of the effects of Hartz 3 in the macro context. A growing macroeconomic literature (Krause and Uhlig, 2012; Krebs and Scheffel, 2013; Launov and Wälde, 2016; Felbermayr et al., 2018; Bradley and Kugler, 2019; and Merkl and Sauerbier, 2023) investigates the contribution of the different parts of the Hartz reform packages to the subsequent decline in the unemployment rate and rise in wage inequality.

The sequel of the paper is organized as follows. The empirical part in section 2 analyzes the effects of Hartz 3 on the job finding probability of unemployed job seekers and the hiring wages of previously unemployed workers. It also includes the investigations of the underlying mechanism and the suitability hypothesis of our theory. Section 3 presents the theoretical directed search model with two search channels; the PEA and the private market. Section 4 concludes. All proofs and some omitted tables are collected in the Appendix.

2 Empirical Analysis

In the empirical analysis we use the regional roll-out of the Hartz 3 reform from early 2004 to late 2005 as natural experiment.

2.1 The Public Employment Agency

Unemployed job seekers, who want to receive unemployment benefits, have to register with the PEA. Upon registration they are assigned to a case manager. The case manager will interview the person and can, with the threat of sanctions, demand a certain search effort. Case managers do not only push unemployed job seekers, they also encourage search, broaden the view of applicants, and propose jobs, which workers would not have considered on their own. Using exogenous variation in unplanned absences among caseworkers Schiprowski (2020) shows that a meeting between an unemployed and her case manager increases the number of vacancy referrals a job seeker receives by 3.5 to 4.8 percent and reduces unemployment duration by around 5 percent. In our data used in section 2.4 54.8 percent of unemployed job seekers with an unemployment spell of at most 12 months receive at least one vacancy referral during their unemployment spell. Van den Berg, Hofmann and Uhlendorff (2019) report that in early 2000s around 71 percent of unemployed job seekers received at least one vacancy referral during their unemployment spell. Their number is higher, since they include also long-term unemployed with unemployment spells of more than 12 months. Vacancy referrals cannot easily be turned down by unemployed workers, since the case manager might take a refusal to apply for the job as a reason to sanction the worker.

The PEA also provides an online search platform (https://jobboerse.arbeitsagentur.de). As on many private online search platforms job seekers can upload their curriculum vitae, post job wanted adds, and search actively for vacancies posted. Equivalently, firms can post their vacancies and search actively for registered workers. In addition, the PEA offers recruiting assistance to vacancies. Firms that register a vacancy make it available for vacancy referrals by case managers. They can in addition ask their contact person at the PEA to propose job seekers, which they can contact. The contact person is asked to recommend at least one worker within 48 hour. This type of recruiting assistance does not only lower recruitment costs, but also enables firms to minimize the risk of not receiving any applicant.

To summarize the PEA has three missions: to bring unemployed people back into work, to help PEA-registered job vacancies find workers, and to administer unemployment benefits for unemployed.

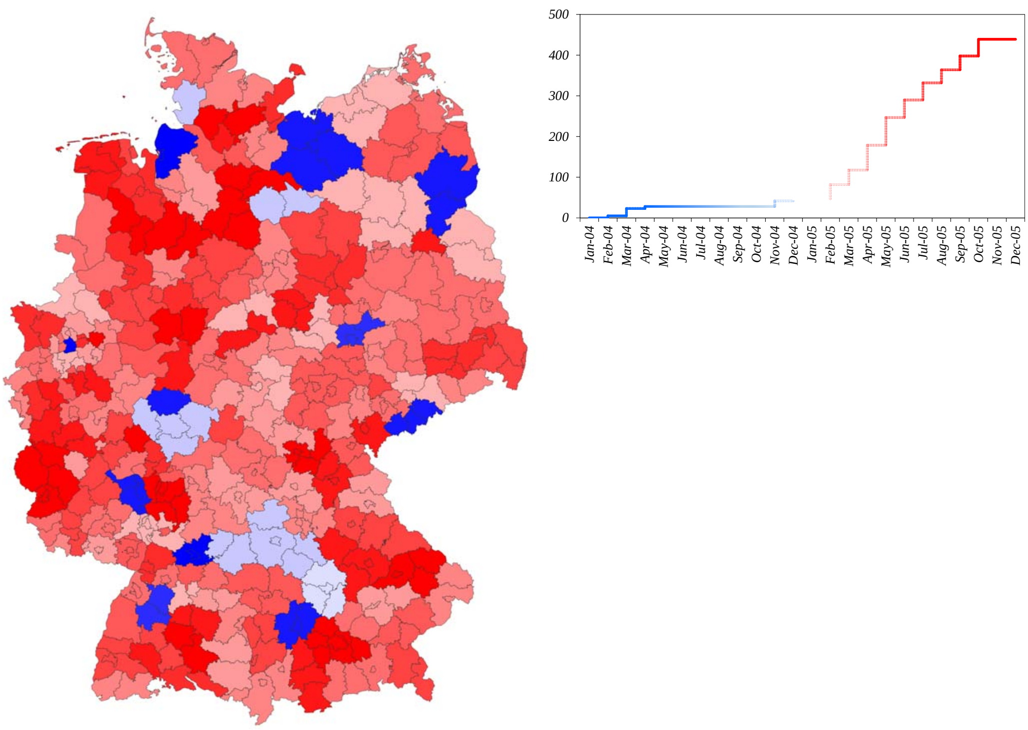
2.2 The Hartz 3 reform

The Hartz 3 reform helped and incentivized case managers to focus on the first mission, i.e., on getting the unemployed back into work as fast as possible.

The reform supported case managers by introducing an upstream reception center at the entrance of each local PEA. This helped speed up the counseling process by requiring job seekers to enter their CV information into PEA's internal IT platform and by arranging an initial appointment with a case manager on the first day whenever possible. Together with the stricter sanction rules applicable through the Hartz 4 reform, which came in force in January 2005 nationwide, case managers were able to demand a higher search intensity from unemployed job seekers.[5] To incentivize case managers to focus on the first mission the central PEA management also adjusted the controlling system. Before the reform case managers were rewarded for matching unemployed job seekers with PEA-registered job vacancies, which is usually done by making vacancy referrals to job seekers. After the reform they were rewarded for integrating unemployed back into work, regardless of whether it was with a PEA-registered job vacancy or not.

Figure 1: Roll-out of the Hartz 3 reform

(a) Geographic roll-out (b) Temporal roll-out



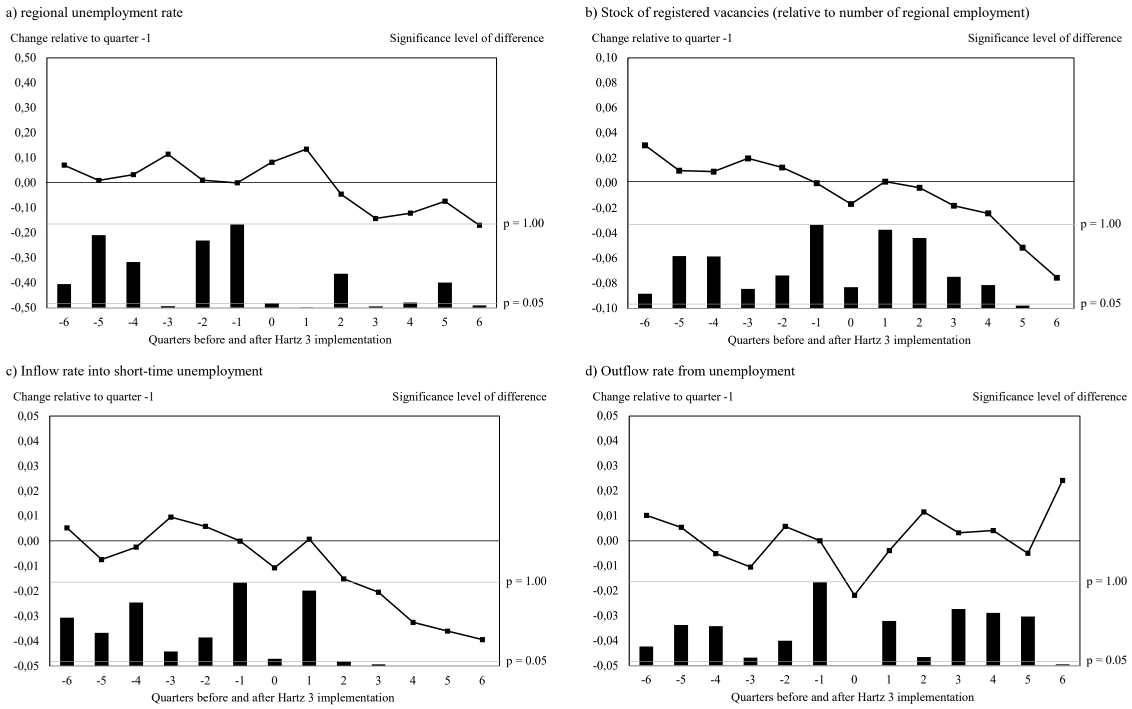
Notes: Part (b) shows in how many counties Hartz 3 has been implemented at a given point in time. The colours are used to highlight the respective counties in part (a) and to illustrate the geographical distribution of the roll-out.

The Hartz 3 law, which took effect on 1st January 2004, was *not* implemented in all local PEAs immediately. Instead, the roll-out of the reform in the 175 local PEAs, covering 439 counties, started in early 2004 and ended in late 2005. The federal PEA divides Germany into 10 main regions, and in each of these regions the roll-out started in spring 2004 with local pilot PEAs. After an internal assessment, the reform was rolled out nationwide in 9 three month waves from November 2004 to October 2005 (see Bundesagentur für Arbeit, 2005) in each of the 10 main regions separately - giving us a very nice geographic spread of treatment. Figure 1a) shows the spacial dimension of when the roll-out was finished in the respective region and Figure 1b) the respective number of regions treated over time. This variation across regions and time is used as natural experiment.

To check whether the timing of the roll-out among local PEAs is uncorrelated with local labor

[5] Hartz 4 is no threat for our identification, since its effect is absorbed by time-fixed effects.

Figure 2: Roll-out of the Hartz 3 reform and independence of local labor market characteristics



Notes: Based on a monthly panel of 385 counties from January 2002 to December 2007 with 27,720 observations. We can only take 385 out of 439 counties, since the boundaries of the other regions changed until 2010, the year for which we have county identifiers in our data-sets. The official regional unemployment rate in a), the stock of registered vacancies (relative to regional employment) in b), the inflow rate into short-time unemployment (SGB 3) in c) and the outflow rate from unemployment (not necessarily into employment). The lines show the event study coefficients β^k from equation (2) with the scale on the left axis. The columns show the p-values of the significance level with the scale on the right axis.

market characteristics we investigate whether local labor market measures have a significant effect prior to the local implementation of Hartz 3. To do so we conduct the following event study regression,

$$y_{rt} = \sum\nolimits_{k=-7}^{7} \beta^k \tau_r^k + \psi_r + \upsilon_t + \varepsilon_{rt}, \tag{1}$$

where y_{rt} is the local labor market measure under consideration, ψ_r are the region fixed effects, υ_t the monthly time-fixed-effects, and τ_r^k the event study indicator variables, which are equal to one for region r in the kth quarter before/after the implementation of Hartz 3 and zero otherwise. The boundary indicators $k = -7$ and $k = 7$ pool all indicators before -7 and after 7, respectively.

Figure 2 plots the event study coefficients β^k based on the regression (1) for the monthly regional unemployment rate, the monthly stock of vacancies registered with the PEA (relative to the number of employees in the same region, multiplied by 100), the monthly inflow rate into unemployment, and the monthly outflow rate from unemployment (not necessarily into employment) for short-term unemployed, i.e., those unemployed treated by Hartz 3. The shown pre-treatment trends for these local labor market measures are not statistically different from zero, as the black columns for the p-values show. Based on this event study the respective labor market measures have had no significant impact on the timing of the roll-out.

2.3 Data

For our main empirical analysis we use two datasets, the IZA/IAB Administrative Evaluation Dataset (AED) and the Linked-Employer-Employee-Data of the IAB (LIAB), which we introduce in detail below. In section 2.7 we use the German Job Vacancy Survey, which we introduce in the respective section. The AED and the LIAB are individual level and individual-firm level datasets, respectively.

In our analysis we include only individuals with an age between 20 to 60. In order to ensure that we capture only unemployed, who are (potentially) treated, we include only previously unemployed, who receive regular unemployment benefits administered by the local PEAs, i.e., not long-term unemployment benefit recipients, who were administered after the reform by local job centers (another kind of institution only responsible for long-term unemployed). We also exclude all previously unemployed whose unemployment spell lasted more than 12 months in order to ensure that the German-wide cut of the regular UI-benefit entitlement period in 2005 does not affect the composition of the previously unemployed under consideration.

IZA/IAB Administrative Evaluation Dataset (AED) We use the AED to analyze the effect of the Hartz 3 reform on unemployed job seekers probability to receive a vacancy referral and their job finding probability. The AED is a 4.66 percent random sample of inflows into unemployment in Germany from 1st January 2001 to 31th December 2008 drawn from the Integrated Employment Biographies (IEB) of the Institute for Employment Research (IAB). The IEB consist of individuals with employment subject to social security, marginal employment, unemployment benefit receipt or (planned) participation in programs of active labor market policies.

The AED includes many personal characteristics and a lot of individual labor market information. In the regressions we use the information on age, gender, education, previous unemployment and employment experience and an indicator variable for dependent children. Column 1 in Table B.2 in Appendix B.1 provides descriptive statistics of the variables used in our analysis. We only know the number of vacancy referrals an individual received during her unemployment spell but not their exact issuing date. We therefore investigate whether an individual received a vacancy referral or not during her unemployment spell. The information on vacancy referrals is - due to a change in the PEA-wide IT system - only available for job seekers entering unemployment until June 2006. We therefore only consider spells within the period February 2002 until June 2006. The second set of outcome variables are the UE-transition probabilities within 3, 6, 9 and 12 months. Table B.1 in Appendix B.1 provides descriptive statistics of the outcome variables used.

For identification we use the information on the unemployed job seeker's county of residence and her entry date into unemployment.

Linked-Employer-Employee-Data of the IAB (LIAB) We use the linked-employer-employee data-set to evaluate the effect on wages. The LIAB combines establishment level data with individual level information from administrative records. We use the 2010 cross sectional version of the LIAB (liab_qm_9310_v1). The cross sectional version provides us with information of all individual employed at an IAB Establishment Panel establishment at the cutoff date 30th June each year. We only consider new hires, since we are interested in how wages of new hires react after the Hartz 3 reform. For each individual we observe the average daily wage paid at the cutoff date. We also observe the day at which an individual entered the establishment. This date together with the information about the employer region is used to pin down whether a firm has been in a region in which the PEA has been treated at the time when the worker started working. We also know the age, gender, nationality, education, occupational status, employment and unemployment experience. For our analysis we use data on individuals who have been hired between January 2002 and December 2007. Column 2 in Table B.2 in Appendix B.1 provides descriptive statistics of the variables used in our analysis.

The rather old version from 2010 provides in contrast to the recent version additional information, which proved to be very valuable for identification. The 2010 version has additional information on the employment status 8 days prior to hiring, the length of the unemployment or employment spell prior to hiring, and the average daily wage 8 days prior to hiring. The entry date into employment and the length of the previous unemployment spell allows us to calculate the entry date into unemployment. The average daily wage in case of a previously unemployed equals daily UI-benefits, i.e., 60 percent of the previous wage in case of a childless person and 67 percent in case of a person with dependent child. We also have the information on the county of residence of an individual, which provides us with information on which local PEA was responsible for a previous unemployed individual. Around 40% of all newly hired unemployed were taken care of local PEAs, which differed from the local PEA responsible for the establishment. How this information is used for identification is described in section 2.6 below.

