Measuring coordination frictions[*]

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Abstract

Many markets are characterized by coordination frictions, e.g. job seekers do not coordinate to which vacancy to apply. We propose to measure coordination frictions by looking at how even applications are distributed across vacancies. We apply our method to evaluate the performance of the Public Employment Agency (PEA) in Germany by comparing the distribution of applicants vacancies receive via the PEA with the distribution of applicants coming via the private market. Our analysis shows that the intermediation services provided by the PEA reduce coordination frictions and that reduced coordination frictions decrease the search duration for vacancies.

Keywords: Coordination Frictions, Intermediation, Public Employment Agency

JEL: J6

1   Introduction

Workers and firms are trying to find a suitable matching partner. Firms post wages to attract applicants, but workers do not know to which vacancies other workers apply. This lack of coordination is seen by the theoretical search literature as a major reason for why a fraction of workers and vacancies remain unmatched (see, for example Butters, 1977; McAfee, 1993; Peters and Seyerinov, 1997; Burdett et al., 2001; Shimer, 2005; Albrecht et al., 2006; Galenianos and Kircher, 2009; and Satterthwaite and Shneyerov, 2007; Wright et al. 2017).

Despite its importance in the theoretical literature, there is no empirical literature which investigates the degree or importance of coordination frictions. This is partly due to the fact that it is not clear, how to measure coordination frictions. We propose to look at the distribution of applicants across vacancies. Without frictions all job seekers apply at all vacancies. The number of applications would in this case be the same across vacancies, or equivalently the number of applications would be evenly distributed across vacancies. If it is too costly to apply to all vacancies, then the lack of coordination among job seekers leads to a less equal distribution of applications across vacancies. The less equal the distribution the more likely it is that some vacancies and some workers remain unmatched. We therefore suggest to use inequality measures like the Gini-coefficient, the variance of logs, and the coefficient of variation to measure the degree of coordination frictions.

Looking at the distribution of applications across all types of vacancies implicitly assumes that all vacancies are part of one labor market. In reality, however, markets are segmented along occupations, industries, regions as well as firm- and vacancy-characteristics. By decomposing the number of applicants into an explained and an unexplained part we can investigate which part of the variation in the number of applicants can be attributed to the respective sub-markets (explained part) and which part can be attributed to the underlying random application process (unexplained part). The search literature interprets the underlying random application process as coordination frictions. This interpretation is based on the common assumption made in this literature that job seekers observe the type of sub-market a vacancy belongs to but they do not know to which vacancies – of the same sub-market – other job seekers apply (see, for example, Burdett et al., 2001; Shimer, 2005; Albrecht et al., 2006; and Galenianos and Kircher, 2009). We therefore use the distribution of the residuals to characterize the degree of coordination frictions.

We apply our method to compare coordination frictions across markets. We exploit the unique feature that in Germany the Public Employment Agencies (PEA) with their services explicitly aim at reducing the costly and time-consuming search process by offering intermediation services. They encourage unemployed workers to search more and to apply to vacancies, which they would not have considered on their own. The PEA also supports employers in finding suitable personnel by making recommendations. All these measures aim at reducing coordination frictions and at helping job seekers and vacancies to find suitable matching partners. It therefore seems natural to evaluate the performance of the PEA using our method. We compare the market place provided by the PEA with the private

search market (which includes newspaper ads, internet websites, social media, networks, etc.).

Our approach demands a certain type of data. To apply our method we need to know the number of applications coming via the PEA and via the private market. Our data-set, the German Job Vacancy Survey, contains this information not only for the number of applicants but also for the number of suitable applicants. By restricting ourselves to the sub-sample of vacancies, which are registered with the PEA, allows us to use within vacancy variation and thus to perfectly control for vacancy characteristics.

All inequality measures based on the overall number of (suitable) applicants and on the respective unexplained (residual) part, which we use to account for differences across sub-markets, show that the PEA helps its job seekers to distribute their applications more evenly across vacancies than the private market. This holds, if we estimate the inequality measures for (suitable) applicants coming via the PEA and the private market using within vacancy variation by restricting our sample to vacancies registered with the PEA. The more even distribution of (suitable) applicants coming via the PEA, however, also holds in general if we include non-registered vacancies as well. For the intermediation service provided by the PEA it is good news that the result holds not only for the number of applicants but also for the number of suitable applicants. The result is very robust. It holds if we – in order to rule out reverse causality – concentrate on a sub-sample of vacancies, which includes only vacancies that were able to hire within their intended time, or if we take measurement errors into account.

We also investigate whether there are differences in the job search behavior of job seekers across the two markets. Using the German Socio Eoconomic Panel (GSOEP), we find that those, who use the PEA as search channel, use more search channels compared to those, who do not use the PEA. The increased search activity of workers using the PEA can be one channel to explain the more even distribution of applications coming via the PEA, because sending out more applications leads to a more even distribution of applications across vacancies if the number of contemplable vacancies is small. The evidence on the search behavior of non-employed job seekers also suggests that job seekers using the PEA use other search channels in the same proportions as job seekers not using the PEA. This is reassuring since it implies that our findings cannot be driven by the over- or under-proportional use of another search channel by job seekers using the PEA compared to those, who do not use the PEA.

Search theory predicts that a reduction in coordination frictions leads to more matches. Our findings that the intermediation services provided by the PEA reduce coordination frictions therefore suggest that vacancies registered with the PEA should be less likely to fail to hire a worker. Since our sample includes only successful vacancies, we can not test this hypothesis directly. We test it indirectly by looking at those vacancies, which are at risk of failing to hire, i.e., search longer than initially intended. We investigating whether using the PEA search channel increases their hazard of hiring a worker or decreases their search duration. Using the information on the search duration of vacancies provided by the German Job Vacancy Survey we can show that after registering the vacancy with the PEA the hazard of hiring a worker increases and increases especially for vacancies, which are at risk of failing to hire. The same result holds if we look at the search duration directly. We also find that the search

duration is shorter if the PEA sends more suitable applicants (after controlling for the total number of applicants and total number of suitable applicants).

Our application regarding the intermediation services provided by the PEA complements the empirical literature, which has focused on understanding the effect of specific PEA policies such as the level of unemployment benefits and its entitlement duration,[1] counseling,[2] sanctions,[3] and training programs[4] on the job finding probability of unemployed workers. By investigating the intermediation service of the PEA and its effect on the distribution of (suitable) applicants across vacancies, we are the first to show how vacancies benefit from the intermediation services provided by the PEA.

Our findings also help to understand the importance of the Hartz III reform, which restructured the intermediation service of the Public Employment Agency, as part of the Hartz reform package. A growing macroeconomic literature (see for example, Krause and Uhlig, 2012; Krebs and Scheffel, 2013; Launov and Wälde, 2016; Felbermayr et al., 2016; and Bradley and Kugler, 2017) has investigated the contribution of the different parts of the Hartz reform package on the remarkable decline in unemployment using structural models. Our analysis suggests that modeling the Hartz III reform as improving the matching efficiency is appropriate.