2.4 The effect of Hartz 3 on vacancy referrals

Identification We analyze the effect of Hartz 3 on vacancy referrals using the following event-study design. The implementation of the Hartz 3 reform in each local PEA took around 3 months. We take the quarter prior to the implementation quarter as reference quarter. Given the total roll-out period of around 7 quarters, we limit the effect window to 6 quarters of leads and lags and bin the endpoints of the window at 7+ quarters before and after the treatment quarter. As shown by Schmidheiny and Siegloch (2023) binning the endpoints overcomes the under-identification problem in panel data event-studies pointed out by Borusyak and Jaravel (2017) if at least one non-treated observation is binned at each endpoint. Given that the first PEAs started with the implementation in the beginning of 2004 and the last PEAs finished end of October 2005 this condition is meet.

We estimate a number of different models, all of which include regional and monthly time-fixed-effects, ψ_r and υ_t, respectively. In the second specification we additionally include with X_i the individual characteristics age, gender, education, previous unemployment and employment experience and an indicator variable for dependent children of the newly unemployed. In the third specification we include in addition the following regional time varying variables, Z_{rt} : stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies.

Identification is achieved by within-county variation over time and the fact that the treatment occurred at different points in time in different counties. The event-study treatment indicator variable for person i in region r, τ_{ir}^k, is equal to 1 if person i entered unemployment in the "k" quarters before/after the implementation of Hartz 3 in region r and zero otherwise.

Identification of causal effects in such models requires a flat and insignificant pre-treatment trend, i.e., the coefficients β^k for $k \in \{-2, ..., -6\}$ need not to be significantly different from to the reference period $k = -1$. We also have to assume that the timing of the roll-out locally is not systematically driven by local shocks that would also affect vacancy referrals. This assumption is likely to be fulfilled given the flat pre-treatment trends of other local labor market characteristics shown in Figure 2. If confounding local unemployment shocks were important, our estimates would vary if we include them, which they don't. Formally, we estimate,

$$y_{irt} = \sum\nolimits_{k=-7}^{7} \beta^k \tau_{ir}^k + \delta X_i + \zeta Z_{rt} + \psi_r + \upsilon_t + \varepsilon_{irt}, \tag{2}$$

where y_{irt} is an indicator variable, which equals one if an unemployed i in region r, who entered unemployment at time t, received a vacancy referral within the unemployment spell with a maximum length of 3, 6, 9, and 12 months. Due to the fact that we only know whether an unemployed received a vacancy referral but not the exact issuing date, the results do not depend much on the number of months under considerations.

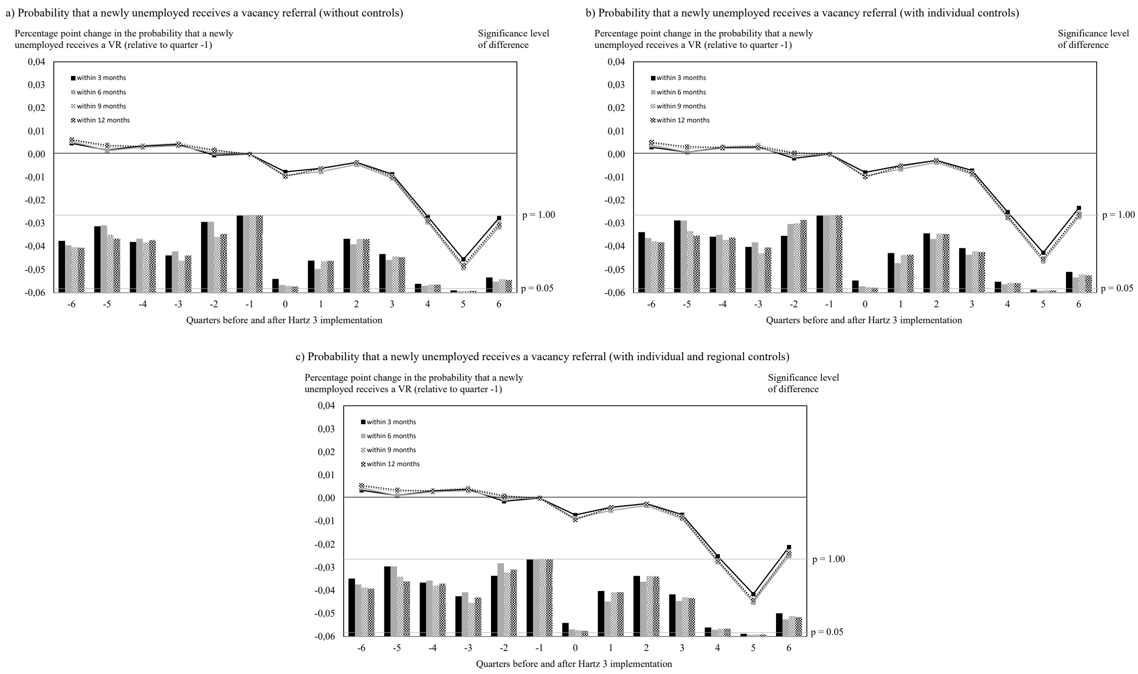
Since all regions are eventually treated, i.e., we have no permanent control group, we cannot identify a long-run average treatment effect on the treated. This is due to the fact that the start and end bin-points in an event study incorporate the level-effect of the control group as shown by Schmidheiny and Siegloch (2023). This is also the reason why we do not report them in the Figures below. In order to estimate the average effect of Hartz 3 on vacancy referrals for the period in which this is possible, we keep the start and end bin-points -7 and 7+ and set the event window treatment (EWT) indicator T_{ij} to 1 if person i in region j entered unemployment in the 4th until the 6th quarter after Hartz 3 was implemented in region j and 0 otherwise. We choose the 4th quarter as starting point, since the event study suggests this delay.

$$y_{irt} = \beta^{-7} \tau_{ir}^{-7} + \beta^T T_{ir} + \beta^{+7} \tau_{ir}^{+7} + \delta X_i + \zeta Z_{rt} + \psi_r + \upsilon_t + \varepsilon_{irt}. \tag{3}$$

Event study results We estimate equation (2) using the AED entry sample of unemployed individuals. Figure 3 shows the event study indicator coefficients β^k (connected with lines) with the scale on the left axis and the significance level (p-value) of the difference to the reference quarter $k = -1$ in columns with the scale on the right axis. Below on the x-axis we show the quarters before and after the implementation quarter. Quarter 0 is the quarter in which the reorganization took place.

Figure 3 shows the event study coefficients for the probability that unemployed received at least one vacancy referral during their unemployment spell with a maximum length of 3, 6, 9 or 12 months. There is almost no difference between the specifications based on the lengths of an unemployment spell. The reason is that our vacancy referral information only contains the information on the number of vacancy referrals received during the entire unemployment spell and not on the precise date a vacancy referral was handed out. In Figure 3a) we show the event study coefficients without further control variables, in Figure 3b) the event study coefficients with the additional individual controls, and in

Figure 3: Event study of the Hartz 3 reform on vacancy referrals



Notes: Based on 440,552 individual observations of the AED data-set from February 2002 to June 2006. The outcome variable is an indicator variable, which equals 1 if unemployed received at least one vacancy referral during their unemployment spell with a maximum length of 3, 6, 9 or 12 months and zero otherwise. The lines show the event study coefficients β^k from equation (2) with the scale on the left axis. The columns show the p-values of the significance level with the scale on the right axis. Figure 3a) shows the event study coefficients without further control variables, Figure 3b) with the additional individual controls age, gender, education, previous unemployment and employment experience and an indicator variable for dependent children of the newly unemployed, and Figure 3c) with the additional regional controls stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies.

Figure 3c) with the additional regional controls. All specifications show the same pattern, namely a flat pre-trend before the reform, a slight but only marginally significant drop of less than 1 percentage points in the quarters 0 to 3, and a significant reduction in the probability to receive a vacancy referral of around 4 to 5 percent in the 5th quarter after Hartz 3 was implemented.

Average treatment effect on the treated (ATT) Table 1 shows the event window treatment estimates for the probability that an unemployed receives at least one vacancy referral during the unemployment spell with a maximum length of 3, 6, 9 or 12 months. Based on the event study above we define the event window indicator variable to equal 1 for the 4th to the 6th quarter after the reform.

In summary, the results of our preferred specification with individual and regional controls in Table 1 show that the Hartz 3 reform decreased significantly the probability that unemployed received vacancy referrals by around 2.2 to 2.3 percentage points. The probability to receive a vacancy referral in the reference quarter -1 equals 56.1 to 58.8 percent for individuals with an unemployment spell with a maximum length of 3 to 12 months. Hence, the Hartz 3 reform decreased the probability to receive vacancy referrals over the quarters 4 to 6 on average by around 4 percent.

The fact that Hartz 3 decreased the probability that an unemployed receives at least one vacancy referral during the unemployment spell confirms that the reform reduced the incentive of case managers

Table 1: ATT of the Hartz 3 reform on receipt of vacancy referrals

	Event window treatment estimates during an unemployment spell of			
	3 months	6 months	9 months	12 months
	without further controls			
Hartz 3 (β^T)	-0.0230**	-0.0242**	-0.0240**	-0.0239**
	(0.0095)	(0.0096)	(0.0096)	(0.0095)
	with individual controls			
Hartz 3 (β^T)	-0.0221**	-0.0233**	-0.0230**	-0.0229**
	(0.0095)	(0.0096)	(0.0096)	(0.0095)
	with individual and regional controls			
Hartz 3 (β^T)	-0.0218**	-0.0231**	-0.0228**	-0.0227**
	(0.0094)	(0.0095)	(0.0094)	(0.0094)
N	440,552	440,552	440,552	440,552

Notes: Based on 440,552 individual observations of the AED data-set from February 2002 to June 2006. The outcome variable is an indicator variable, which equals 1 if an unemployed received at least one vacancy referral during the unemployment spell with a maximum length 3, 6, 9 or 12 months and zero otherwise. In the Table we show coefficients β^T from equation (3). Standard errors in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

to mediate PEA induced matches via vacancy referrals. However, the reduced use of vacancy referrals does not imply that the overall effect of Hartz 3 on the job finding rate is negative. If vacancy referrals of the PEA crowd out private search - as hypothesized by Pissarides (1979) - then a reduction of vacancy referrals can be compensated by the increase in private search. Also, the changes in the counseling process that were implemented with Hartz 3 could have encouraged case managers to push workers to search more in the private market.

2.5 The effect of Hartz 3 on the UE-transition probability

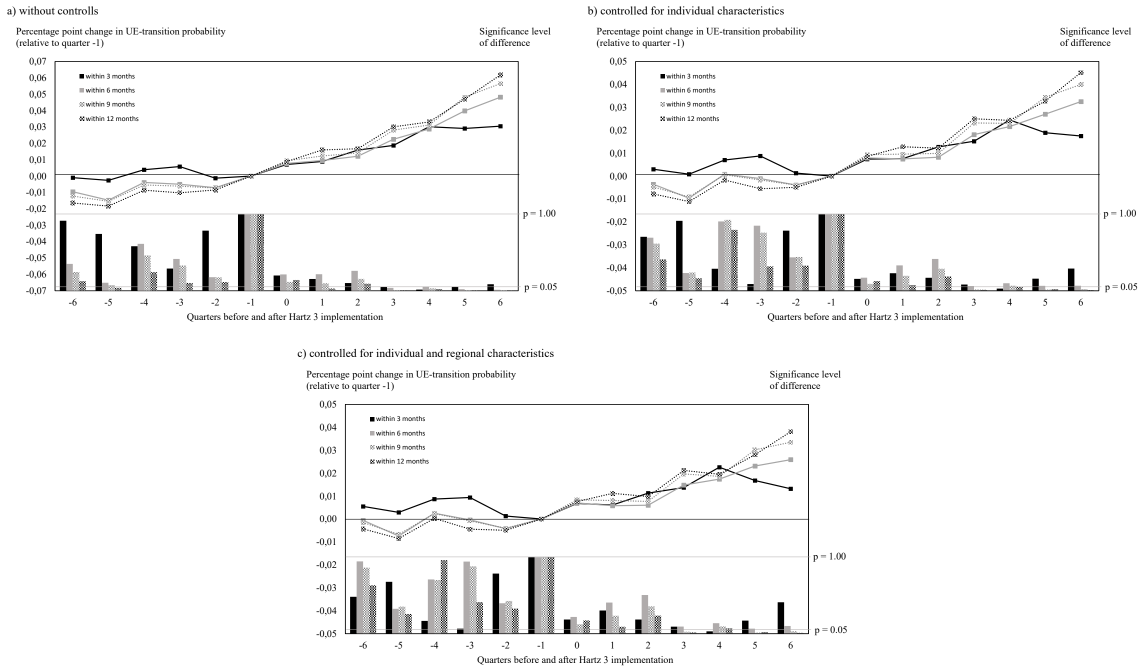
The analysis of the effect of Hartz 3 on the UE-transition probabilities follows the same identification strategy as outlined above. The event study regression is therefore identical to equation (2) and the event window regression identical to equation (3).

2.5.1 UE-transition probability of all individuals

Event study results The outcome variables in the event study regressions (2) and the event window regressions (3) are indicator variables that equal 1 if an unemployed found a job within 3, 6, 9, or 12 months, respectively. Figure 4 shows the event study indicator coefficients β^k (dots connected with lines) with the scale on the left axis and the significance level (p-value) of the difference relative to the reference quarter $k = -1$ in columns with the scale on the right axis. Below on the x-axis we show the quarters before and after the implementation quarter. Quarter 0 is the quarter in which the reorganization took place.

Figure 4 shows the event study coefficients for the UE-transition probabilities of unemployed within

Figure 4: Event study of the Hartz 3 reform on the UE-transition probabilities



Notes: Based on 440,552 individual observations of the AED data-set from February 2002 to June 2006. The outcome variable is an indicator variable, which equals 1 if an unemployed found a job within 3, 6, 9 or 12 months and zero otherwise. The lines show the event study coefficients β^k from equation (2) with the scale on the left axis. The columns show the p-values of the significance level with the scale on the right axis. Figure 4a) shows the event study coefficients without further control variables, Figure 4b) with the additional individual controls age, gender, education, previous unemployment and employment experience and an indicator variable for dependent children of the newly unemployed, and Figure 4c) with the additional regional controls stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies.

3, 6, 9 or 12 months. Figure 4a) shows the event study coefficients without control variables, Figure 4b) with individual controls, and Figure 4c) with, in addition, regional controls. The pre-trends before the reform are flat and not significantly different from zero. After the Hartz 3 reform the UE-transition probabilities increase and the increase becomes significant after the 2nd quarter. Controlling for individual and regional characteristics reduces the size of the effect. With individual and regional controls the UE-transition probabilities within 3 months increase by 2.0 percentage points and the UE-transition probabilities within 12 months by up to 3.8 percentage points 6 quarters after the reform. The reference UE-transition probabilities within 3 and 12 months (in the reference quarter -1) are 30.4 and 47.7 percent, respectively. This implies that the Hartz 3 reform increased the UE-transition probability in the 6th quarter after the Hartz 3 reform by 6.6 to 8.0 percent.

Average treatment effect on the treated (ATT) Table 2 shows the event window treatment estimates for the UE-transition probabilities of unemployed within 3, 6, 9 or 12 months. Based on the event study above we defined the event window indicator variable to equal 1 for the 3rd to the 6th quarter after the reform and 0 otherwise.

The results of our preferred specification with individual and regional controls in Table 2 show that Hartz 3 significantly increased the job finding probability of unemployed workers within 6, 9, and

Table 2: ATT of the Hartz 3 reform on UE-transition probabilities

	Event window treatment estimates for UE-transition probabilities within			
	3 months	6 months	9 months	12 months
	without further controls			
Hartz 3 (β^T)	0.0095**	0.0137***	0.0160***	0.0147***
	(0.0044)	(0.0051)	(0.0051)	(0.0051)
	with individual controls			
Hartz 3 (β^T)	0.0072*	0.0113**	0.0137***	0.0126***
	(0.0043)	(0.0050)	(0.0049)	(0.0047)
	with individual and regional controls			
Hartz 3 (β^T)	0.0074*	0.0100*	0.0123***	0.0110***
	(0.0043)	(0.0051)	(0.0049)	(0.0046)
N	440,552	440,552	440,552	440,552

Notes: Based on 440,552 individual observations of the AED data-set from February 2002 to June 2006. The outcome variable is an indicator variable, which equals 1 if an unemployed found a job within 3, 6, 9 or 12 months and zero otherwise. In the Table we show coefficients β^T from equation (3). Standard errors in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

12 months by around 1.0 to 1.2 percentage points. The reference UE-transition probabilities within 6, 9, and 12 months are 43.3, 48.4, and 51.1 percent, respectively. Hence, the Hartz 3 reform increased the UE-transition probability within 6, 9, and 12 months on average over the quarter 3 to 6 by 2.3, 2.5, and 2.2 percent respectively.

Given that Hartz 3 decreased vacancy referrals but increased the overall UE-transition probability we investigate next whether Hartz 3 affected UE-transition probabilities of individuals with and without vacancy referrals differently.

2.5.2 UE-transition probability of individuals with and without vacancy referrals

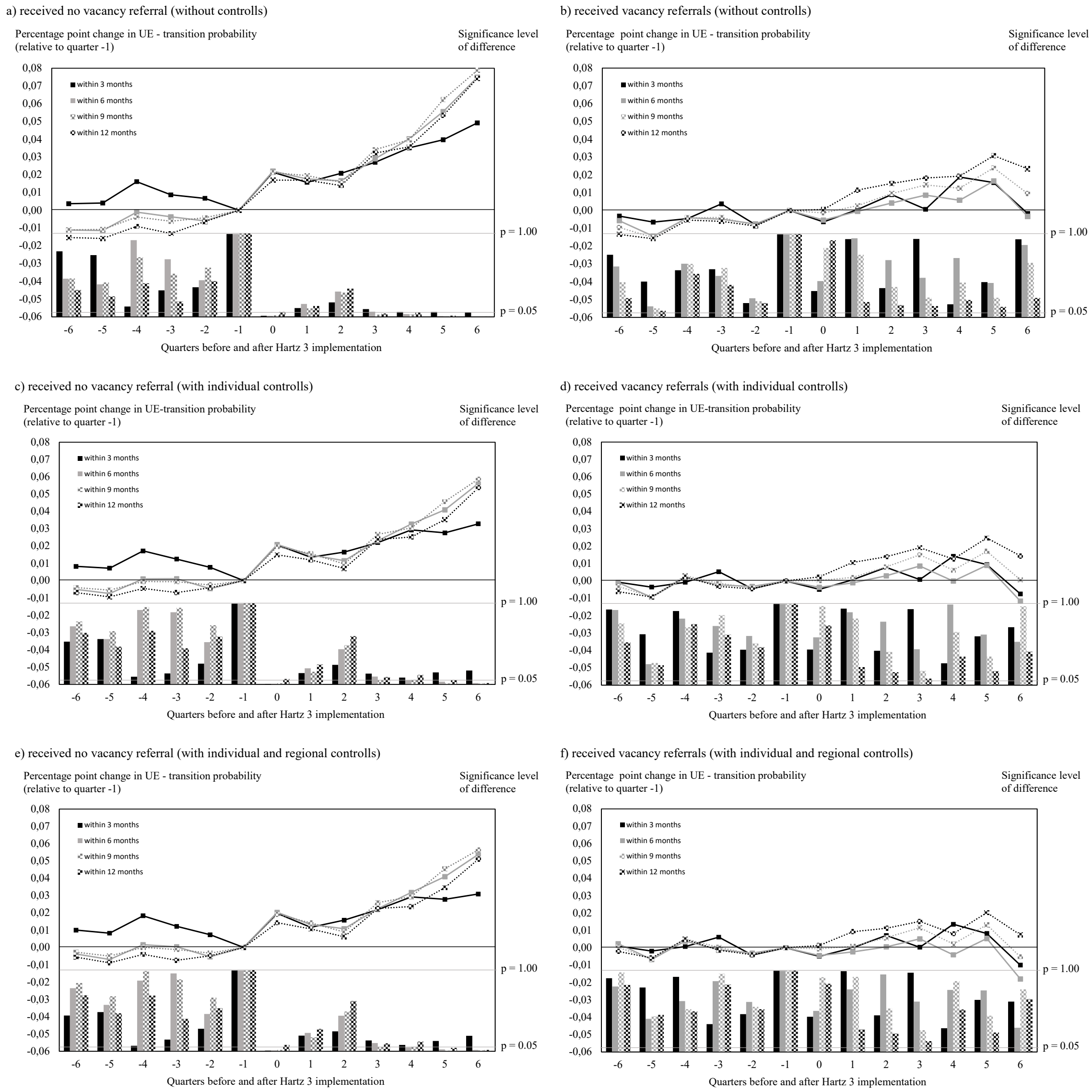
Event study results Figure 5 shows the same event studies as in Figure 4 differentiated according to individuals with and without vacancy referrals during their unemployment spell.

Figure 5 shows that the positive effect of the Hartz 3 reform on the UE-transition probability is driven by job seekers that did not receive vacancy referrals during their unemployment spell. Those without vacancy referral experience an up to 5 percentage point increase in their job finding probability (Figure 5e)), while those with vacancy referrals are not affected.

The reference UE-transition probabilities within 3 months equals 33.6 for those without vacancy referrals and 28.4 for those with vacancy referrals. The reference UE-transition probabilities within 12 months (in quarter -1) equals 51.2 for those without vacancy referrals and 50.9 for those with vacancy referrals. The difference in the reference UE-transition probabilities suggest that when deciding on whom to offer a vacancy referral case managers give preference to job seekers, who are expected to be less successful in finding a job. Since the number of job seekers that receive a vacancy referral decreases after Hartz 3, those, who would have received a vacancy referral before the reform but do

Figure 5: Event study of the Hartz 3 reform on the UE-transition probabilities

Differentiated according to having received at least one vacancy referral



Notes: Depending on the specification the sample is based on 198,967 to 241,585 individual observations of the AED data-set from February 2002 to June 2006. The outcome variable is an indicator variable, which equals 1 if an unemployed found a job within 3, 6, 9 or 12 months and zero otherwise. The lines show the event study coefficients β^k from equation (2) with the scale on the left axis. The columns show the p-values of the significance level with the scale on the right axis. Figure 4a) shows the event study coefficients without further control variables, Figure 4b) with the additional individual controls age, gender, education, previous unemployment and employment experience and an indicator variable for dependent children of the newly unemployed, and Figure 4c) with the additional regional controls stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies.

not receive a vacancy referral after the reform, are expected to be on average less successful in finding a job than those that did not receive a vacancy referral before the reform. Thus, if this compositional effect is present, this effect tends to decrease the UE-transition probability of unemployed without vacancy referrals after the reform. Our estimates are therefore a lower bound.

Average treatment effect on the treated (ATT) Table 3 shows the event window treatment estimates of the UE-transition probabilities of job seekers with and without vacancy referrals. Based on the event study above we define the event window indicator variable equal to 1 for the 3rd to the 6th quarter after the reform and 0 otherwise.

Table 3: ATT of the Hartz 3 reform on UE-transition probabilities
Differentiated according to having received at least one vacancy referral (VR)

	Event window treatment estimates for UE-transition probabilities within			
	3 months	6 months	9 months	12 months
Hartz 3 (β^T)	without further controls			
without VR	0.0106*	0.0150**	0.0187***	0.0175***
	(0.0063)	(0.0068)	(0.0066)	(0.0064)
with VR	0.0017	0.0052	0.0068	0.0055
	(0.0063)	(0.0066)	(0.0066)	(0.0065)
Hartz 3 (β^T)	with individual controls			
without VR	0.0088	0.0128*	0.0163**	0.0150**
	(0.0060)	(0.0066)	(0.0065)	(0.0061)
with VR	0.0005	0.0041	0.0064	0.0054
	(0.0066)	(0.0063)	(0.0062)	(0.0059)
Hartz 3 (β^T)	with individual and regional controls			
without VR	0.0101	0.0133*	0.0165**	0.0149**
	(0.0061)	(0.0068)	(0.0067)	(0.0067)
with VR	0.0006	0.0028	0.0050	0.0040
	(0.0066)	(0.0062)	(0.0061)	(0.0058)
N (without VR)	208,313	202,031	199,649	198,967
N (with VR)	232,239	238,521	240,903	241,585

Notes: Based on individual observations of the AED data-set from February 2002 to June 2006. The outcome variable is an indicator variable, which equals 1 if an unemployed found a job within 3, 6, 9 or 12 months and zero otherwise. In the Table we show coefficients β^T from equation (3). Standard errors in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

The displayed coefficients of our preferred specification with individual and regional controls in Table 3 show that the Hartz 3 reform significantly increased the job finding probability of job seekers without vacancy referrals by 1.3, 1.7, and 1.5 percentage points within 6, 9, and 12 months, respectively. The reference UE-transition probabilities are 45.1, 49.0, and 51.2 percent, respectively. Thus, the Hartz 3 reform increased the job finding probability of unemployed workers without vacancy referrals in the quarters 3 to 6 after the reform by roughly 3 percent.

The findings that Hartz 3 decreased the probability of receiving a vacancy referral and that it increased the overall job finding probability of unemployed job seekers by increasing the job finding probability of unemployed job seekers without vacancy referrals suggests that Hartz 3 increased the job finding probability by reducing the PEA's own share of matches in the labor market. The Hartz 3 reform achieved this by incentivizing case managers to focus more on increasing the search intensity of unemployed job seekers instead of using vacancy referrals to bring unemployed back into work.

In all standard job search models an increase in the job finding probability of unemployed job seekers triggered by an increase in job seekers search intensity, would go along with a decrease in wages, since firms' outside option to find an alternative worker increases. However, the opposite is true, i.e., wages of previously unemployed increased after the Hartz 3 reform as we will show in the following section.

2.6 The effect of Hartz 3 on wages of newly hired unemployed

Identification The Hartz 3 reform can affect wages via the unemployed job seekers' residence region PEA and via the workplace region PEA, i.e., via changes in job seekers' search behavior resulting from changes in the counseling process of the PEA responsible for the unemployed job seekers and via changes in firms' recruitment behavior or wage policies resulting from changes in the way the PEA responsible for the firm handles firms' vacancy postings. The two channels can potentially be disentangled due to the fact that unemployed are treated at different times then their later employers, especially if the residence and workplace regions are looked after by different local PEAs. Due to the high correlation between the timing of the treatment of unemployed job seekers and the timing of the treatment of their later employers we have to deal with a high degree of multicollinearity between the respective treatment indicators.

To measure the first effect we use the information on the treatment date of the residence region PEA responsible for the unemployed job seeker and the date when the job seeker entered unemployment. For the second effect we use information on the treatment date of the workplace region PEA responsible for the firm (establishment) and the date when the newly hired worker entered the firm (establishment). If the workplace region PEA has been treated while the residence region PEA is still untreated, then wage changes of newly hired unemployed relative to newly hired employed workers are only driven by the effect that Hartz 3 has on firms' wage policies. If the unemployed entered unemployment after the residence region has been treated while the workplace-region PEA is still untreated, then the wage changes can only be driven by the effect of Hartz 3 on the job seekers' search behaviour.

We therefore use a DiD event study specification for the identification of how Hartz 3 affected wages via job seekers' search behaviour. We obtain the two differences by comparing the hiring wages of previously unemployed in treated and untreated *residence* regions before and after the reform using the variation resulting from the roll-out of the Hartz 3 reform. More specifically, in the event study regressions shown in equation (4) we include an indicator variable for person i in region r, τ_{ir}^{k}, which is equal to 1 if person i entered unemployment in the "k" quarters before/after the implementation of Hartz 3 in the residence region r and zero otherwise. This indicator variable is constructed in the same way as the indicators in the previous sections where we investigated the effect of Hartz 3 on vacancy referrals and UE-transition probabilities.

For the identification of the effect that Hartz 3 has on firms' wage policies we use a DiDiD event study specification. For the first two differences, we compare the hiring wages of previously unemployed in treated and untreated *workplace* regions before and after the reform using again the variation resulting from the roll-out of the Hartz 3 reform. For the third difference we use the hiring wages of previously employed workers as additional within firm control group. To do so we include in the regressions shown in equation (4) event study indicators for each "k" quarter prior and after the Hartz 3 reform took place in the workplace region PEA. We include one set of event study indicators for all newly hired workers and one set of event study indicators for newly hired, previously unemployed workers only. The first set of indicator variables (d_{ij}^k) is equal to 1 in the k-th quarter in which a newly hired worker i entered firm j and zero otherwise. To identify the effect on newly hired, previously unemployed we interact the first set of indicator variables with the previously unemployment indicator variable ($unemp \times d_{ij}^k$). This identification strategy works if hiring wages of previously unemployed (treatment group) and previously employed workers (control group) had the same pre-treatment trend. We show below that this is indeed the case.

We also ensure that the composition of firms does not change systematically with the roll-out of the Hartz 3 reform by using establishment fixed effects μ_j. In other words, we rely only on within establishment changes of hiring wages over time to identify the effect. Furthermore, we use the wage of the worker's previous employment spell $w_{i,t-1}$ to control for worker-fixed effects.[6] For previously employed workers this is the wage of the employment spell which includes the 8th day prior to hiring, for previously unemployed workers this equals the UI-benefits of the UI-spell, which includes the 8th day prior to hiring.[7] To be able to control for the previous wage we make use of the fact that UI-benefits equal exactly 60 percent (67 percent for individuals with kids) of previous wages and interact the previous wage with the indicator for previously unemployed, which captures the replacement rate. To make sure that the UI-benefits are determined by the 60 percent replacement rate (67 percent for individuals with kids) of previous wages, we only take previously short-term unemployed (unemployed for less than 12 months) and delete all long-term unemployed from our analysis. This is also necessary, because the latter are taken care of by local job centers - a different institution than the local PEAs.

The explicit regression model used for the event study is as follows,

$$\begin{aligned} w_{ijrt} &= \alpha w_{i,t-1} + \sum\nolimits_{k=-7}^{7} \beta^k \tau_{ir}^k + \sum\nolimits_{k=-7}^{7} \gamma^k d_{ij}^k + \gamma_u unemp + \sum\nolimits_{k=-7}^{7} \gamma_u^k \left(unemp \times d_{ij}^k\right) \\ &\quad + \delta X_i + \eta Y_{jt} + \zeta Z_{jt} + \mu_j + \psi_r + \upsilon_t + \varepsilon_{ijrt}, \end{aligned} \tag{4}$$

For each full-time employed individual we observe the average daily (log) hiring wage, w_{ijrt}, paid in the spell on 30th June each year. The index i denotes the newly hired individual, and the index j the establishment, the index r the residence region of the worker, and index t the month the worker entered the firm.

We estimate a number of different models, all of which include firm- (establishment-), residence region-, and monthly time-fixed-effects, μ_j, ψ_r, and υ_t, respectively. Since we exclude the handful establishments that changed regions over time, the firm-fixed effects also capture employer region fixed effects. In the second specification we include the individual characteristics age, gender, education, nationality (non-German), previous unemployment and employment experience, X_i, and some firm (establishment) characteristics like the age of the establishment, the size of the workforce (log) and

[6] We do not use the panel of wages observed after hiring, because wages later in the tenure-spell are highly correlated with the hiring wage. The individual fixed effect would then to a large extend capture the circumstances, which determined the hiring wage - in our case to a large extend the effect of the Hartz 3 reform.

[7] The 8 days period between two spells is chosen by the IAB, who provides the data-set, because it best eliminates reporting errors in the administrative data-set.

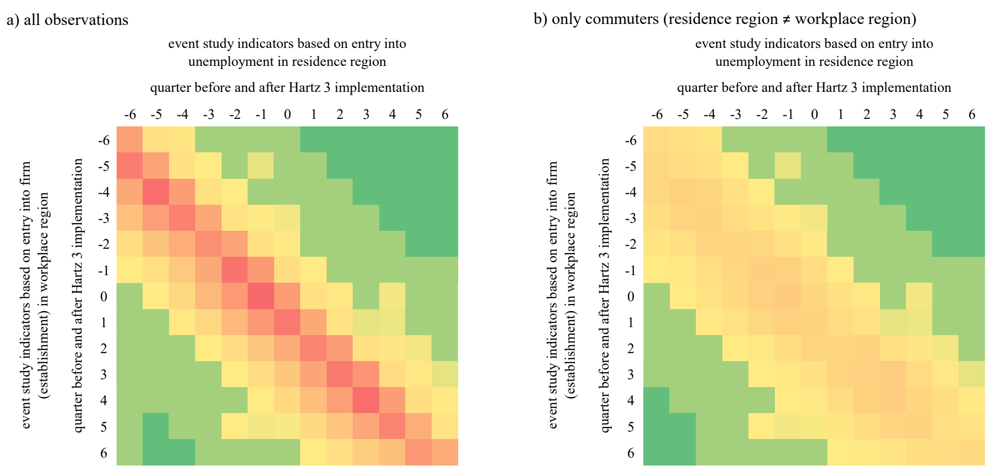
the (log) number of total hiring and quits, Y_{jt}. Given the data is collected at the cutoff date 30th June each year the wage information might be recorded up to 12 months after the entry of the individual. Thus, the wage could have changed in the meanwhile. We control for this effect by including monthly tenure indicators in X_i. In the third specification we include in addition regional time varying variables of the employer region, Z_{jt}: stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies.