The remainder of the paper is organized as follows. In Section 2, we explain how the PEA works in Germany. In Section 3 we describe the data-sets. In Section 4, we present our main analysis. Section 5 concludes. Some omitted tables are collected in the Appendix.

2 The Public Employment Agency

In 2015 the PEA in Germany had an overall budget of 31.5 Billion Euros. Around one fourth of the total budget, i.e., 7.93 Billion Euros (0.3% of German GDP), was spent on administration including the wage costs for the roughly 90,000 employees. The employees administer unemployment benefits and work in the intermediation to help workers and vacancies to find a good match.

If a worker becomes unemployed, she registers with the PEA and is assigned to a caseworker. The caseworker will interview the person. All unemployed workers, who receive benefits, are required to

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[1]Early studies on the effects of unemployment benefits and unemployment entitlement duration show that higher unemployment benefits and longer unemployment entitlement durations increase unemployment spells Narendaranathan et al. (1985), Katz and Meyer (1990), Hunt (1995), and Nickell and Layard (1999). More recent studies based on natural experiments by Lalive and Zweimüller (2004), Lalive (2007), and Lalive et al. (2015) confirm these results.

[2]Hainmueller et al. (2016) use a pilot study in the German PEA to show that a lower caseworker-to-unemployed ratio decreases the duration of unemployment. For Switzerland Behncke et al. (2010) show that caseworkers, who behave less co-operative and less harmonic increase the employment chances of their unemployed. Belot, Kircher and Muller (2016) use a field experiment to show that providing tailored advice on alternative occupations to unemployed job seekers on the internet broadens the set of jobs they consider and increases their job interviews.

[3]Sanctioning unemployed job seekers, who fail to fulfill the search requirements, has a positive effect on the exit rate from unemployment for those, who are sanctioned and those who are threatened to be sanctioned, as shown by Van den Berg et al. (2004), Abbring et al. (2005), Lalive et al. (2005), and Svarer (2011).

[4]The studies by Couch (1992), Heckman et al. (1999), Lechner and Wunsch (2009), Graversen and van Ours (2010), Gautier et al. (2014) and Lechner et al. (2011) among others have shown that that short job-search training programs and intensive long-term training programs (the latter after an initial look-in-effect) a positive effect on reemployment probability of unemployed workers.

sign an agreement that determines the individual specific search effort, e.g. number of applications send out per week. The caseworker will propose certain jobs to the worker, if the worker's qualifications match the job description. With their experience case managers can encourage job seekers to search, broaden their view and apply to jobs, which job seekers would not have considered on their own (e.g. neighboring occupations).

For the PEA it is equally important to offer recruiting assistance to vacancies. The registration of vacancies is voluntary. Firms, which post a vacancy on the PEA provided internet platform, can search actively for registered workers and decide whether to make the vacancy available for recommendations by case managers. They can also ask their contact person at the PEA to propose workers. They can then contact these workers via the internal mailing system provided by the platform. The contact person is asked to recommend at least one worker within 48 hour. If no suitable applicant is in the system, the contact person will tell the firm within 48 hours. The firm can also set a maximum for the number of applications it wants to receive (in order to limit screening costs). In case the firm asks for recruiting assistance the contact person can view the platform account of the specific vacancy and manage the number of recommendations made by case managers accordingly. The contact person can also provide additional information about other services (e.g. subsidies) provided by the PEA. This type of recruiting assistance does not only lower recruitment costs, but also enables firms to minimize the risk of not receiving any applicant.

In the years 2005 to 2008, 55.7% of all vacancies in Germany were advertised in news papers, 48.3% used the services provided by the PEA (12.6% only at the agency, 12.7% only on the PEA-online platform and 23.0% both), and 45.3% of all vacancies were posted on the internet (excluding the online-platform of the PEA). The PEA is thus the second most used search channel by firms to contact workers. The PEA is also the second most important search channel of non-employed workers. In the years 2005 to 2007, 73.7% of all non-employed individuals, who actively searched in the last four weeks, search through job ads in news papers, 70.9% used the PEA as search channel, 64.2% searched via their personal network, 50.5% searched on the internet (possibly including the online-platform of the PEA), and 25.5% send speculative applications to firms.

3   Data

The main data-set used in this analysis is the German Job Vacancy Survey. It contains detailed information about the recruitment process. In some part of the analysis we also use the German Socio-Economic Panel (GSOEP) to gain information on how the PEA influences workers' job search behavior.

German Job Vacancy Survey

The German Job Vacancy Survey is collected by the Institute for Employment Research (IAB), a

research institute at the Federal Employment Agency in German.[5] 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.

The survey includes establishment level data on the number of employees, number of vacancies, hires and quits in the last 12 months, and information on the industry and region of the firm. The economic conditions of a firm can be proxied by binary indicator variables for "low sales", "financial constraints", and "skilled labor shortage". It also contains detailed questions concerning the last case of a successfully filled vacancy. In this part of the survey firms were asked when they started to search, when they intended to start the employment relationship, when it hired the worker, and when the hired worker started working. Firms are also asked which search channels they used and through which channel they hired. The survey also provides information on the number of applicants, the number of suitable applicants, the qualification and experience level required for the job, information on job characteristics like occupation, permanent/temporary, full-/part-time, and weekend-work required. It also contains information on the person hired for the job. We know the age, gender, the previous employment status, and for the year 2014 the wage.

For the main analysis on whether the PEA reduces coordination frictions we can use the information on the number of applicants and the number of suitable applicants in total and the number of applicants and the number of suitable applicants sent by the PEA.[6] This information is available for the years 2005 to 2008. We can therefore compare the distribution of (suitable) applicants sent by the PEA and the distribution of (suitable) applicants coming through the private market for the same set of vacancies.

Since our data contains only vacancies, which successfully hired a worker, each vacancy has at least one applicant and at least one suitable applicant. The distributions of (suitable) applicants are therefore conditional on firms having been successful. The German Job Vacancy Survey also questions vacancies, which were not successful in hiring. Unfortunately, these vacancies are not asked about the number of (suitable) applicants, which they received. According to IAB statistics the unsuccessful vacancies amount to around 4.6 percent of all posted vacancies.

German Socio Economic Panel

The German Socio Economic Panel (GSOEP) is used to complement the picture and provide an inside into which search channels are used by workers. The GSOEP is a longitudinal survey of German households. It started in 1984 and is conducted on the annual basis ever since.[7] The GSOEP is the largest and most comprehensive household panel in Germany, which provides detailed job search information of non-employed job seekers.

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[5]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.

[6]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?"

[7]The data used in this article is made available to us by the German Institute for Economic Research (DIW), Berlin.