Similar to the previous section we estimate the ATT of Hartz 3 on hiring wages. Given that we cannot estimate a long-run effect since all regions are eventually treated, we keep the start and end bin-points -7 and 7+ and set the event window treatment (EWT) indicator for the residence region PEA, T_{ir}, and the event window treatment indicator for the workplace region PEA, D_{ij}, equal to 1 from the 3rd until the 6th quarter after the reform in the respective region and 0 otherwise. We choose the 3rd quarter as starting point, since the event study suggests this delay. The explicit event window regression is given as follows,

$$\begin{aligned} w_{ijrt} \quad = \quad & \alpha w_{i,t-1} + \beta^{-7}\tau_{ir}^{-7} + \beta^{T}T_{ir} + \beta^{+7}\tau_{ir}^{+7} + \gamma^{-7}d_{ij}^{-7} + \gamma^{T}D_{ij} + \gamma^{+7}d_{ij}^{+7} \\ & + \gamma_u unemp + + \gamma_u^{-7}\left(unemp \times d_{ij}^{-7}\right) + \gamma_u^{T}\left(unemp \times D_{ij}\right) + \gamma_u^{+7}\left(unemp \times d_{ij}^{+7}\right) \\ & + \delta X_i + \eta Y_{jt} + \zeta Z_{jt} + \mu_j + \psi_r + \upsilon_t + \varepsilon_{ijrt}. \end{aligned} \tag{5}$$

Multicollinearity Whether we are empirically able to disentangle the two channels of the Hartz 3 reform on hiring wages via the unemployed job seekers' residence region PEA and via the workplace region PEA depends on whether there is enough variation across the residence region event study indicators and the workplace region event study indicators. The following heat maps in Figures 6a) and 6b) show the degree of multicollinearity between residence region based event study indicators and the workplace region based event study indicators. In Figure 6a) we include all observations, while in Figure 6b) we include only observations where the residence region PEA and the workplace region PEA are treated at different points in time. By design, the later sample only includes workers who commute between different counties.

Figure 6: Correlation between treatment at residence region and treatment at workplace region



The correlation coefficient between the residence region event study indicators and the workplace region event study indicators in Figure 6a) is 0.90 and the correlation coefficient for Figure 6b) is 0.81. This high degree of multicollinearity inflates the standard errors of the estimated event study coefficients. Including only one set of event study coefficients, i.e., either residence region event study indicators or workplace region event study indicators, results in significant estimates. Because the estimated coefficients of both sets of event study indicators are quite similar in size, we also provide estimates where we constrain the estimated event study coefficients to the same value.

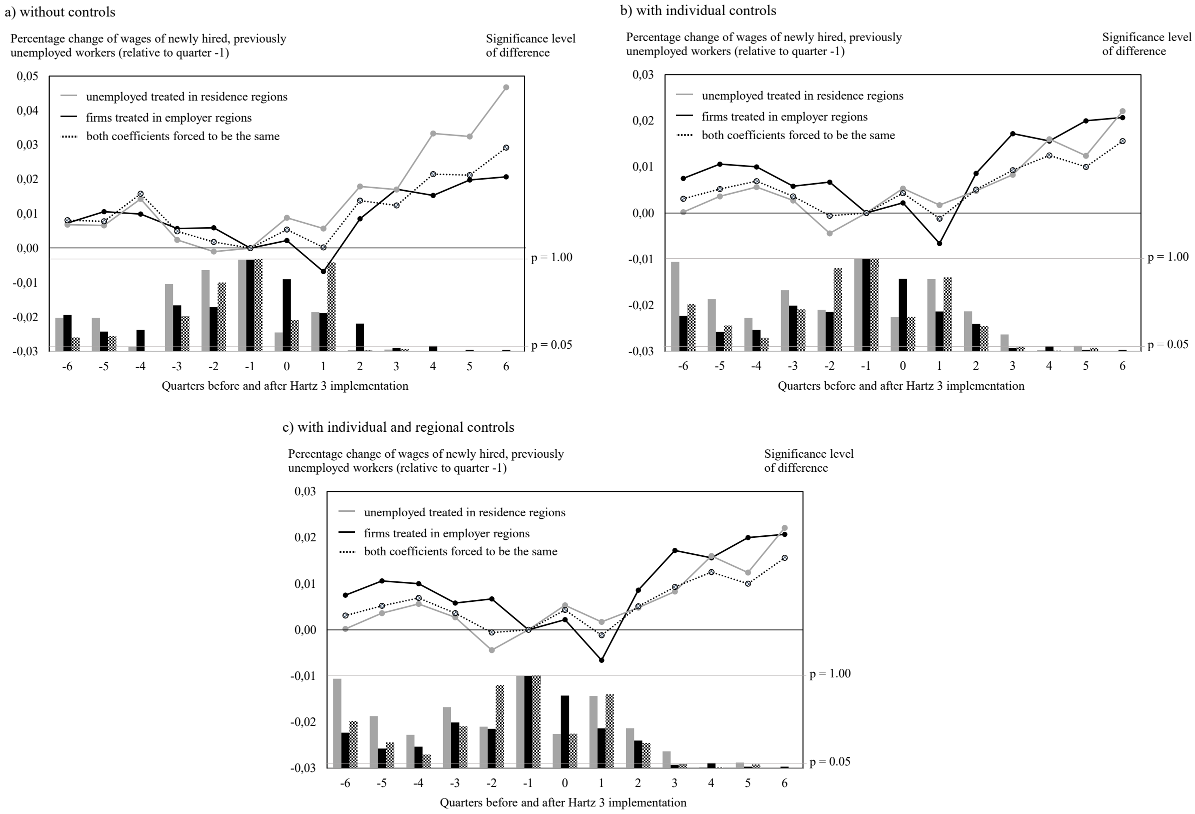
Event study results Figure 7 shows different specifications of equation (4). Given the high multicollinearity between the residence region event study indicators and the workplace region event study indicators it only makes sense to include only one set of event study indicators in one regression. The black lines in Figures 7a), b), and c) show the regression results, where we only include the event study indicators τ_{ir}^k with coefficients β^k, which capture the effect of Hartz 3 via residence region PEA. The grey lines show the regression results, where we only include the event study indicators d_{ij}^k with coefficients γ_u^k, which capture the effect via workplace region PEA. Note, that the later measure the wage effect of Hartz 3 on newly hired, previously unemployed relative to previously employed workers. The black and the grey lines have a similar pattern. This suggests that the estimated effects via the residence and the workplace region PEA are not statistically different from each other and that we can restrict the coefficients to be the same. The black dotted lines show the coefficients for the case where we include both sets of event study indicators and restrict $\beta^k = \gamma_u^k$ to avoid the inflation of standard errors due to the multicollinearity between τ_{ir}^k and $unemp \times d_{ij}^k$. Figure 7a) is based on a regression without individual and regional controls, Figure 7b) includes individual and firm level controls, and Figure 7c) includes in addition time varying regional controls for the employer region. As in Figures 3, 4, and 5 the size of the coefficients of the event study indicators are shown on the y-axis on the left and to indicate the significance of the coefficients we show the respective p-values as columns on the bottom with the scale pictured on the y-axis on the right.

In all specifications, where we control for individual and/or regional characteristics in Figure 7b) and c), the pre-trend are flat as required for identification. Figure 7 shows a steady increase in the average hiring wage of previously unemployed job seekers after the reform. The coefficients become significant form the 3rd quarter onward and suggest that the average hiring wage of previously unemployed job seekers increase by up to 2 percent after the reform.[8] Note, that we cannot observe whether the respective hiring was initiated by a vacancy referrals of the PEA or not. The estimates therefore represent increases in the average wages of newly hired, previously unemployed job seekers irrespective of whether the hiring was mediated by the PEA or not.

Average treatment effect on the treated (ATT) Table 4 shows the event window treatment effects (EWTE) for different specifications. In all specifications we set the event window indicator equal to 1 in the quarters 3 to 6 after the Hartz 3 reform and 0 otherwise. Whereby we follow the

[8] If we take the commuter sample equivalent to Figure 6b) where we include only observations where the residence region PEA and the workplace region PEA are treated at different points in time we get similar estimates. The respective coefficients are shown in Figure B.1 in Appendix B.2.

Figure 7: Event study of the Hartz 3 reform on hiring wages of previously unemployed



Notes: The estimates are based on 132,008 individual observations of the LIAB data-set from January 2002 to December 2007. The outcome variable is the daily (log) hiring wage. The black lines show the event study indicator coefficients β^k, the grey lines the event study indicator coefficients γ_u^k (grey lines) from equation (4). The black dotted lines show the coefficients for the case where we restrict $\beta^k = \gamma_u^k$ to avoid the inflation of standard errors due to the multicollinearity. Figure 7a) is based on a regression without individual and regional controls, Figure 7b) includes the individual controls; age, gender, education, nationality (non-German), previous unemployment and employment experience and the firm controls; age of the establishment, the (log) size of the workforce and the (log) number of total hiring and quits, and Figure 7c) includes in addition the regional controls stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies. The size of the coefficients of the event study indicators are shown on the y-axis on the left and to indicate the significance of the coefficients we show the respective p-values as columns on the bottom with the scale pictured on the y-axis on the right.

results of the event study in (Figure 7), where the effect of Hartz 3 starts to become significant after the 3rd quarter onward. The specifications are the same as those in the event study. The 1st column in Table 4 shows the residence region based EWTE, where we exclude the event window indicator for the workplace region in order to avoid multicollinearity, and column 2 shows the employer region based EWTE, where we exclude the event window indicator for the residence region. In column 3 we constrain the coefficients of both EWTEs to be the same.

The estimates in Table 4 show that Hartz 3 has primarily an effect via the residence region PEA, which is responsible for the counseling of unemployed job seekers, while the effect via the workplace region PEA, which captures the effect of the PEA on the employers recruitment and wage policy, is weaker and insignificant in comparison. Given the multicollinearity in the event window indicators we prefer to interpret the joint effect of both residence and workplace region, where we restrict both coefficients to be the same. According to these estimates Hartz 3 increases average wages of newly

Table 4: ATT of Hartz 3 on the average hiring wages of previously unemployed workers

	Event window treatment estimates (EWTE)		
	separate regressions		one regression
	unemployed treated in residence regions (β^T)	firms treated in employer regions (γ_u^T)	both coefficients forced to be the same ($\beta^T = \gamma_u^T$)
	without further controls		
Hartz 3	0.0235***	0.0113***	0.0126***
	(0.0036)	(0.0039)	(0.0023)
	with individual controls		
Hartz 3	0.0119***	0.0063*	0.0073***
	(0.0030)	(0.0034)	(0.0020)
	with individual and regional controls		
Hartz 3	0.0120***	0.0063*	0.0073***
	(0.0031)	(0.0034)	(0.0020)
N	132,008	132,008	132,008

Notes: Based on 132,008 individual observations of the LIAB data-set from January 2002 to December 2007. The outcome variable is the daily (log) hiring wage. The first row estimates are based on regressions without individual and regional controls, the second row estimates include the individual controls age, gender, education, nationality (non-German), previous unemployment and employment experience and the firm controls the age of the establishment, size of the workforce and the (log) number of total hiring and quits, and third row estimates include in addition the regional controls stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies. In the Table we show coefficients β^T and γ_u^T from equation (5) in columns 1 and 2 respectively and coefficients with $\beta^T = \gamma_u^T$ in column 3. Standard errors in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

hired, previously unemployed workers by 0.73 percent via each of both channels. Thus, in total Hartz 3 increases average hiring wages of previously unemployed by 1.5 percent. If we take the commuter sample equivalent to Figure 6b) where we include only observations, where the residence region PEA and the workplace region PEA are treated at different points in time, the all estimates are statistically significant and the estimated effects for the residence and workplace region are 1.2 percent each. The estimates based on the restriction that both effects are identical suggest that in total Hartz 3 increases average hiring wages of previously unemployed by 2.1 percent.[9]

Summary We can summarize our empirical findings as follows. The Hartz 3 reform:

1. decreased the fraction of unemployed that received vacancy referrals,
2. increased the UE-transition probability of unemployed job seekers, who did not receive vacancy referrals, and left the UE-transition probability of unemployed job seekers, who received vacancy referrals, unaffected,
3. increased average wages of newly hired, previously unemployed workers.

[9]The respective coefficients are shown in Table B.3 in Appendix B.2.

Before we present our model in section 3, which is able to explain all three empirical findings, we want to show some empirical evidence, which supports the assumption that job seekers differ in their expected suitability for a job. To do so, we have to give away one result of our model, namely that more suitable job seekers are more willing to search in the private market. This result implies that the fraction of suitable applicants among all applicants coming via the private market is higher than the respective fraction of suitable applicants coming via the PEA.

2.7 Suitability of applicants according to the search channel used

In this section we investigate first whether the fraction of suitable workers is higher among applicants that apply privately compared to applicants that are coming via the PEA. Given that suitability can have a very different meaning for each vacant position, we also compare it to firms' hiring decisions, i.e., we investigate whether suitable applicants that apply through the private market are more likely to be hired than suitable applicants that come via the PEA.

German Job Vacancy Survey For our analysis we use the German Job Vacancy Survey collected by the Institute for Employment Research in German.[10] It is based on a representative sample of establishments, which is newly sampled each year. The yearly survey started in 1989 and was initially conducted to provide an estimate of the total number of vacancies in Germany relative to the number of vacancies registered with the PEA, i.e., it contains also vacancies that are not registered with the PEA.

For our analysis we use the questions concerning the last case of a successfully filled vacancy. In this part of the survey firms were asked which search channels they used for the vacancy under consideration and through which channel they hired. The survey also provides information on the number of applicants and the number of suitable applicants. For the years 2005 to 2008 the survey also provides information on the number of (suitable) applicants sent by the PEA.[11]

The survey does not contain a county identifier. The only regional information provided relates to the level of the 10 main PEA-regions into which the Federal-PEA divides Germany. This implies that the roll-out of the Hartz 3 reform cannot be used for identification.

Research design and identification Our identification relies on within-vacancy variation. In other words, we use the within-vacancy variation in the fraction of suitable applicants coming via the PEA and the fraction of suitable applicants coming via the private market to test our hypothesis that less suitable applicants come via the PEA than the private market. Formally, we test,

$$H_0 : E\left(\frac{N_{suit}^{PEA}}{N_{total}^{PEA}}\right) - E\left(\frac{N_{suit}^{PM}}{N_{total}^{PM}}\right) = 0, \qquad (6)$$

where N_{suit}^{PEA} (N_{total}^{PEA}) and N_{suit}^{PM} (N_{total}^{PM}) stand for the number of suitable applicants (total number of applicants) coming via the PEA and the private market, respectively. We control for all vacancy

[10] The data used in this article were made available to us by the Research Data Centre of the German Federal Employment Agency at the Institute for Employment Research (IAB), Nuremberg.

[11] The precise questions are "If you have searched via the PEA, how many applicants did the PEA send to you?" and "How many suitable applicants were among them?"

characteristics, since the respective fraction is calculated for the same vacancy.