The main information used is the information on the search behavior of non-employed individuals. For the years 2005 to 2007 non-employed individuals were asked whether they search actively for a job in the last four weeks. We select those non-employed workers, who send at least one application and who are below the age of 60.[8] For them the GSOEP provides the information on the search channels they used (PEA, job ads, internet, personal network, speculative application) and a host of personal characteristics including whether they are registered as unemployed with the PEA.

4   Empirical evidence

This section empirically analyzes whether the intermediation services provided by the PEA reduce search frictions. To pin down the relationship of interest, we take the following approach. Given the definition of search (coordination) frictions used in the literature we first investigate whether the PEA is able to distribute applications of its job seekers more evenly across vacancies than the private market. To do so we use within vacancy information of registered vacancies on the number of (suitable) applicants coming from the PEA and the private market, respectively. We will then address a range of concerns regarding a causal interpretation of our findings and show that our finding also hold if we include non-registered vacancies. In the second step we investigate whether the mediated suitable applicants coming from the PEA are associated with a higher hazard of finding a suitable applicant and an shorter search duration for vacancies. We conclude our analysis by looking at indicators for worker suitability and match quality.

4.1   Distribution of (suitable) applicants

The intermediation services provided by the PEA aim at reducing search frictions, which arise because applications – due to the lack of coordination – are unevenly distributed across vacancies. Our hypothesis is that the guidance of job seekers provided by the PEA result in a more even distribution of applications across vacancies compared to the distribution of applications coming via the private market.

Identification

To empirically test this hypothesis, we use data on the number of (suitable) applicants coming from the PEA and the private market for those vacancies in our data, which are registered. We therefore can calculate inequality measures - based on the same set of vacancies - for the distributions of (suitable) applicants coming via the PEA and the private market, respectively. This allows us to control perfectly for vacancy characteristics, observed and unobserved. The differences between the distributions of the number of (suitable) applicants coming via the PEA and via the private market can be driven by differences in the search behavior of job seekers using the PEA compared to the search behavior of job

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[8]Workers above the age of 60 are excluded, since they can receive unemployment benefits without actively searching for a job.

seekers using the private market or by the intermediation services provided by the PEA. In order to be able to identify the effect of the intermediation services provided by the PEA we need to make the identifying assumption that the difference in the distribution of the number of (suitable) applicants coming via the PEA compared to the private market is not caused by differences in job seekers search behavior. We will argue in section 4.4 that differences in job seekers search behavior do not drive the differences across these two distributions.

We will first analyze whether the absolute number of (suitable) applicants coming from the PEA is more evenly distributed than the absolute number of (suitable) applicants coming from the private market. This gives us a first understanding whether (suitable) applicants coming via the PEA are on average - across all sub-markets - more evenly distributed than (suitable) applicants coming via the private market. In order to control for differences across occupations, industries and sub-markets with certain vacancy characteristics, we will in a second step analyze whether our finding also holds once we control for occupation fixed effects, industry fixed effects and observable vacancy characteristics.

To analyze our main hypothesis we use three commonly used inequality measures to characterize the (in)equality of the distribution of (suitable) applicants; the Gini coefficient, the variance of logs, and the coefficient of variation.[9] We decided to exclude all observations with zero (suitable) applicants for the calculation of the inequality measures, since having zero (suitable) applicants has no value to the firm. By doing so we want to avoid that a distribution is characterized as "equal", because many observations have zero (suitable) applicants. We will nevertheless start with describing how many vacancies receive no (suitable) applicant via the PEA or the private market in order to see how well the respective search channels do in providing at least one (suitable) applicant.
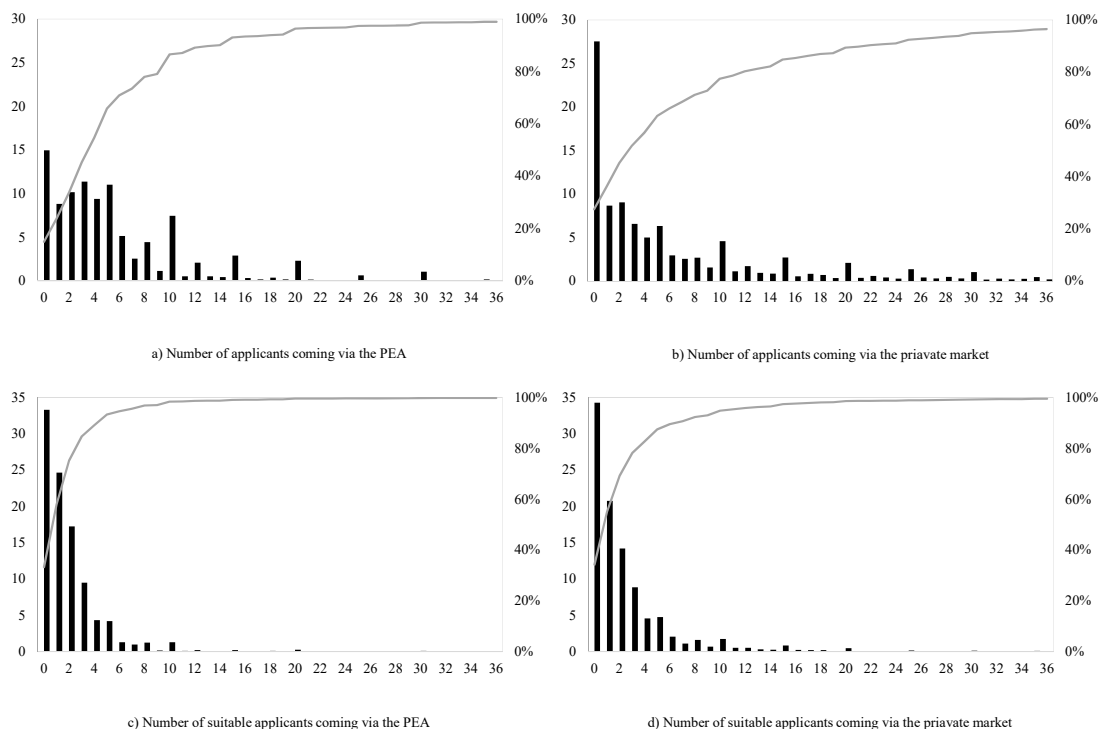
Absolute number of (suitable) applicants

The histograms in Figure 1 show the densities of the number of (suitable) applicants coming via the PEA and the private market, respectively. All vacancies used to calculate Figure 1 are registered with the PEA. Comparing Sub-figures a) and b) shows that the private market leaves a higher fraction of vacancies without an applicant than the PEA (27.5% private market compared to 15.0% PEA). This difference - calculated based on the same sample of firms - is statistically significant. Sub-figures c) and d) show that this difference vanishes almost completely when looking at the fraction of vacancies, which do not receive a suitable applicant from the respective search channel (33.2% private market compared to 32.2% PEA). The difference is no longer statistically significant. Since our sample includes only vacancies, which were successful in hiring a worker, all vacancies, which did not receive a (suitable) applicant via the private market received at least one (suitable) applicant from the PEA and visa versa.

Looking at the fraction of vacancies without any (suitable) applicant shows that the PEA compared to the private market is more likely to send at least one applicant and equally likely to send at least one

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[9]The three measures differ in their sensitivity towards changes in the mean or changes in the tails (see e.g. Bendel et al., 1989; Cowell and Flachaire, 2007). The coefficient of variation and the Gini coefficient are more sensitive to shifts in the mean compared to the variance of logs. The coefficient of variation and the variance of logs are more sensitive to changes in the tails of the distribution compared to the Gini coefficient.

Figure 1: Number of (suitable) applicants according to PEA and private market search channel

a) Number of applicants coming via the PEA

b) Number of applicants coming via the priavate market

c) Number of suitable applicants coming via the PEA

d) Number of suitable applicants coming via the priavate market

Germany Job Vacancy Survey, 2005-2008.

suitable applicant. Given this first evidence, which suggest that the PEA is able to reduce coordination frictions more than the private market, let us now look at the distribution of (suitable) applicants conditional on having at least one (suitable) applicant. The histograms reveal that the distribution of (suitable) applicants coming via the PEA is less dispersed than the respective distribution of (sutiable) applicants coming via the private market. This already suggests that (suitable) applicants coming via the PEA are more evenly distributed than (suitable) applicants coming via the private market.

Table 1 shows the Gini coefficients, the variances of logs, and the coefficients of variation for the number of applicants and the number of suitable applicants. Column (3) presents the difference between the Gini coefficients in column (1) to column (2) and the ratios of the variance of logs, and the coefficient of variation in column (1) to column (2), respectively. The inference on the statistical significance of the difference in the Gini coefficients is based on a t-test and the statistical significance of the difference of the variance of logs on a variance-ratio-test. The coefficient of variation (CV) is calculated based on the assumption that the respective variable is log-normally distributed, i.e., $CV(x) = \sqrt{e^{Var(ln(x))-1}}$. This allows us to infer the significance of the ratio of CVs from the variance ratio test of the variance of logs.

The Gini coefficient, the variance of logs, and the coefficient of variation for the number of applicants sent by the PEA are smaller than the respective measures for the number of applicants, who apply

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Table 1: **Inequality measures for the number of (suitable) applicants coming via the PEA and the private market**

	Private Market	PEA	Difference / Ratio
	(1)	(2)	(3)
		Gini coefficients	
number of applicants	0.5312	0.4586	0.0726**
	(0.0039)	(0.0052)	
number of suitable applicants	0.5493	0.4544	0.0948**
	(0.0078)	(0.0107)	
		Variance of logs	
number of applicants	1.2179	0.7403	1.6451**
number of suitable applicants	0.8941	0.5694	1.5704**
		Coefficient of variation	
number of applicants	1.5427	1.0472	1.4732**
number of suitable applicants	1.2021	0.8759	1.3725**

Source: German Job Vacancy Survey 2005-2008.
The sample contains 3,526 (2,017) observations for the absolute number of (suitable) applicants. The t-test (H_0: Difference = 0) is based on the standard error, which are provided in the parentheses. Variance-ratio-test (H_0: Ratio = 1) is based on the F-statistic with the degree of freedom given by the respective number of observations minus 1. ** indicates $p < 0.01$; * $p < 0.05$.

through private market search channels. All three inequality measures therefore show that the number of applicants coming from the PEA are more evenly distributed than the number of applicants coming from the private market. The differences in the Gini coefficients are statistically significant at a 1% level and the ratios for the variance of logs and the coefficient of variation are also statistically different from 1 at a 1% level. Table 1 also presents the results based on the number of suitable applicants. The respective differences and ratios are slightly smaller but equally significant.

The size of the difference between the inequality measures is difficult to interpret. It is, however, not negligible. For example, according to OECD statistics the difference between the Gini for household disposable income inequality in the US (0.41) and Germany (0.31) in 2013 was 0.10, which is similar to the difference found in the Gini coefficients for the distributions of suitable applicants coming via the private market and the PEA.

Residual number of (suitable) applicants

Considering the absolute number of (suitable) applicants across all types of vacancies implicitly assumes that all vacancies are part of one labor market. In reality, however, markets are segmented along occupations, industries, regions as well as vacancy characteristics. By decomposing the number of (suitable) applicants into an *explained* and an *unexplained* part we can investigate which part of the variation in the number of (suitable) applicants can be attributed to the respective sub-markets (explained part)

and which part can be attributed to the underlying random application process (unexplained part). The search literature interprets the underlying random application process as coordination frictions. This interpretation is based on the common assumption made in this literature that job seekers observe the type of sub-market a vacancy belongs to but they do not know to which vacancies – of the same sub-market – other job seekers apply (see, for example, Burdett et al., 2001; Shimer, 2005; Albrecht et al., 2006; and Galenianos and Kircher, 2009).

The decomposition will again be done separately for the number of (suitable) applicants coming from the PEA and the private market. Table 2 presents the respective regression results for the number of (suitable) applicants. The results for the total number of applicants coming via the PEA are presented in columns (1) and via the private market in column (2). Similarly, the results for the number of suitable applicants coming via the PEA and the private market are presented in columns (3) and (4).

Table 2: **Number of (suitable) applicants through the PEA and the private market**

	OLS-Regressions			
	log of total nr. of applicants		log of suitable nr. of applicants	
	PEA	private market	PEA	private market
	(1)	(2)	(3)	(4)
low qualification	-0.0382	-0.0921	0.0431	-0.0393
	(0.0800)	(0.0909)	(0.0913)	(0.1099)
high qualification	-0.0331	0.2259**	0.0567	0.2974**
	(0.0684)	(0.0887)	(0.0837)	(0.0988)
occupation specific experience	-0.0554	0.0307	-0.0462	-0.0916
	(0.0376)	(0.0473)	(0.0447)	(0.0566)
permanent	0.0711	0.2268**	0.0109	0.1543**
	(0.0400)	(0.0485)	(0.0479)	(0.0582)
full-time	0.1307*	0.1408*	0.0608	0.0126
	(0.0538)	(0.0677)	(0.0589)	(0.0782)
weekend-work	-0.0129	-0.0419	0.1068	0.0395
	(0.0602)	(0.0779)	(0.0724)	(0.0840)
firm size (log)	-0.0017	0.0891**	0.0526**	0.0756**
	(0.0140)	(0.0176)	(0.0163)	(0.0214)
"financial constraints"	-0.0502	-0.0938	-0.0305	-0.1165
	(0.0655)	(0.0773)	(0.0682)	(0.0881)
"low sales"	0.0015	-0.0096	0.0333	0.0434
	(0.0503)	(0.0610)	(0.0618)	(0.0806)
"skilled labor shortage"	-0.0698	-0.0664	-0.2474**	-0.3334**
	(0.0591)	(0.0721)	(0.0771)	(0.0950)
year-, region-, occup.-, ind.-FE	yes	yes	yes	yes
(year x region)-FE	yes	yes	yes	yes
R^2	0.2197	0.2676	0.3484	0.3500
N	2,484	2,484	1,463	1,463

Source: German Job Vacancy Survey 2005-2008.
Robust standard errors in brackets. ** indicates $p < 0.01$; * $p < 0.05$.