Being regarded as "suitable for a job" is a very broad measure. We will therefore in addition investigate whether suitable applicants arriving through the PEA are as "suitable" as suitable applicants arriving through the private market. To do so we use indirect evidence on the fraction of vacancies using the PEA not only as search but also as hiring channel. If suitable applicants coming via the PEA are regarded as equally good, they should be equally likely to be hired compared to suitable applicants coming via the private market. If this is the case, then we should observe that the fraction of vacancies hiring through the PEA is as high as the fraction of suitable applicants coming via the PEA among all suitable applicants. Formally, we test,

$$H_0 : E\left(\frac{N_{suit}^{PEA}}{N_{suit}^{PEA} + N_{suit}^{PM}}\right) - E\left(I_{hire}^{PEA}\right) \quad = \quad 0, \tag{7}$$

where I_{hire}^{PEA} is an indicator variable that equals 1 if the firm hires via vacancy referrals and 0 otherwise.

Besides the full sample, we also use - what we call - the in-time sample. The in-time sample consists only of vacancies, which were filled until the intended hiring date. We prefer the in-time sample, since it excludes vacancies, which might have turned to the PEA for help after having failed to hire until the intended hiring date because of too few suitable applicants.[12] Hence, the in-time sample excludes cases, which could bias our results due to reverse causality.

Fraction of suitable applicants Table 5 shows that the fraction of suitable applicants sent by the PEA is significantly lower than the respective fraction of suitable workers, who applied through the private market. The difference in the fraction of suitable applicants of 2.2 percentage points (in-time sample) is equivalent to 5.7 percent taking into account the fraction of suitable applicants of 39.2 percent. The respective coefficient estimated on the full sample is higher, which is likely due to reverse causality.

Table 5: **Fraction of suitable applicants via PEA and private market**

	Fraction of suitable applicants coming via			
	PEA	private market	difference	N
full sample	0.3348	0.3826	-0.0478***	3,270
	(0.0060)	(0.0058)	(0.0082)	
in-time sample	0.3695	0.3915	-0.0220**	1,872
	(0.0081)	(0.0077)	(0.0109)	

Notes: The significance of the difference is based on a t-test. The full sample contains all vacancies surveyed by the German Job Vacancy Survey, 2005-2008, and that searched via both search channels, the PEA and the private market. The in-time sample is restricted to all vacancies, which were successful in hiring an applicant before the intended starting date. Robust standard errors are in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

Since this within-vacancy variation approach only includes vacancies that used both the private market and the PEA search channel, we check the external validity of our results by including vacancies that are not registered with the PEA, i.e., only use one search channel. The results are presented in

[12] Ehrenfried and Holzner (2019) provide evidence that this is indeed the case.

Table B.4 in the Appendix B. These results are based on OLS regressions with many vacancy and firms controls. These regressions show that using the PEA is associated with a 7.9 to 9.0 percentage points decrease in the overall fraction of suitable applicants, which suggests that the results found above hold in general.

Suitability of suitable applicants As shown in Table 6 47.8% of registered vacancies in the in-time sample hire an applicant, whom they first meet through the PEA. However, the fraction of suitable applicants coming via the PEA among all suitable applicants is equal to 51.3%. This shows that suitable applicants coming via the private market are more often hired than suitable applicants via the PEA. The difference of 3.5 percentage points is significantly different from zero at a 1% level.

Table 6: **Hiring of suitable applicants coming via the PEA**

	Fraction of ...			
	firms hiring through PEA	suit. appl. via PEA rel. to all suit. appl.	difference	N
full sample	0.4633	0.4916	-0.0283***	5,675
	(0.0066)	(0.0056)	(0.0057)	
in-time sample	0.4779	0.5126	-0.0347***	3,216
	(0.0088)	(0.0074)	(0.0077)	

Notes: The significance of the difference is based on a t-test. The full sample contains all vacancies surveyed by the German Job Vacancy Survey, 2005-2008, and that searched via both search channels, the PEA and the private market. The in-time sample is restricted to all vacancies, which were successful in hiring an applicant before the intended starting date. Robust standard errors are in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

To summarize, we find that the fraction of suitable applicants sent by the PEA is lower than the respective fraction of suitable applicants, who applied through the private market. We also find that suitable applicants coming via the PEA are less likely to be hired than suitable applicants coming via the private market. These findings support the hypothesis that the fraction of suitable applicants among all applicants coming via the private market is higher than the respective fraction of suitable applicants coming via the PEA. This supports the mechanism suggested by our model, namely that the assumption that workers differ in their expected suitability can lead to the adverse selection observed in the data.

3 Theoretical Analysis

In this theory section we build a simple equilibrium search model where in addition to the private directed search market the PEA offers intermediation via vacancy referrals to match unemployed workers with vacant jobs registered with the PEA. Given our primary objective of providing an explanation for the increase in wages of newly hired, previously unemployed workers after the Hartz 3 reform, our focus lies on the wage formation process.

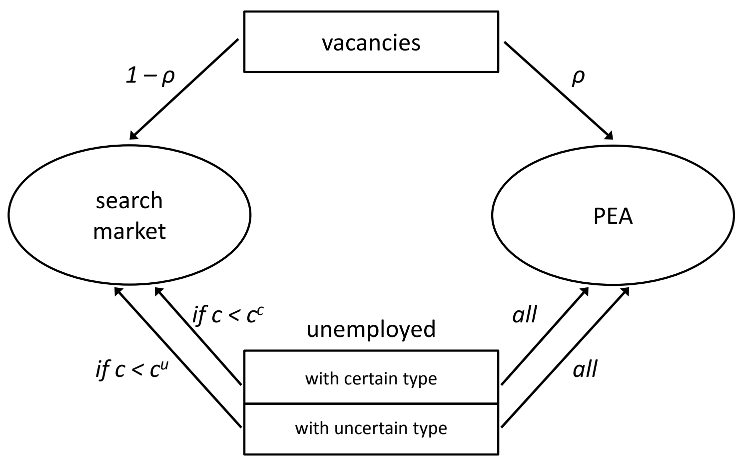
All proofs can be found in Appendix A.

3.1 Setup

We consider an economy with a mass of unemployed workers and firms.[13] For simplicity we disregard employed workers. We denote by $v \in (0, \infty)$ the population ratio of firms to unemployed workers. Each firm has one job vacancy that needs to be filled, and each worker wishes to find a job. The matching process is shaped by coordination and information frictions.

There are two types of workers, who differ in their uncertainty about the expected suitability for a job. Uncertainty about suitability arises because jobs require several skills. For simplicity we assume that a fraction m of them is certain that they are suitable for the posted job, the remaining fraction $1 - m$ uncertain. Certain workers are always productive, i.e., they produce output normalized to unity. Uncertain workers are only productive with probability $\delta \in (0, 1)$. So, with probability $1 - \delta$, a match between an uncertain worker and a firm produces 0. If an uncertain worker turns out to be suitable, she is as productive as a certain worker. The worker's type (certain or uncertain) is private knowledge. The information about whether or not a worker - certain or uncertain - is productive for a job is revealed to the firm at the stage of the job interview. This setup allows us to combine uncertainty about match quality with private information about suitability on the workers' side.

Figure 8: Search Channels:



Notes: The proportion ρ of vacancies use the PEA and the proportion $1-\rho$ use the search market. Unemployed workers enter the search market if $c < c^c$ for certain types and if $c < c^u$ for uncertain types.

There are two channels through which matching between firms and unemployed workers can occur (see Figure 8). One channel is provided by the PEA, where all unemployed workers are registered in order to collect unemployment benefit (normalized to zero). We model the intermediation via vacancy referrals by the PEA as follows. All vacancy referrals made to unemployed job seekers result in applications. The PEA coordinates vacancy referrals such that workers and firms are brought together on a one by one basis. We denote by $a \in (0, 1]$ the maximum number of matching pairs the PEA can propose. a is a technological parameter representing the PEA's vacancy referral activity. The other channel is a directed search market, which may be referred to as a decentralized or private

[13]Our analysis will go through with free entry and vacancy creation costs as well as with non-negligible interviewing costs.

market. Following Pissarides (1979) search in the private market - unlike in the PEA - is costly for workers and workers are unable to coordinate their applications. Workers have to incur an individual specific search cost represented by c drawn from a uniform distribution with support $[0,1]$. The cost parameter c is uncorrelated with the worker's ex-ante type.[14] How workers search in the private market will be specified below.

The timing is as follows. First, firms decide on their wage strategy, i.e., whether they want to offer a wage, which makes the vacancy attractive in the private market and which we therefore equate with deciding not to register a vacancy with the PEA, or to offer a wage for vacancy referrals, in which case the firm has to register the vacancy with the PEA and rely on its intermediation to receive applicants. Given the underlying wage strategy choice, all firms post simultaneously a wage at which they are willing to hire a worker. The wage posted in the private market is denoted by w, and the wage posted in the PEA by w_a. Having observed those wages, workers decide whether or not to enter the private search market in the third stage. Once in the search market, workers must choose to which firm to send an application. Each worker sends only one application in the private market. Assuming that workers cannot coordinate their actions over which vacancy to apply, we investigate a symmetric equilibrium where all workers use the identical application strategy for any distribution of announced wages. This is the standard notion of directed search equilibria, see e.g. the survey by Wright et al. (2021). Next, the PEA selects randomly $\min\{v\rho, a\}$ workers, where $\rho \in [0,1]$ is the fraction of vacancies registered with the PEA, and suggests each of them to match with one of the registered vacancies. Finally, given the applications received via the private market or the applications received due to vacancy referrals by the PEA, firms select a productive applicant (if any) and make a job offer. Those workers, who receive multiple offers, can select the highest wage. Once employment decisions are made, production starts and matched workers and firms receive their payoffs. Unmatched workers and firms receive a payoff of zero.

In what follows, we construct a labor market equilibrium which has the following characteristics. A fraction $\rho \in [0,1)$ of firms registered with the PEA post a wage $w_a = 0$ and a fraction $1-\rho$ of firms in the private search market post a wage $w \in (0,1)$. All workers are registered in the PEA and accept the wage $w_a = 0$ if it is the only offer they have received. A certain (uncertain) worker enters the private market if and only if his search cost c is no greater than a reservation value c^c (c^u) (see Figure 9), and is hired with probability η ($\delta\eta$) in the private market (yet to be derived endogenously). Each individual firm in the directed search market is characterized by an *effective* queue of applicants,

$$\tilde{x} = \frac{mc^c + \delta(1-m)c^u}{v(1-\rho)}, \tag{8}$$

which measures the expected queue of productive applicants for the job. The numerator equals the total number of productive workers in the search market (mc^c certain and $\delta(1-m)c^u$ uncertain types, as shown below), while the denominator equals the total number of vacancies in the private search market. Each firm employs a productive worker (and can produce an output of 1) with some probability (see below). In the following we show that workers and firms have no incentive to deviate from the proposed equilibrium.

[14] Our main result will go through even if we allow for such a correlation (see Appendix A.7).

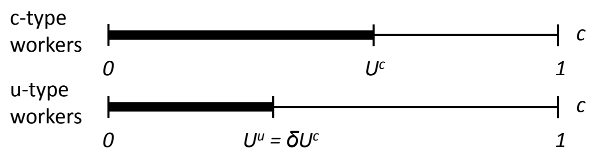
3.2 Equilibrium

Workers' search decision Assuming for the moment the existence of an equilibrium, we first describe workers' search decision. Denote by U^c (U^u) the equilibrium value of searching in the private market for a worker with certain (uncertain) type. Since a worker with certain (uncertain) type and search cost c searches if and only if $c \leq U^c$ ($c \leq U^u$), we can describe the participation decision by a reservation value for the search cost, i.e.,

$$c^c = U^c, \text{ and } c^u = U^u,$$

respectively. Given that search costs are uniformly distributed over $[0, 1]$, the threshold values c^c and c^u determine the fraction of certain and uncertain workers that choose to search in the private market. Figure 9 illustrates the search population of certain and uncertain types of workers.

Figure 9: Participation in the search markets



Notes: The proportion of workers that enter the search market is larger for certain workers (c-type) than for uncertain workers (u-type), since the respective utility is higher, i.e., $U^c > U^u = \delta U^c$ due to $\delta \in (0, 1)$.

Given the participation decision, we now describe workers' application decision in the search market. Each worker observes the wages posted by firms in the private market and forms expectations about the average effective queue of productive workers applying to each vacancy. In order to be able to calculate the expected utility from applying at a particular firm, we first need to compute the probability that a productive applicant gets employed by a firm, η.

Lemma 1 *The employment probability of productive applicants is homogeneous of degree one, and can be written as a function of the effective queue $\tilde{x} \in (0, \infty)$ given by (8), i.e., $\eta = \eta(\tilde{x})$. Further, it satisfies the standard properties of matching functions (see e.g. Pissarides, 2000): $\eta(\tilde{x})$ ($\tilde{x}\eta(\tilde{x})$) is strictly concave and decreasing (increasing) in $\tilde{x}$.*

Suppose a worker observes a firm in the search market with a wage offer $w' > 0$ and an associated effective queue $\tilde{x}'$. Given the employment probability function $\eta(\tilde{x})$, the worker calculates the value of applying to such a firm. In any equilibrium, where U^c is the expected value of search for certain workers offered by the private market, a certain worker will apply to such a firm, if the effective queue $\tilde{x}'$ satisfies,

$$U^c \leq \eta(\tilde{x}')w', \tag{9}$$

because certain workers will be suitable to any firm. Similarly, for uncertain workers it is,

$$U^u \leq \delta\eta(x')w', \tag{10}$$

since the employment probability for an uncertain worker is given by $\delta\eta(\tilde{x}')$. In equilibrium equations (9) and (10) will hold with equality, since firms are not willing to offer workers more than the market utility U^c and U^u. In equilibrium we therefore have $\delta U^c = U^u$ and $\delta c^c = c^u$. Equation (9), which ensures that workers will apply, determines the effective queue of productive workers $\tilde{x}' = \tilde{x}(w'|U^c)$ as a strictly increasing function of the wage w' given the market value U^c (and U^u).

Firms' Wage Offers Given the search behavior of workers described above, the next step is to characterize equilibrium wages. Given the wage offer $w_a = 0$ by firms registered with the PEA (which will be verified shortly), we first derive an equilibrium wage in the search market. In any equilibrium where U^c (U^u) is the market value of a certain (uncertain) worker, the optimal wage of a firm, denoted by $w(U^c)$, satisfies, $w(U^c) = \arg\max_{w'} \Pi_s(\tilde{x}')$ where

$$\Pi_s(\tilde{x}') = \tilde{x}'\eta(\tilde{x}')(1 - w'). \tag{11}$$

Note here that, given $\tilde{x}' = \tilde{x}(w'|U^c)$, the firm takes into account that the higher the offered wage w', the larger the effective queue of productive workers $\tilde{x}'$ and the higher the probability of hiring successfully a suitable (productive) worker. Hence, the standard first order condition implies that firms in the private market will offer a wage $w = w(U^c) > 0$ in equilibrium.

Given the wage offer $w > 0$ in the search market, we show next that the equilibrium wage offer in the PEA must satisfy $w_a = 0$. Given that a proportion $\rho \in [0, 1)$ of firms registered their vacancy with the PEA, the wage $w_a = 0$ in the PEA yields an equilibrium profit,

$$\Pi_a(\tilde{x}) = \min\left\{\frac{a}{v\rho}, 1\right\}[m(1 - c^c\eta(\tilde{x})) + \delta(1 - m)(1 - c^u\delta\eta(\tilde{x}))], \tag{12}$$

where, given the probability of being allocated a worker by a vacancy referral $\min\{a/(v\rho), 1\}$, the term $m(1-c^c\eta(\tilde{x}))$ (or $(1-m)(1-c^u\delta\eta(\tilde{x}))$) represents the expected number of certain (or productive uncertain) workers, who do not receive a job offer in the search market and are willing to accept $w_a = 0$.

The PEA matches registered workers and firms via vacancy referrals. This allocation is independent of the wages offered by registered firms. The fact that registered firms cannot increase the PEA-internal matching probability $\min\{a/v\rho, 1\}$ by offering a higher wage implies that registered firms will never compete among themselves. They will only compete with firms in the private market. This is the reason why a wage offer $w_a' \in (0, w)$ cannot be profitable, since such a deviation implies a mere increase in the wage cost without improving the probability of hiring a suitable worker. If a deviating firm posts $w_a' \geq w$, then it can hire an assigned productive worker (if any), irrespective of whether the worker gets another offer in search markets. However, the associated increase in expected productivity is not high enough to be able to compensate for the higher wage cost. This guarantees - together with the absence of PEA-internal wage competition due to vacancy referrals - that $w_a = 0$ is the unique equilibrium wage for firms relying on vacancy referrals.