The variation in the number of (suitable) applicants, which can be explained by accounting for occupation-, industry-, and region-fixed effects, as well as for vacancy characteristics like required qualification and experience, part-time/full-time, permanent/temporary, etc. is 22.0% (34.8%) for

(suitable) applicants coming via the PEA and 26.8% (35.0%) for (suitable) applicants coming via the private market. The fact that 65% to 78% in the variation of the number of (suitable) applicants cannot be explained by differences across sub-markets indicates how important coordination frictions are.

The regression results are also informative about the mechanism leading to a more even distribution of (suitable) applicants coming via the PEA along the explained part dimension, i.e., across different sub-markets for vacancies. While jobs requiring high qualifications receive more suitable applicants from the private market, no such effect can be found for applicants sent by the PEA. A similar phenomena can be observed if the job is permanent. The cases, where job or firm characteristics are insignificant in explaining the number of suitable applicants coming from the PEA but significant in explaining the number of applicants coming from the private market, suggest that the PEA in contrast to the private market distributes its applicants irrespective of these vacancy characteristics. The picture for the number of applicants is similar.

In order to investigate to which degree coordination frictions between the private market and the PEA differ, we take the OLS residuals from the above estimation equations and calculate the inequality measures of the respective distributions. Since the dependent variable in the OLS regressions is the log of the number of (suitable) applicants, the residuals of the OLS regressions are the log of the unexplained part of the number of (suitable) applicants. We can therefore obtain the inequality measure variance of logs by calculating the variance of the residuals. Given the fact that the residuals are the *log* of the unexplained part of the number of (suitable) applicants, we can transform the residuals into the unexplained part of the number of (suitable) applicants by taking the exponential operator. Since the OLS regressions force the mean of the residuals to be equal to zero, the means of the unexplained parts of the number of (suitable) applicants are always equal to one. The respective coefficient of variation is therefore given by the variance of the transformed residuals. The Gini coefficients are also calculated based on the transformed residuals. The results are shown in Table 3.

The results based on the residuals of the OLS regression confirm our findings based on the absolute number of (suitable) applicants. They are equally significant and therefore strongly support our hypothesis that the PEA ensures that the applications of (suitable) job seekers registered with the PEA are more evenly spread than the applications of (suitable) workers coming via the private market. In other words, our results suggest that the PEA is indeed successful in reducing coordination frictions.

4.2   External validity

In order to control for unobserved vacancy characteristics, we restricted the sample in the previous section to registered firms for which we observed the number of (suitable) applicants coming via the PEA and via the private market for the same sample of vacancies. In this section we show that if we add non-registered firms, which exclusively search via the private market, we find the same picture, i.e., that the number of (suitable) applicants coming via the PEA are more evenly distributed than the number of (suitable) applications coming via the private market. Table 4 shows the respective

Table 3: **Inequality measures for the residuals of the number of (suitable) applicants coming via the PEA and the private market**

	Private Market	PEA	Difference / Ratio
	(1)	(2)	(3)
	Gini coefficients		
number of applicants	0.4829	0.4036	0.0793**
	(0.0060)	(0.0058)	
number of suitable applicants	0.4422	0.3562	0.0860**
	(0.0089)	(0.0078)	
	Variance of logs		
number of applicants	0.8918	0.5638	1.5818**
number of suitable applicants	0.5918	0.3769	1.5702**
	Coefficient of variation		
number of applicants	1.1998	0.8702	1.3787**
number of suitable applicants	0.8984	0.6765	1.3280**

Source: German Job Vacancy Survey 2005-2008.
The sample contains 2,484 (1,463) observations for the absolute number of (suitable) applicants. The t-test (H_0: Difference = 0) is based on the standard error, which are provided in the parentheses. Variance-ratio-test (H_0: Ratio = 1) is based on the F-statistic with the degree of freedom given by the respective number of observations minus 1. ** indicates $p < 0.01$; * $p < 0.05$.

inequality measures for the total number of (suitable) applicants and the residual number of (suitable) applicants.

The differences in the inequality measure between applicants coming via the PEA and via the private market are similar compared to the sample of registered firms only, which suggests that our finding that the PEA is able to reduce coordination frictions applies in general.

4.3 Robustness checks

To analyze further whether our findings can be interpreted causally, we investigate whether reverse causality or measurement error drive our results.

Reverse causality

To mitigate concerns that our results are driven by vacancies, which during their search process changed their recruitment strategy, we look at the sub-sample of vacancies, for whom we know that they were successful in finding a suitable applicant before their intended starting date. By excluding vacancies, which hired a worker only after the intended starting date we are confident to exclude those vacancies, which decided to post their vacancies with the PEA, because they received only few (suitable) applicants initially and were thus unable to hire a worker in time.

Table 4: **External validity check for the inequality measures**

	Private Market	PEA	Difference / Ratio
	(1)	(2)	(3)
		Gini coefficients	
absolute number of			
applicants	0.5120	0.4671	0.0450**
	(0.0020)	(0.0039)	
suitable applicants	0.5208	0.4708	0.0499**
	(0.0034)	(0.0073)	
residual number of			
applicants	0.4773	0.4298	0.0475**
	(0.0028)	(0.0045)	
suitable applicants	0.4660	0.4156	0.0504**
	(0.0041)	(0.0069)	
		Variance of logs	
absolute number of			
applicants	1.1629	0.7889	1.4742**
suitable applicants	0.8163	0.6009	1.3585**
residual number of			
applicants	0.9460	0.6488	1.4581**
suitable applicants	0.6557	0.4889	1.3410**
		Coefficient of variation	
absolute number of			
applicants	1.4830	1.0958	1.3533**
suitable applicants	1.1234	0.9076	1.2378**
residual number of			
applicants	1.2551	0.9556	1.3134**
suitable applicants	0.9625	0.7941	1.2121**

Source: German Job Vacancy Survey 2005-2008.
The sub-sample contains 12,346 (12,493) observations for the absolute number of (suitable) applicants coming via the private market and 6,153 (4,600) observations for the absolute number of (suitable) applicants coming via the PEA. The respective observations for the residual number of applicants are given by 9,426 (9,633) and 4,486 (3,326). The t-test (H_0: Difference = 0) is based on the standard error, which are provided in the parentheses. Variance-ratio-test (H_0: Ratio = 1) is based on the F-statistic with the degree of freedom given by the respective number of observations minus 1. ** indicates $p < 0.01$; * $p < 0.05$.