Lemma 2 *For any $\rho \in (0, 1)$, the equilibrium wage is higher in the search market than in the PEA, $w > w_a$.*

The size of the wage gap between the private market and the PEA, $w - w_a$, depends on the reservation wage of job seekers, which we normalized to zero for simplicity. As shown by van den Berg, Foerster and Uhlendorff (2019) the reservation wage will depend on the level of UI-benefits and the sanctions a worker has to expect if turning down a job offer resulting from a vacancy referral.

Firms' Market Choice In the first stage, firms decide on their wage strategy, i.e., on whether to enter the PEA or the search market for hiring a worker. Firms will choose the market that offers the highest expected profit. Thereby, the equilibrium condition is given by,

$$\rho = \begin{cases} 0 & \text{if } \Pi_a(\tilde{x}) < \Pi_s(\tilde{x}), \\ (0,1) & \text{if } \Pi_a(\tilde{x}) = \Pi_s(\tilde{x}), \\ 1 & \text{if } \quad \Pi_a \ > \Pi_s, \end{cases}$$

where the equilibrium effective queue length in the search market $\tilde{x} = \tilde{x}(\rho)$ is given in equation (8) for $\rho \in [0, 1)$, and the equilibrium profits $\Pi_s(\tilde{x})$ and $\Pi_a(\tilde{x})$ are given by equation (11) with $\tilde{x}' = \tilde{x}$ and equation (12), respectively. If $\rho = 1$, all firms are in the PEA. By offering the equilibrium wage $w_a = 0$ they earn $\Pi_a = \min\{a/v, 1\}[m + (1 - m)\delta]$. Since no jobs are posted in the private market, only workers with zero search costs will participate in it. Hence, if a firm deviates and enters the search market with a wage $w' = \varepsilon > 0$, then the firm meets with a productive worker for sure, and makes profits, $\Pi_s = (1 - \varepsilon)$. This deviation is always profitable for an arbitrary small ε.

Proposition 1 summarizes that a labor market equilibrium with an active PEA, i.e., a PEA that uses vacancy referrals to match unemployed job seekers and vacant jobs, exists if the market tightness v exceeds a critical value v^*.

Proposition 1 *A search market equilibrium with an active PEA exists for $v \geq v^*$, some $v^* \in (0, \infty)$, and with an inactive PEA for $v \leq v^*$. This equilibrium is unique.*

Our theory establishes that despite the high wage costs and coordination frictions in the application stage, some or all firms find it profitable to use the private search market instead of relying on vacancy referrals by the PEA. This has two reasons. First, the benefit of using the search market is to obtain a higher chance of receiving an application from a suitable (productive) worker. The second reason is due to the flexibility of the private market. Depending on the market tightness v and the selection of workers the probability of successfully hiring a productive worker can be very high in the private market, while it is fixed in the PEA given the vacancy referral capacity a. In addition, the wage in the private market is lower if the number of firms v is lower, i.e., the search market is less tight and less competitive. Hence, as shown in Proposition 1, an equilibrium with active private search market always exists and is unique.

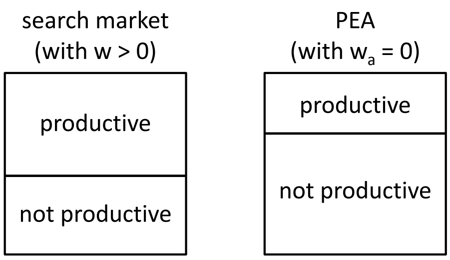
The following two corollaries are immediate consequences of Proposition 1, but derive further implications of the above equilibrium. Certain types have a better prospect of getting a job offer than uncertain types, because they are productive at any firm. Hence, the high wage offer in the private market induces a high participation rate of certain types, so that the private market can offer a better selection of workers than the PEA does (see Figure 10). In section 2.7 we provide empirical evidence that the fraction of suitable applicants among all applicants is higher among applicants coming via the private market than via vacancy referrals.

Corollary 1 *The fraction of suitable applicants out of all available applicants is higher for applicants who come through the private market than for applicants who come through the PEA.*

$$\theta \equiv \frac{m + (1-m)\delta^2}{m + (1-m)\delta} > \frac{m(1 - c^c\eta(\tilde{x})) + \delta(1-m)(1 - c^u\delta\eta(\tilde{x}))}{m(1 - c^c\eta(\tilde{x})) + (1-m)(1 - c^u\delta\eta(\tilde{x}))},$$

for any $m \in (0,1)$ *and* $\delta \in (0,1)$.

Figure 10: Selection of workers in search market and PEA



Notes: The proportion of productive workers in the search market is larger than in the PEA.

In an extension, Pissarides (1979) considers the limiting case where the vacancy referral capacity in the PEA is high enough to eliminate all search frictions in the PEA. He finds that in this case the private market collapses and all workers search via the PEA. This is in contrast to our model.

Corollary 2 *For large enough values of the vacancy referral capacity parameter a to enable the PEA to match the short side of the whole market, i.e.,* $a \geq \min\{v, 1\}$*, the private search market will still be active in equilibrium.*

In our framework with heterogeneous workers and endogenous wages, the higher probability of receiving a suitable (productive) applicant ensures the existence of an active decentralized market even if the PEA manages to match the short side of the market.

Comparative statics We examine the effects of parameter changes related to the Hartz 3 reform. For this purpose, we shall introduce an upper bound of search cost denoted by $\bar{c} \leq 1$. With this modification, the fraction of certain (uncertain) types who participate in the search market becomes $\frac{c^c}{\bar{c}}$ ($\frac{c^u}{\bar{c}}$) rather than c^c (c^u). To maintain the key punchline of the model, we assume $\frac{c^c}{\bar{c}} \leq 1$ (and hence $\frac{c^u}{\bar{c}} < 1$) so that Figure 10 remains the same and the worker selection in search market still survives. Hence, given the value of searching for a job, a lower $\bar{c}$ increases the fraction of job seekers searching in the private market. Now with this modification, we can show that our model is able to explain all empirical findings of section 2.

Proposition 2 *(Comparative statics): Consider a labor market equilibrium in which both, the PEA and the search market are active, i.e.,* $\rho \in (0,1)$. *A lower probability to receive a vacancy referral* $a(\leq v\rho)$ *or a lower cost of searching in the private market* $\bar{c}$ *leads to:*

- *a higher overall job finding probability (higher total number of matches) for relatively low values of* a *and* $\bar{c}$*,*

- *a higher job finding probability for job seekers without vacancy referral for relatively low values of a and $\bar{c}$ and an unchanged job finding probability for job seekers with vacancy referral,*
- *a higher average wage of newly hired, previously unemployed workers.*

The results are explained as follows. The lower probability to receive a vacancy referral decreases the number of matches created by the PEA. But, if the number of vacancy referrals in the PEA (i.e., the parameter a) decreases, it becomes less profitable for a firm to operate in the PEA and so the number of registered vacancies (ρ) decreases, and the number of vacancies in the private market $(1-\rho)$ increases. Then, we have a tighter private market (i.e., a lower $\tilde{x}$), which leads to a higher job finding probability for job seekers actively searching in the private market. This increases the benefit of searching in the private market and the fraction of job seekers, who actively search in it. If the cost of searching in the private market and the number of vacancy referrals in the PEA are relatively low, then this effect is large enough to compensate the lower number of matches created via vacancy referrals. Thus, like in Pissarides (1979) a decrease in the PEA's matching activity can increase the overall job finding probability of job seekers. This explains the first claim.

Given that the job finding probability for job seekers with a vacancy referral is by construction always equal to one, the overall increase in the job finding probability must result from the higher job finding probability for job seekers without vacancy referrals. This explains the second claim.

The third claim follows from the fact that with a tighter private market, firms have to post a more competitive wage. This increases both the wage in the private market w and the average wage of newly hired, previously unemployed workers given by $h_s w + (1-h_s)w_a$, where h_s denotes the share of matches in the private market relative to all matches. Remember that firms registered with the PEA set the wage equal to the reservation wage.

A similar logic applies to the comparative statics with respect to cost of searching in the private market $\bar{c}$. Lower search costs induce more job seeker to search in the private market, which further induces more firms to search in the private market rather than in the PEA. This increases the job finding probability in the private market and makes the private market more competitive for firms, i.e., increases wages in the private market.

4 Conclusion

Before the Hartz 3 reform, case managers, who are responsible for counseling unemployed job seekers, were rewarded for matching job seekers with registered vacancies. This is usually done via vacancy referrals. After the reform, case managers were rewarded for a high unemployment-to-employment (UE) transition rates irrespective of whether they helped unemployed job seekers to find a job with the help of a vacancy referral or demanded from them a higher search effort in the private market. We show that this reform decreased the fraction of unemployed that received vacancy referrals, increased the UE-transition probability of unemployed job seekers in the private market, i.e., of those who did not receive vacancy referrals, and left the UE-transition probability of job seekers, who received vacancy referrals, unaffected. Hartz 3 also increased the average wage of newly hired, previously unemployed workers.

The existing literature is not able to explain the overall increase in the UE transition rate and the rise in average hiring wages if matching efficiency decreases - here the number of vacancy referrals. Given the fact that the UE-transition rate affected unemployed job seekers with and without vacancy referrals differently suggests the use of a model with different search channels. Building on the pioneering PEA model by Pissarides (1979), which is able to explain the observed pattern in UE-transition rates, but which is silent on the effect on wages, we develop a theoretical directed search model where firms chose not only their search channel but also the wages they offer. Our model predicts that jobs, which are mediated by the PEA via vacancy referrals, pay less than jobs in the private market, which have to compete for unemployed jobs seekers. If the fraction of matches generated via the PEA decreases while the fraction of matches filled via the private market increases - as suggested by our second empirical finding, then our model is able to explain the increase in average hiring wages of previously unemployed workers and all the other findings mentioned above.

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A Appendix: Proofs

A.1 Proof of Lemma 1

Given the search behaviors of workers, each individual firm in the directed search market is characterized by a queue of applicants, denoted by x. The number of applicants $n = 1, 2, 3, ...$ each individual firm receives is a random variable and follows from a Poisson distribution with density $\text{Prob}[n = \tilde{n}] = \left(x^{\tilde{n}} e^{-x}\right) / (\tilde{n}!)$. The effective queue of applications is $\tilde{x} = \theta x$ where

$$\theta \equiv \frac{mc^c + \delta(1-m)c^u}{mc^c + (1-m)c^u}$$

is the share of productive applicants in the search market. Given a worker applies for a firm, where he turns out to be productive, his employment probability from this firm is derived as follows. Suppose that $\tilde{n}$ other *productive* workers also apply for it, which happens with probability $\left(\tilde{x}^{\tilde{n}} e^{-\tilde{x}}\right) / (\tilde{n}!)$. Then the worker is hired with probability $1/(\tilde{n}+1)$. η is the sum of this probability over all $\tilde{n} = 0, 1, 2, ...$ as follows:

$$\begin{aligned} \eta &= e^{-x} + xe^{-x}\left[\frac{\theta}{2} + 1 - \theta\right] + \frac{x^2 e^{-x}}{2}\left[\frac{\theta^2}{3} + \frac{2\theta(1-\theta)}{2} + (1-\theta)^2\right] + ... \\ &\quad + \frac{x^i e^{-x}}{i!}[\theta^i \frac{1}{i+1} + i(1-\theta)\theta^{i-1}\frac{1}{i} + \frac{i!}{2!(i-2)!}(1-\theta)^2\theta^{i-2}\frac{1}{i-1} + ... \\ &\quad + \frac{i!}{j!(i-j)!}(1-\theta)^j\theta^{i-j}\frac{1}{i-j+1} + ... + (1-\theta)^i] + ... \end{aligned}$$

To see how it works, consider the case $i = 2$ where two other applicants are at the firm, which occurs with probability $\frac{x^2 e^{-x}}{2}$ (the third term in the above expression). If both of these applicants appear to be suitable at this firm, which happens with probability θ^2, then the given applicant will receive an offer with probability $\frac{1}{3}$. If one of them is suitable but the other of them is not, which occurs in 2 ways and with probability $\theta(1-\theta)$, then the given applicant will be offered with probability $\frac{1}{2}$. If none of the other applicants happen to be suitable, which happens with probability $(1-\theta)^2$, then the given applicant will be offered with probability one. By induction, the same logic applies to general case with i other applicants (with probability $\frac{x^i e^{-x}}{i!}$): if $j \leq i$ of the other applicants turn out to be suitable, which comes in $\frac{i!}{j!(i-j)!}$ ways and occurs with probability $\theta^j(1-\theta)^{i-j}$, then the given applicant will be offered with probability $\frac{1}{i-j+1}$.

Note that we can simplify the terms,

$$\begin{aligned} &\theta^i \frac{1}{i+1} + i(1-\theta)\theta^{i-1}\frac{1}{i} + \frac{i!}{2!(i-2)!}(1-\theta)^2\theta^{i-2}\frac{1}{i-1} + \frac{i!}{j!(i-j)!}(1-\theta)^j\theta^{i-j}\frac{1}{i-j+1} + ... + (1-\theta)^i \\ = &\frac{1}{(i+1)\theta}\sum_{j=0}^{i}\frac{(i+1)!}{j!(i+1-j)!}(1-\theta)^j\theta^{i+1-j} \\ = &\frac{1}{(i+1)\theta}\left[\sum_{j=0}^{i+1}\frac{(i+1)!}{j!(i+1-j)!}(1-\theta)^j\theta^{i+1-j} - (1-\theta)^{i+1}\right] \\ = &\frac{1-(1-\theta)^{i+1}}{(i+1)\theta}. \end{aligned}$$

Using this simplification, we have

$$\eta = \sum_{i=0}^{\infty}\frac{x^i e^{-x}}{i!}\frac{1-(1-\theta)^{i+1}}{(i+1)\theta} = \frac{1}{x\theta}\sum_{i=0}^{\infty}\frac{x^{i+1}e^{-x}(1-(1-\theta)^{i+1})}{(i+1)!}.$$

Setting $h \equiv i+1$, it is further simplified to

$$\begin{aligned} \eta &= \frac{1}{x\theta}\sum_{h=0}^{\infty}\left[\frac{x^h e^{-x}}{h!} - \frac{[x(1-\theta)]^h e^{-x}}{h!}\right] = \frac{1}{x\theta}\left[1 - e^{-x\theta}\sum_{h=0}^{\infty}\frac{[x(1-\theta)]^h e^{-x(1-\theta)}}{h!}\right] \\ &= \frac{1-e^{-x\theta}}{x\theta} = \eta(\tilde{x}), \end{aligned}$$

with $\tilde{x} \equiv \theta x$. The standard properties stated in Lemma are immediate from this expression. This completes the proof of Lemma 1. ■

A.2 Proof of Lemma 2

Substituting out w' using equation (9), the objective function of a firm, denoted by $\Pi_s(\tilde{x}')$, can be written as,

$$\Pi_s(\tilde{x}') = \tilde{x}'\eta(\tilde{x}') - \tilde{x}'U^c,$$

where $\tilde{x}' = \tilde{x}(w'|U^c)$ satisfies equation (9). The first-order condition is,

$$\frac{\partial \Pi_s(\tilde{x}')}{\partial \tilde{x}'} = e^{-\tilde{x}'} - U^c = 0.$$

The second order condition can be easily verified. By rearranging this condition using equation (9) one can obtain,

$$w(U^c) = \frac{\tilde{x}'e^{-\tilde{x}'}}{1 - e^{-\tilde{x}'}}.$$

In a directed search equilibrium, workers must be indifferent between any of the individual firms. This leads to,

$$w = \frac{\tilde{x}e^{-\tilde{x}}}{1 - e^{-\tilde{x}}}, \quad (13)$$

$$U^c = e^{-\tilde{x}}. \quad (14)$$

Hence, given that $w_a = 0$, the equilibrium wage in the search market $w > 0$ is given by equation (13).

We now prove $w_a = 0$ in the PEA, given the search market $w > 0$. Any $w'_a \in (0, w)$ is not profitable so consider a deviation $w'_a \geq w$. Then the deviating firm can hire an assigned productive worker (if any), irrespective of whether the worker gets another offer in search markets. Hence, the best deviation $w'_a = w$ yields the profit,

$$\Pi'_a = \min\left\{\frac{a}{v\rho}, 1\right\}[m + \delta(1 - m)](1 - w).$$

Substituting $c^c = U^c$ and $c^u = U^u$ using (9) and $w' = w$, we have $\Pi_a(\tilde{x}) > \Pi'_a \iff$

$$mw(1 - \eta(\tilde{x})^2) + \delta(1 - m)w(1 - \delta^2\eta(\tilde{x})^2) > 0,$$

which holds true for any $\tilde{x} \in (0, \infty)$. Thus, $w_a = 0$ is the unique equilibrium wage in the PEA. This completes the proof of Lemma 2. ■

A.3 Proof of Proposition 1

Applying the equilibrium wages in the private market, w, in (13) and the employment probability $\eta(\tilde{x})$ derived in Lemma 1 to (11), we get the equilibrium profit of firms searching in the private market,

$$\Pi_s(\tilde{x}) = 1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}}, \quad (15)$$

where by (8) and (14), $\tilde{x} = \tilde{x}(\rho)$ is determined by

$$\frac{e^{-\tilde{x}}}{\tilde{x}} = \frac{v(1 - \rho)}{m + (1 - m)\delta^2}. \quad (16)$$

This expression shows that $\tilde{x}(\rho)$ is strictly increasing in $\rho \in [0, 1)$ and satisfies $\tilde{x}(0) \equiv \underline{\tilde{x}} \in (0, \infty)$ and $\tilde{x}(\rho) \to \infty$ as $\rho \to 1$.

Define $\Gamma \equiv \Pi_s(\tilde{x}) - \Pi_a(\tilde{x})$ for $\tilde{x} \in [0, \infty)$. In what follows, we use the implicit equation $\Gamma = 0$ to show the existence and uniqueness of an equilibrium $\rho \in [0, 1)$. There are two possible cases. Suppose in equilibrium $a > v\rho$. This implies $\rho \in [0, \bar{\rho})$ where $\bar{\rho} \equiv \min\{\frac{a}{v}, 1\}$. Then, using (12) and (15), we can write $\Gamma = \Gamma(\tilde{x})$ where

$$\Gamma(\tilde{x}) = 1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}} - (m + (1-m)\delta) + \big(m + (1-m)\delta^3\big)\, \frac{e^{-\tilde{x}}(1 - e^{-\tilde{x}})}{\tilde{x}}. \tag{17}$$

Observe that: $\Gamma(0) = -(1-m)\delta(1-\delta^2) < 0$; $\Gamma(\tilde{x}) \to 1 - (m + (1-m)\delta) > 0$ as $\tilde{x} \to \infty$. Hence, since $\Gamma(\tilde{x})$ is continuous in $\tilde{x} \in [0, \infty)$, there exists an $\tilde{x}^* \in (0, \infty)$ that satisfies $\Gamma(\tilde{x}^*) = 0$. Observe further that $\frac{\partial \Gamma(\tilde{x})}{\partial \tilde{x}} |_{\tilde{x}=\tilde{x}^*} =$

$$\begin{aligned}
&= \tilde{x}e^{-\tilde{x}} - (m + (1-m)\delta^3)\frac{e^{-\tilde{x}}}{\tilde{x}^2}\left[(\tilde{x}+1)(1-e^{-\tilde{x}}) - \tilde{x}e^{-\tilde{x}}\right] |_{\tilde{x}=\tilde{x}^*} \\
&= \frac{\tilde{x}^* e^{-\tilde{x}^*}}{1 - e^{-\tilde{x}^*} - \tilde{x}^* e^{-\tilde{x}^*}}\,(m + (1-m)\delta) \\
&- \big(m + (1-m)\delta^3\big)\, \frac{\tilde{x}^* e^{-\tilde{x}^*}}{1 - e^{-\tilde{x}^*} - \tilde{x}^* e^{-\tilde{x}^*}} \left[\frac{e^{-\tilde{x}^*}(1 - e^{-\tilde{x}^*})}{\tilde{x}^*} + \frac{1 - e^{-\tilde{x}^*} - \tilde{x}^* e^{-\tilde{x}^*}}{\tilde{x}^{*3}}\left[(\tilde{x}^*+1)(1-e^{-\tilde{x}^*}) - \tilde{x}^* e^{-\tilde{x}^*}\right]\right] \\
&> \frac{(m + (1-m)\delta)\, e^{-\tilde{x}^*}}{1 - e^{-\tilde{x}^*} - \tilde{x}^* e^{-\tilde{x}^*}}\left[\tilde{x}^* - (1 - \frac{1 - e^{-\tilde{x}^*}}{\tilde{x}^*})e^{-\tilde{x}^*} - (\frac{1 - e^{-\tilde{x}^*}}{\tilde{x}^*} - e^{-\tilde{x}^*})(\tilde{x}^*+1)\frac{1 - e^{-\tilde{x}^*}}{\tilde{x}^*}\right] \\
&= \frac{(m + (1-m)\delta)\, e^{-\tilde{x}^*}}{1 - e^{-\tilde{x}^*} - \tilde{x}^* e^{-\tilde{x}^*}}\left[\frac{(\tilde{x}^* - (1 - e^{-\tilde{x}^*}))(\tilde{x}^* + 1 - e^{-\tilde{x}^*})}{\tilde{x}^*} - \frac{(1 - e^{-\tilde{x}^*} - \tilde{x}^* e^{-\tilde{x}^*})^2}{\tilde{x}^{*2}}\right] \\
&> 0.
\end{aligned}$$

In the above, we use

$$\Gamma(\tilde{x}^*) = 0 \Leftrightarrow \tilde{x}^* e^{-\tilde{x}^*} = \frac{\tilde{x}^* e^{-\tilde{x}^*}}{1 - e^{-\tilde{x}^*} - \tilde{x}^* e^{-\tilde{x}^*}}\left[(m + (1-m)\delta) - \big(m + (1-m)\delta^3\big)\, \frac{e^{-\tilde{x}^*}(1 - e^{-\tilde{x}^*})}{\tilde{x}^*}\right]$$

in the second equality, and $\tilde{x} + 1 - e^{-\tilde{x}} > \frac{1 - e^{-\tilde{x}}}{\tilde{x}} - e^{-\tilde{x}}$ and $\tilde{x} - (1 - e^{-\tilde{x}}) > 1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}}$ in the last inequality. Since $\Gamma(0) < 0 < \Gamma(\infty)$, $\frac{d\Gamma}{d\tilde{x}} > 0$ at $\tilde{x} = \tilde{x}^*$ implies $\tilde{x}^* \in (0, \infty)$ is unique (that is, $\Gamma(\tilde{x})$ curve cannot cross the line $\Gamma(\tilde{x}) = 0$ more than once).

Finally, notice that the $\tilde{x}^* \in (0, \infty)$ satisfying $\Gamma(\tilde{x}^*) = 0$ determined above does not depend on v, whereas $\underline{\tilde{x}}$ ($\equiv \tilde{x}(0)$) determined by (16) is strictly decreasing in v. Hence, we have

$$\tilde{x}^* > \underline{\tilde{x}} \Leftrightarrow v > v^* \equiv \big(m + (1-m)\delta^2\big)\, \frac{e^{-\tilde{x}^*}}{\tilde{x}^*}.$$

On the other hand, denote by $\bar{\tilde{x}}$ the solution of $\tilde{x} = \tilde{x}(\rho)$ to (16) as $\rho \to \bar{\rho} \equiv \min\{\frac{a}{v}, 1\}$. If $\frac{a}{v} \geq 1$ then $\bar{\rho} = 1$ and $\bar{\tilde{x}} = \infty$, so $\tilde{x}^* < \bar{\tilde{x}}$. If $\frac{a}{v} < 1$ then $\bar{\rho} = \frac{a}{v} < 1$ and $\bar{\tilde{x}} < \infty$. In this case, $\tilde{x}^* < \bar{\tilde{x}}$ if and only if $v < v^* + a$, since by (16),

$$\frac{e^{-\bar{\tilde{x}}}}{\bar{\tilde{x}}} - \frac{e^{-\tilde{x}^*}}{\tilde{x}^*} = \frac{1}{m + (1-m)\delta^2}(v(1 - \frac{a}{v}) - v^*) = \frac{1}{m + (1-m)\delta^2}(v - a - v^*),$$

which implies

$$\tilde{x}^* < \bar{\tilde{x}} \iff \frac{e^{-\bar{\tilde{x}}}}{\bar{\tilde{x}}} < \frac{e^{-\tilde{x}^*}}{\tilde{x}^*} \iff v < v^* + a.$$

To sum up, we have shown that there exists a unique $\rho \in (0, \bar{\rho})$ that satisfies (16) with $\tilde{x} = \tilde{x}^*$ and $\Pi_s(\tilde{x}^*) = \Pi_a(\tilde{x}^*)$ if and only if $v \in (v^*, v^* + a)$, and $\rho = 0$, satisfying $\Pi_s(\tilde{x}^*) > \Pi_a(\tilde{x}^*)$, if and only if $v \in (0, v^*)$

Suppose next in equilibrium $a \leq v\rho$. This implies $\rho \in [\bar{\rho}, 1)$, where $\bar{\rho} \equiv \min\{\frac{a}{v}, 1\}$, and is possible only when $\frac{a}{v} < 1$. Then, $\Gamma = \Gamma(\rho, \tilde{x})$ where

$$\Gamma(\rho, \tilde{x}) = 1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}} - \frac{a}{\rho v}\left[(m + (1-m)\delta) - \big(m + (1-m)\delta^3\big)\, \frac{e^{-\tilde{x}}(1 - e^{-\tilde{x}})}{\tilde{x}}\right], \tag{18}$$

where $\tilde{x} = \tilde{x}(\rho)$ is determined by (16) as before. Observe that:

$$\Gamma(\bar{\rho}, \bar{\tilde{x}}) = 1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}} - \left[\left(m + (1-m)\delta\right) - \left(m + (1-m)\delta^3\right) \frac{e^{-\tilde{x}}(1 - e^{-\tilde{x}})}{\tilde{x}} \right] \leq 0,$$

if and only if $v \geq v^* + a$ (see above that $\Gamma(\bar{\rho}, \bar{\tilde{x}}) = \Gamma(\bar{\tilde{x}}) < 0$ for $v \geq v^* + a$); $\Gamma(\rho, \tilde{x}) \to 1 - \frac{a}{v}(m + (1 - m)\delta) > 0$ as $\rho \to 1$. Hence, since $\Gamma(\cdot)$ is continuous in $\rho \in [\bar{\rho}, 1)$, there exists a $\rho^* \in [\bar{\rho}, 1)$ that satisfies $\Gamma(\rho^*, \tilde{x}(\rho^*)) = 0$ if and only if $v \geq v^* + a$. Observe further that

$$\frac{d\Gamma(\cdot)}{d\rho} |_{\rho=\rho^*} = \frac{\partial\Gamma(\cdot)}{\partial\rho} + \frac{d\tilde{x}}{d\rho}\frac{\partial\Gamma(\cdot)}{\partial x} |_{\rho=\rho^*},$$

where $\frac{\partial\Gamma(\cdot)}{\partial\rho} = \frac{a}{\rho^2 v}\left[m + (1-m)\delta - (m + (1-m)\delta^3)\frac{e^{-\tilde{x}}(1-e^{-\tilde{x}})}{\tilde{x}}\right] > 0$, $\frac{d\tilde{x}}{d\rho} > 0$ (by (16)), and

$$\frac{\partial\Gamma(\cdot)}{\partial\tilde{x}} |_{\rho=\rho^*} > \frac{a}{\rho v}\frac{e^{-\tilde{x}}}{1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}}}\left[\frac{(\tilde{x} - (1 - e^{-\tilde{x}}))(\tilde{x} + 1 - e^{-\tilde{x}})}{\tilde{x}} - \frac{(1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}})^2}{\tilde{x}}\right] |_{\rho=\rho^*} > 0,$$

which follows from exactly the same procedure as developed above to show $\frac{\partial\Gamma(x)}{d\tilde{x}} |_{\tilde{x}=\tilde{x}^*} > 0$ in (17). Therefore, $\rho^* \in [\bar{\rho}, 1)$ that satisfies $\Gamma(\rho^*, \tilde{x}(\rho^*)) = 0$ is unique given $v \geq v^* + a$.

Combining with the previous result, we have shown that there exist a unique $\rho \in (0, 1)$ if and only if $v > v^*$, and $\rho = 0$ if and only if $v \leq v^*$. This completes the proof of Proposition 1. ■

A.4 Proof of Corollary 1

The inequality follows immediately by applying $c^c = e^{-\tilde{x}}$ and $c^u = \delta e^{-\tilde{x}}$. This completes the proof of Corollary 1. ■

A.5 Proof of Corollary 2

In text. ■

A.6 Proof of Proposition 2

The introduction of $\bar{c} \leq 1$ modifies the following part of the model. The determination of $\tilde{x}$, (16) in the Appendix A.3 becomes

$$\frac{e^{-\tilde{x}}}{\tilde{x}} = \frac{v\bar{c}(1-\rho)}{m + (1-m)\delta^2}, \tag{19}$$

and the firm's profit in the PEA given in (12) to

$$\Pi_a(\tilde{x}) = \min\left\{\frac{a}{v\rho}, 1\right\}\left[m\left(1 - \frac{c^c}{\bar{c}}\eta(\tilde{x})\right) + \delta(1-m)\left(1 - \frac{c^u}{\bar{c}}\delta\eta(\tilde{x})\right)\right]. \tag{20}$$

The rest of the setup is exactly the same as before.

Consider the comparative statics with respect to a. Note that changes in high values of $a > v\rho$ have no influence on the equilibrium outcome. For $a \leq v\rho$, the fixed point condition for $\rho \in [\bar{\rho}, 1)$, where $\bar{\rho} \equiv \min\{\frac{a}{v}, 1\}$, is given by $\Gamma(\rho, \tilde{x}(\rho)) = 0$ in (18) (see the Appendix A.3) with the modified profit (20). There, we have already shown that at the fixed point, $\frac{d\Gamma}{d\rho} > 0$. On the other hand, it holds that $\frac{d\Gamma}{da} < 0$. Hence, we have $\frac{d\rho}{da} > 0$. Remember that $\tilde{x} = \tilde{x}(\rho)$ is increasing in ρ (see (16)) and w is decreasing in $\tilde{x}$ (see (13)). Hence, w is decreasing in a.

Now, the total number of matches denoted $T = T(\rho)$ is given by

$$T = v(1-\rho)\tilde{x}\eta(\tilde{x}) + v\rho\min\left\{\frac{a}{v\rho}, 1\right\}\left[m\left(1 - \frac{c^c}{\bar{c}}\eta(\tilde{x})\right) + \delta(1-m)\left(1 - \frac{c^u}{\bar{c}}\delta\eta(\tilde{x})\right)\right],$$

where the first term represents the number of newly hired via the search market ($\equiv v(1-\rho)T_s$) and the second term represents the number of new hired via the PEA ($\equiv v\rho T_a$). Notice that the latter term equals the total profit of firms, ($= v\rho\Pi_a$), and that $\Pi_a = \Pi_s = 1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}}$ when $\rho \in (0,1)$. Therefore,

$$\frac{T}{v} = 1 - e^{-\tilde{x}} - \rho\tilde{x}e^{-\tilde{x}}.$$

Noting $\frac{d\tilde{x}}{d\rho} = \frac{\tilde{x}}{(\tilde{x}+1)(1-\rho)}$ from (16), we have

$$\frac{d}{d\rho}\frac{T}{v} = \frac{\tilde{x}^2 e^{-\tilde{x}}}{(\tilde{x}+1)(1-\rho)}(2\rho - 1).$$

This implies, T is increasing in ρ if and only if $\rho \in (\frac{1}{2}, 1)$ and is decreasing in ρ if and only if $\rho \in (0, \frac{1}{2})$. Note that $\rho < \frac{1}{2}$ is guaranteed only when $\bar{\rho} \equiv \min\{\frac{a}{v}, 1\}$ since for $a \leq v\rho$, the equilibrium must satisfy $\rho[\bar{\rho}, 1)$. Since $\rho \to 0$ as $a \to 0$ and $\frac{d\rho}{da} > 0$, given $\frac{d\rho}{d\bar{c}} > 0$ (see below), we have $\rho \in (0, \frac{1}{2})$ and hence $\frac{dT}{da} < 0$ for relatively low values of a and $\bar{c}$ ($\geq U^c$).