Table A.1 in the Appendix shows the results for this sub-sample. The results are robust irrespective of whether we look at the absolute number of applicants or the absolute number of suitable applicants. The same holds, if we consider the unexplained part of the number of (suitable) applicants by looking at the residuals of the respective OLS-regressions, where we control for occupation-, industry-, and region-fixed effects, as well as a large set of vacancy characteristics.

The results in Table A.1 in the Appendix show that our finding that the PEA distributes (suitable) applicants more evenly than the private market is robust to excluding vacancies, which might adjust

their recruitment strategy because they are unable to find a suitable applicant within the planned time.

Measurement error

The data used is survey data. It is therefore likely that firms round large numbers of (suitable) applicants at certain focal points. Such measurement errors might bias our inequality measures, if the rounding at focal points induces a more even distribution in one but not in the other distribution. A first look that the histograms in Figure 2 reveals that there are indeed mass points at certain focal points in the distribution like 5, 10, 15, 20, and 30.

Figure 2: Weighted and unweighted number of (suitable) applicants coming via the PEA and the private market
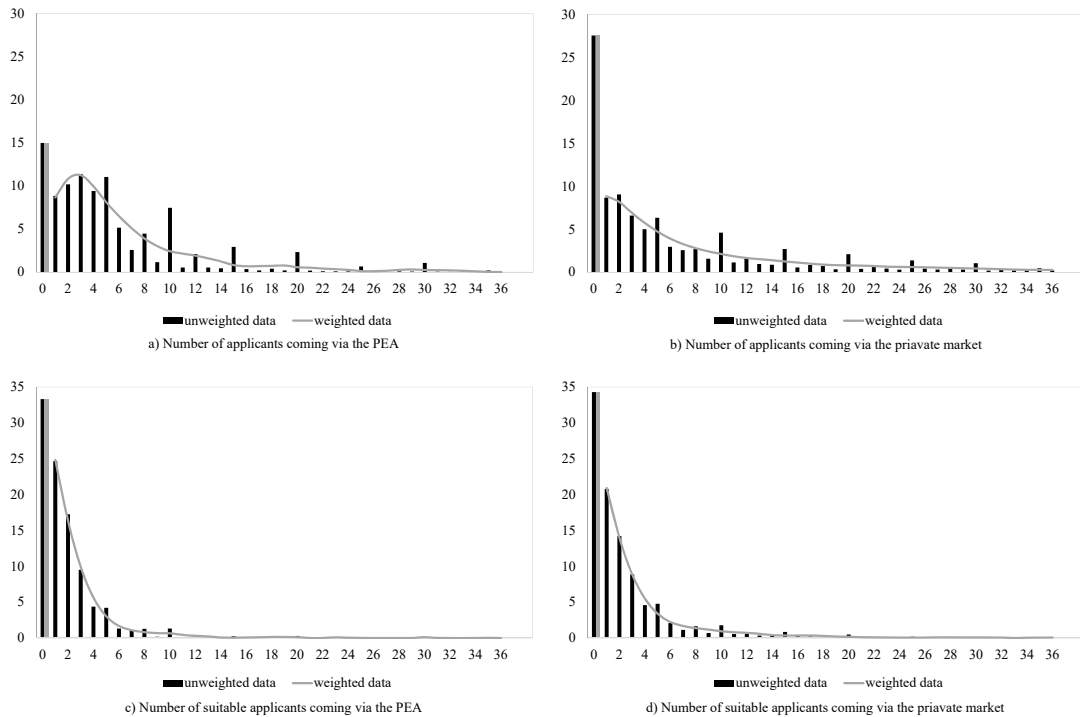
Germany Job Vacancy Survey, 2005-2008.

To investigate whether these mass points are driving our results, we smooth out the mass points using kernel density estimates. Since measurement error is unlikely to occur, if a firm reports zero (suitable) applicants (via the PEA or the private market), we hold the number of vacancies reporting zero applicants of the respective type constant and use the kernel density estimates only to even out the mass points at positive numbers of applicants. The resulting kernel density distributions are shown by the solid gray lines in the respective histograms.

Given the weights implied by the kernel density estimates, we re-calculate our inequality measures with the weighted sample. All inequality measures based on the weighted sample show again that the

PEA distributes its (suitable) applicants more evenly than the private market. The respective results are shown in Table A.2 in the Appendix.

4.4   Potential confounding factors

In our main analysis we use within vacancy variation and can thus control for unobserved vacancy characteristics. With the German Job Vacancy Survey, however, we are unable to control for the search behavior of job seekers. Since the search behavior of job seekers might differ depending on whether job seekers search via the PEA or not, we have to assume that differences in workers' job search behavior do not confound our results. In the following we will present evidence, which supports this assumption.

The empirical literature, which investigates the efficiency of the PEA search channel compared to other search channels using worker level data, has shown that the PEA is mostly used by unemployed and less skilled workers and that the productivity of the PEA search channel (in generating offers and acceptances) is lower than the productivity of networks and speculative applications.[10] These results suggest that job seekers using the PEA as search channel differ from job seekers using private market search channels. The fact that different job seekers-types use the PEA compared to the private market causes a problem for our identification only if these job seekers differ in their job search behavior and if these differences lead to a more or less even distribution of (suitable) applicants across vacancies.

To address these concerns we will first investigate in which characteristics job seekers using the PEA differ from those that use private market search channels exclusively. The first characteristic, which we want to investigate, is the employment status of job seekers. Since no administrative data and no survey data with information on employed workers' job search behavior exists in Germany, we will use the information of the previous labor market status of the hired worker in the German Job Vacancy Survey to provide indirect evidence that employed workers use the private market search channel more frequently. For non-employed job seekers we can use the GSOEP to investigate in which characteristics job seekers using the PEA differ from job seekers not using the PEA.

In order to test the hypothesis whether employed workers are equally likely to search via the PEA and the private market we investigate whether the probability that a hired worker was previously employed depends on the share of (suitable) applicants coming from the private market relative to all (suitable) applicants. By regressing the probability that a hired worker was previously employed on the share of (suitable) applicants coming from the private market we test two hypothesis jointly; the hypothesis whether employed workers are equally likely to search via the PEA and the private market and the hypothesis whether suitable and previously employed applicants are regarded as "suitable" as suitable and previously unemployed applicants. We cannot test the latter hypothesis directly. However, in section 4.6 we test whether suitable applicants coming via the private market are regarded as "suitable"

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[10]Compare Holzer (1988) and Blau and Robins (1990) for the US, Osberg (1993) for Canada and Gregg and Wadsworth (1996) for the UK, and Weber and Mahringer (2002) for Austria.

as suitable applicants coming via the PEA. Although it is not the same hypothesis the results are still informative. We find small but significant differences in the degree of suitability, i.e., suitable applicants coming via the private market are more often regarded as the better fit and hence are more often hired than suitable applicants coming via the PEA. This evidence suggests that even if we find that a higher share of suitable applicants coming via the private market increases the probability that a previously employed worker is hired, this does not necessarily imply that previously employed workers are more likely to use the private market compared to the PEA.