The share of newly hired via search market relative to all newly hired, h_s, is computed as

$$h_s \equiv \frac{v(1-\rho)T_s}{v(1-\rho)T_s + v\rho T_a} = \frac{\frac{v(1-\rho)T_s}{v\rho T_a}}{\frac{v(1-\rho)T_s}{v\rho T_a} + 1},$$

where

$$\frac{v(1-\rho)T_s}{v\rho T_a} = \frac{1-\rho}{\rho}\frac{1-e^{-\tilde{x}}}{1-e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}}}.$$

Observe that

$$\frac{d\frac{v(1-\rho)T_s}{v\rho T_a}}{d\rho} = -\frac{1}{\rho^2}\frac{1-e^{-\tilde{x}}}{1-e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}}} - \frac{1-\rho}{\rho}\frac{d\tilde{x}}{d\rho}\frac{e^{-\tilde{x}}\left(\tilde{x} - 1 + e^{-\tilde{x}}\right)}{(1-e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}})^2} < 0.$$

Since ρ is increasing in a, this implies that h_s is increasing in a. Combined with the result that w is decreasing in a, this implies that the average wage of newly hired, previously unemployed workers given by $h_s w + (1-h_s)w_a = h_s w$ (because $w_a = 0$) is also decreasing in a.

Consider next the comparative statics with respect to $\bar{c}$. As before, for $a \leq v\rho$, the fixed point condition for $\rho \in [\bar{\rho}, 1)$ is given by $\Gamma(\rho, \tilde{x}(\rho)) = 0$ in (18) (see the Appendix A.3) with the modified profit (20), implying

$$\frac{d\rho}{d\bar{c}} = \frac{\frac{\partial\Gamma}{\partial\tilde{x}}\frac{\tilde{x}}{(\tilde{x}+1)\bar{c}} + \frac{m+(1-m)\delta^3}{\bar{c}^2}\frac{e^{-\tilde{x}}(1-e^{-\tilde{x}})}{\tilde{x}}}{\frac{\partial\Gamma}{\partial\tilde{x}}\frac{\tilde{x}}{(\tilde{x}+1)(1-\rho)}} > 0,$$

since $\frac{\partial\Gamma}{\partial\tilde{x}} > 0$. From (16),

$$\frac{d\tilde{x}}{d\bar{c}} = \frac{\partial\tilde{x}}{\partial\bar{c}} + \frac{d\rho}{d\bar{c}}\frac{\partial\tilde{x}}{\partial\rho} = \frac{m+(1-m)\delta^3}{\bar{c}^2}\frac{e^{-\tilde{x}}(1-e^{-\tilde{x}})}{\tilde{x}}\frac{1}{\frac{\partial\Gamma}{\partial\tilde{x}}} > 0.$$

Given $\frac{d\tilde{x}}{d\bar{c}} > 0$, it is sufficient to observe that w is decreasing in $\tilde{x}$ (see (21)), which implies w and $h_s w$ are both decreasing in $\bar{c}$. The proof of the case $a > v\rho$ is similar. This completes the proof of Proposition 2. ■

A.7 Correlated worker types

We can modify the baseline setup to allow for a correlation between ex ante worker type (normal or difficult) and search costs. Suppose for instance that search costs of difficult types are distributed uniformly between $\underline{c} > 0$ and $1 + \underline{c}$. The search-costs distribution of normal types remains the same as before. Then, with the introduction of $\underline{c} > 0$, the effective queue of workers is modified to

$$\tilde{x} = \frac{mc^c + \delta(1-m)\max\{c^u - \underline{c}, 0\}}{v(1-\rho)},$$

and the profit in the PEA is modified to

$$\Pi_a(\tilde{x}) = \min\{\frac{a}{\rho v}, 1\}\left[m(1 - e^{-\tilde{x}}\frac{1 - e^{-\tilde{x}}}{\tilde{x}}) + \delta(1 - m)(1 - \max\{\delta e^{-\tilde{x}} - \underline{c}, 0\}\delta\frac{1 - e^{-\tilde{x}}}{\tilde{x}})\right].$$

With these modifications, consider

$$\begin{aligned}\Gamma(\tilde{x}) &= \Pi_s(\tilde{x}) - \Pi_a(\tilde{x}) \\ &= 1 - e^{-\tilde{x}} - \tilde{x}e^{-\tilde{x}} - (m + (1 - m)\delta) + \left(me^{-\tilde{x}} + (1 - m)\delta^2 \max\{\delta e^{-\tilde{x}} - \underline{c}, 0\}\right)\frac{(1 - e^{-\tilde{x}})}{\tilde{x}}.\end{aligned}$$

Observe that: $\Gamma(0) = -(1 - m)\delta(1 - \delta \max\{\delta - \underline{c}, 0\}) < 0$; $\Gamma(\tilde{x}) \to 1 - (m + (1 - m)\delta) > 0$ as $\tilde{x} \to \infty$. Since $\Gamma(\tilde{x})$ is continuous in $\tilde{x} \in [0, \infty)$, this implies that there exists an $\tilde{x}^* \in (0, \infty)$ that satisfies $\Gamma(\tilde{x}^*) = 0$. Hence, our equilibrium can survive with the introduction of a workers' type correlation with search costs. ■

B Appendix: Additional empirical tables and results

B.1 Means and standard deviations for variables use in section2

Table B.1: **Mean and standard deviation of outcome variables**

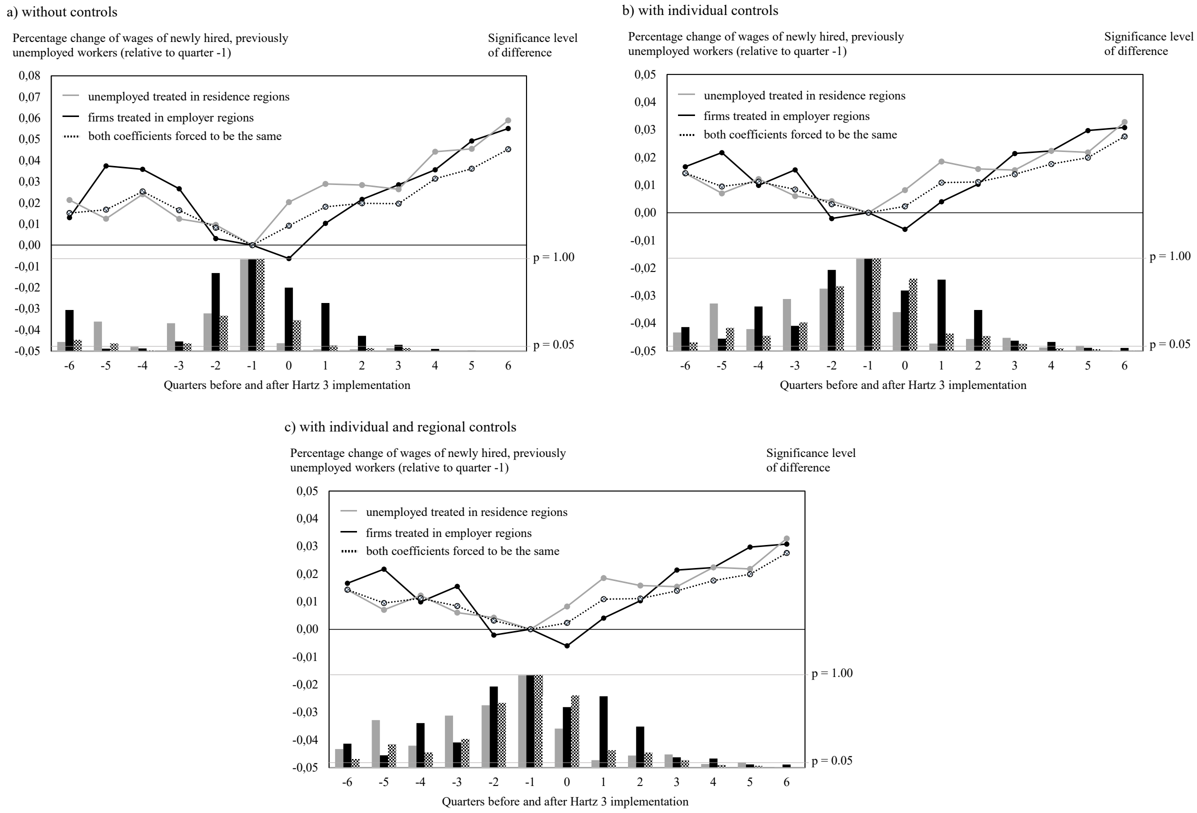
	AED		LIAB	
	mean	standard deviation	mean	standard deviation
Frac. of unempl. with vacancy referrals				
within 3 months	0.527	0.499		
within 6 months	0.541	0.498		
within 9 months	0.547	0.498		
within 12 months	0.548	0.498		
Frac. of unemployed, who found a job				
within 3 months	0.304	0.460		
within 6 months	0.408	0.491		
within 9 months	0.454	0.498		
within 12 months	0.477	0.499		
daily wage of newly hired workers (log)			4.311	0.429
N	440,552		132,008	

Table B.2: **Mean and standard deviation of explanatory variables**

	AED		LIAB	
	mean	standard deviation	mean	standard deviation
daily wage of previously employed (log)	NA	NA	3.521	0.877
daily UI-benefits of prev. unempl. (log)	NA	NA	1.475	1.626
previously unemployed (dummy)	NA	NA	0.462	0.499
gender (female)	0.401	0.490	0.351	0.477
German (dummy)	NA	NA	0.932	0.253
children (dummy yes)	0.032	0.175	NA	NA
age (in regression age-indicator for each year)	34.84	10.34	33.65	9.808
education: school leaving certificate (fraction)				
no vocational qualification	0.066	0.249	0.115	0.319
vocational qualification	0.665	0.472	0.620	0.485
upper sec. school without voc. qual.	0.051	0.220	0.014	0.118
upper sec. school with voc. qual.	0.094	0.292	0.068	0.251
applied university degree	0.044	0.205	0.065	0.246
university degree	0.080	0.271	0.118	0.322
Occupational status and working hours				
Unskilled workers	NA	NA	0.293	0.455
Skilled workers	NA	NA	0.185	0.388
Master craftsmen, foremen	NA	NA	0.005	0.072
employees (excl. workers)	NA	NA	0.517	0.500
nr. of past unempl.-spells				
1	0.198	0.399	NA	NA
2	0.215	0.411	NA	NA
3	0.179	0.383	NA	NA
4 and more	0.407	0.491	NA	NA
weeks of previous unempl. exp. (asinh)	3.231	2.072	3.315	2.050
fraction without previous unempl. exp. (dummy)	0.238	0.426	0.209	0.407
weeks of previous employment exp. (asinh)	6.142	1.001	6.214	1.116
fraction without previous empl. exp. (dummy)	0.014	0.116	0.000	0.000
ave. job tenure in months (dummies in regression)	NA	NA	5.914	3.460
age of establishment (log)	NA	NA	2.881	0.669
nr. of employees (log)	NA	NA	6.221	1.589
nr. of job leavers (log)	NA	NA	4.197	1.534
nr. of new hires (log)	NA	NA	4.350	1.554
regional unempl. rate (log)	2.405	0.419	2.404	0.420
regional stock of vacancies (log)	6.587	1.134	7.020	1.200
regional inflow of vacancies (log)	6.086	1.184	6.442	1.179
regional stock of unemployed (log)	9.492	1.102	9.621	1.104
regional inflow into unempl. (log)	7.634	1.024	7.769	1.176
N	440,552		132,008	

B.2 Wage effects or Hartz 3 in the sample of commuters

Figure B.1: Event study of the Hartz 3 reform on hiring wages of previously unemployed - commuter sample



Notes: The estimates are based on 50,503 individual observations of the LIAB data-set from January 2002 to December 2007. In order to reduce the multicollinearity between the residence region based event study indicators and the workplace region based event study indicators, we only include new hires where the residence regions is different from workplace regions. The outcome variable is the daily (log) hiring wage. The black lines show the event study indicator coefficients β^k, the grey lines the event study indicator coefficients γ_u^k (grey lines) from equation (4). The black dotted lines show the coefficients for the case where we restrict $\beta^k = \gamma_u^k$ to avoid the inflation of standard errors due to the multicollinearity. Figure 7a) is based on a regression without individual and regional controls, Figure 7b) includes the individual controls; age, gender, education, nationality (non-German), previous unemployment and employment experience and the firm controls; age of the establishment, the (log) size of the workforce and the (log) number of total hiring and quits, and Figure 7c) includes in addition the regional controls stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies. The size of the coefficients of the event study indicators are shown on the y-axis on the left and to indicate the significance of the coefficients we show the respective p-values as columns on the bottom with the scale pictured on the y-axis on the right.

Table B.3: ATT of the Hartz 3 reform on the hiring wages of previously unemployed workers
- commuter sample -

	Event window treatment estimates (EWTE)		
	separate regressions		one regression
	unemployed treated in residence regions (β^T)	firms treated in employer regions (γ_u^T)	both coefficients forced to be the same ($\beta^T = \gamma_u^T$)
	without further controls		
Hartz 3	0.0234***	0.0175***	0.0164***
	(0.0061)	(0.0065)	(0.0040)
	with individual controls		
Hartz 3	0.0121**	0.0120**	0.0105***
	(0.0052)	(0.0056)	(0.0034)
	with individual and regional controls		
Hartz 3	0.0118**	0.0122**	0.0104***
	(0.0052)	(0.0056)	(0.0034)
N	50,503	50,503	50,503

Notes: Based on 50,503 individual observations of the LIAB data-set from January 2002 to December 2007. The outcome variable is the daily (log) hiring wage. The first row estimates are based on regressions without individual and regional controls, the second row estimates include the individual controls age, gender, education, nationality (non-German), previous unemployment and employment experience and the firm controls the age of the establishment, size of the workforce and the (log) number of total hiring and quits, and third row estimates include in addition the regional controls stock and inflow rate of unemployed, the unemployment rate, and the stock and inflow rate of vacancies. In the Table we show coefficients β^T and γ_u^T from equation (5) in columns 1 and 2 respectively and coefficients with $\beta^T = \gamma_u^T$ in column 3. Standard errors in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

B.3 Externaly validity of the results in section 2.7

Table B.4: **External validity: Fraction of suitable applicants**

	OLS-Regressions: Fraction of suitable applicants	
	full sample	in-time sample
PEA search channel	-0.0899***	-0.0788***
	(0.0059)	(0.0080)
number of applicants (log)	-0.1334***	-0.1319***
	(0.0029)	(0.0038)
low qualification	0.0249**	0.0296*
	(0.0113)	(0.0160)
high qualification	-0.0082	0.0010
	(0.0108)	(0.0136)
occupation specific experience	-0.0247***	-0.0260***
	(0.0061)	(0.0082)
permanent	-0.0356***	-0.0354***
	(0.0063)	(0.0087)
full-time	-0.0111	-0.0099
	(0.0088)	(0.0111)
firm size (log)	0.0123***	0.0095***
	(0.0023)	(0.0030)
"financial constraints"	0.0029	-0.0018
	(0.0101)	(0.0135)
"low sales"	0.0031	0.0065
	(0.0080)	(0.0112)
"skilled labor shortage"	-0.0781***	-0.0795***
	(0.0088)	(0.0141)
region-, occup.-, ind.-FE	yes	yes
R^2	0.2716	0.2848
N	11,490	6,605

Notes: The full sample contains all vacancies surveyed by the German Job Vacancy Survey, 2005-2008. The in-time sample is in addition restricted to all vacancies, which were successful in hiring an applicant before the intended starting date. The outcome variable equals the fraction of suitable applicants among all applicants. Robust standard errors are in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.