Table 5: **Hired workers' previous employment status and fraction of (suitable) applicants coming via the private market (PM)**

| | OLS-Regressions | | | |
| | fraction of applicants | | fraction of suitable applicants | |
	(1)	(2)	(3)	(4)
frac. of applicants via PM	0.2807** (0.0184)	0.2671** (0.0188)		
total number of applicants		0.0245** (0.0071)	0.0235** (0.0074)	0.0120 (0.0106)
frac. of suit. applicants via PM			0.2904** (0.0177)	0.2915** (0.0178)
total number of suit. applicants				0.0219 (0.0143)
firm- and vacancy characteristics	yes	yes	yes	yes
year-, region-, occup.-, ind.-FE	yes	yes	yes	yes
(year x region)-FE	yes	yes	yes	yes
R^2	0.2807	0.2825	0.3091	0.3095
N	5,046	5,046	4,573	4,573

Source: German Job Vacancy Survey 2005-2008.
Robust standard errors in brackets. ** indicates $p < 0.01$; * $p < 0.05$.

Table 5 presents the results based on a linear probability model. The results remain unchanged, if we estimate marginal effects of a probit regression (see Table A.3 in the Appendix). The coefficients clearly indicate that a one percentage point increase in the share of applicants coming via the private market increases the likelihood that a previously employed worker is hired by 0.3 percentage points. The results are highly significant at a 1% level. The same is true, if we consider suitable applicants instead of applicants. This result could be driven by the fact that suitable and previously employed applicants are more often hired than suitable and previously unemployed workers. Still, the estimated effect is quite strong, which suggests that employed workers are more likely to use private market search channels than the PEA.

Non-employed job seekers, who actively search for a job but do not use the PEA as search channel, might also differ in terms of their characteristics compared from non-employed job seekers, who use the PEA as search channel. In Table A.4 in the Appendix we compare these two groups using individual level data from the GSOEP for the years 2005 to 2007 (the years in which this information is available).

The main differences are that females are somewhat over-represented among non-employed job seekers not using the PEA (59.0% compared to 47.8%) and that 90.9% of all workers actively searching via the PEA are registered with the PEA, while only 70.2% of those not searching via the PEA are registered with the PEA. Apart from these differences non-employed job seekers, who search via the PEA, and non-employed job seekers, who do not search via the PEA, are very similar in terms of age, education, as well as work- and unemployment-experience. All descriptive statistics are shown in Table A.4 in the Appendix.

The above evidence suggests that job seekers using the PEA are on average more often unemployed and registered with the PEA compared to job seekers, who use private market search channels exclusively. Males are also overrepresented among job seekers using the PEA. These differences in characteristics are in themselves not jeopardizing our identification strategy. They only compromise our identification strategy, if these groups differ in their search behavior and if these differences in search behavior were to lead to a more even or uneven distribution. To investigate this we will now analyze whether the two groups differ in their job search behavior. For non-employed workers we can compare the search behavior of those using the PEA and those using the private market exclusively using the information on job search behavior provided by the GSOEP. Since we have no direct information about the job search behavior of employed workers, we can only look at the sub-sample of non-employed workers, who are not registered as unemployed and are therefore most likely to behave like employed job seekers.

The descriptive statistics shown in Table A.4 in the Appendix show that non-employed workers searching via the PEA use on average 3.6 search channels, while workers not searching via the PEA use on average 2.2 search channels. The PEA accounts for one additional search channel, while the other four search channels (job ads, internet, networks, speculative applications) account in almost equal proportions for the 0.4 additional search channels.

In Table 6 we show in the first line the OLS coefficient of the indicator variable "using the PEA as search channel" regressed on the number of search channels used by non-employed workers (and a host of other control variables). The lines two to five show the respective marginal effect that "using the PEA as search channel" has on using the denoted search channel based on a probit regression. The remaining coefficients of the respective regressions can be found in Table A.5 in the Appendix.

Table 6 shows in column (1) that those non-employed individuals, who use the PEA as search channel, use on average 1.26 search channels more, i.e., they do not only use the PEA as additional search channel, they also use other search channels more often. The increased search activity of workers using the PEA can be one channel to explain the more even distribution of applications coming via the PEA, because sending out more applications leads to a more even distribution of applications across vacancies if the number of contemplable vacancies is small. This can be seen by taking the limit as the number of applications approaches the number of contemplable vacancies. In this case all vacancies receive the same number of applications.

Table 6: **Individuals: Search behavior**

| | The influence of searching via the PEA on ... | | | |
	(1)		(2)	
number of search channels	1.2644**	(0.0701)	1.2447**	(0.2080)
job ads	0.0651	(0.0354)	0.0529	(0.0823)
internet	0.0894**	(0.0298)	0.1146	(0.0758)
personal network	0.0622	(0.0381)	0.0622	(0.0827)
speculative applications	0.0720**	(0.0295)	0.0737	(0.0751)

Source: German Socio Economic Panel 2005-2007.
Robust standard errors in brackets. *** indicates $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. The coefficients of using the PEA as search channel for the number of search channels used is based on an OLS regression and the coefficients of using the PEA as search channel for the other search channels (job ads, internet, network, speculative application) are based on the marginal effects of probit regressions.

Since we have not data on the job-search behavior of employed workers, the best we can do is to look that the subgroup of individuals, which is most likely to behave similar to employed workers. To do so, we concentrate in the second column of Table 6 on non-employed individuals, who are not registered as unemployed with the PEA. These individuals can still use the PEA as search channel. The effect of using the PEA search channel on the overall number of search channels used is similar to the one found for the overall sample.

The more frequent use of other search channels by those individuals using the PEA compared to those not using the PEA can lead to a more even distribution of applications send via the PEA. This is the case if the number of applications that an individual sends approaches the number of available vacancies (since nobody applies twice for the same job). To see this consider the limiting case where all individuals apply to all available vacancies. In this case applications are evenly distributed. Since the increased search intensity documented in Table 6 is the result of the intermediation services provided by the PEA (encouragement of search effort), such an effect would be part of the coordination friction reducing effect of the PEA, which we want to identify.

The results presented in column (1) in the lower part of Table 6 show that using the PEA as search channel is associated with a significant increase in the use of all other private market search channels like job ads, internet, personal network, and speculative application by 6.2% to 8.9%. The effects are similar for the subgroup of non-employed job seekers shown in column (2), who are not registered as unemployed and are therefore most likely to behave like employed workers. The coefficients of the different search channels are not statistically different from each other. This indicates that individuals, who use the PEA, do not substitute one search channel for another one, but increase the use of other

search channels in equal proportions. This last result is reassuring, since it implies that the search behavior of job seekers using the PEA is not biased towards a particular search channel. This supports our identifying assumption, since it implies that the more even distribution of (suitable) applicants coming via the PEA cannot be driven by differences in the search channels used.

4.5 PEA use and search duration of vacancies

A more even distribution of (suitable) applicants goes – according to theory – hand in hand with a higher number of matches. Since our sample encompasses only successful vacancies, we are unable to test this hypothesis directly. Instead we will look at those vacancies, which were most likely to fail, and investigate whether registering with the PEA or the suitable applicants send by the PEA helped them to hire a worker faster. We denote those vacancies as most likely to fail, which were unable to hire a worker until the intended starting date.

Hazard rate of hiring a suitable applicant

We will use the information on the date of starting to search via the PEA to determine the effect of the PEA search channel on the hazard of hiring a suitable applicant. Since the information about the timing of registering a vacancy with the PEA is only available in 2014 (not in the years 2005 to 2008), we will use data for 2014 only. In 2014 the overall majority (77.3%) of all vacancies, which eventually used the PEA as search channel, registered their vacancy right at the start of the search process. The respective fraction of vacancies increases up to 98.3% over the first three months.

We estimate a Cox proportional hazards model and estimate the effect of searching via the PEA on the hazard rate in two different ways. First, we assume that the effect is the same over the whole remaining search period (remaining after having started to search via the PEA). We then relax this assumption, since Ehrenfried and Holzner (2018) have shown that the baseline hazard of hiring a suitable applicant differs substantially before and after the intended starting date. Following their approach, we allow the effect of searching via the PEA to differ in four-weeks-constant intervals prior and after the intended starting date.[11]

Under the assumption that the effect of searching via the PEA is constant over the remaining search period, the estimated hazard ratio is with 1.0239 (with standard error 0.0342) not statistically significantly different from 1. If we allow for the effect to differ depending on how close the date is to the intended starting date, we find that prior to the intended starting date using the PEA as search channel decreases slightly the hazard of hiring a suitable applicant. The estimated hazard ratios are, however, not significantly different from 1. After the intended starting date the estimated hazard ratios are all above 1 indicating that after the intended starting date the effect of using the PEA as search channel becomes positive. For the weeks 5 to 9 and 9 to 13 after the intended starting date the positive

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[11]The constant intervals are "more than 15 weeks prior", "between 15 and 11 weeks prior", ..., "between 3 weeks prior and 1 week after", ..., "between 13 and 17 weeks after", "more than 17 weeks after".

effects are statistically significant at a 5% and 10% level, respectively. The respective hazard-ratio estimates are shown in Figure 3. The regression results are shown in Table A.6 in the Appendix.

Figure 3: Hazard-Ratios of using the PEA search channel
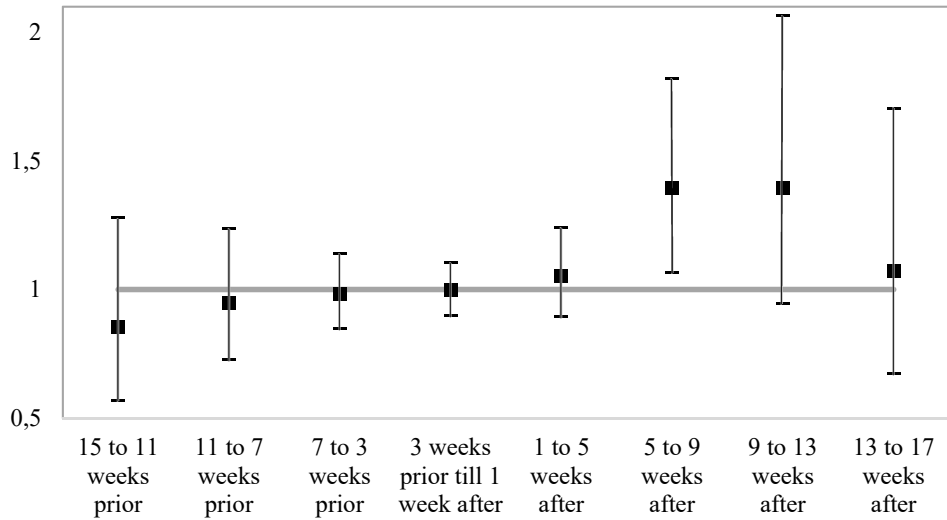
Germany Job Vacancy Survey, 2014.

The negative effect of using the PEA search channel prior to the intended starting date should not be interpreted as harming the firm. Since the firm intends to start employment at the intended starting date (and not before), it will anticipate that registering the vacancy with the PEA will increase the number of workers applying and thus the overall time needed to screen applicants. As long as the firm is able to hire until the intended starting date the additional time needed to hire a suitable applicant does no harm. For firms, which were unable to hire a suitable applicant until the intended starting date and are at risk of failing to hire the positive effect of using the PEA kicks in. Using the PEA in the weeks 5 to 13 after the intended starting date increases the baseline hazard of hiring a worker by 40%. The effect is statistically significant. This supports our hypothesis that the PEA decreases coordination frictions and thereby helps to avoid that firms fail to hire.

Search duration of vacancies

Given that using the PEA affects the hazard differently depending on whether the vacancy was able to hire (before or after the intended starting date) we will split the sample into three sub-groups when investigating the effect on search duration, vacancies, which hired more than 3 weeks before the intended starting date, vacancies, which hired more than 1 week after the intended starting date, and vacancies, which hired in between.

Table 7 presents the respective OLS-estimates. In part (a) we use the year 2014 - like in the hazard estimation above - and restrict our attention to vacancies, which use the PEA from the start of the search process in order to avoid endogeneity issues arising from the activation of the PEA search channel

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later in the recruitment process. In part (a) we analyze the effect of using the PEA taking the effect of applicants and suitable applicants into account. In part (b) we use the years 2005 to 2008 and the information on the number of (suitable) applicants coming via the PEA and the private market respectively in order to analyze the direct impact of the number of (suitable) applicants coming via the PEA on the search duration of vacancies.

The German Job Vacancy Survey allows us to control for occupation, industry, and various firm- and job-characteristics. We are also able to control for the planned search duration. To the extend that firms choose their planned search duration based on their past recruitment experience, this variable allows us to control for unobserved vacancy characteristics.

Table 7: **The effect of using the PEA on the search duration**

	all	before	in time	after
	vacancies		... intended starting date	
(a) PEA use and suitable applicants (2014)				
PEA search channel	0.0011	0.1501	-0.0389	-0.0611
	(0.0474)	(0.0826)	(0.0312)	(0.0697)
suitable applicants (log)	-0.1253*	-0.0417	-0.0933**	-0.1268*
	(0.0501)	(0.0743)	(0.0330)	(0.0640)
applicants (log)	0.1892**	0.1337*	0.0780**	0.1055*
	(0.0372)	(0.0621)	(0.0254)	(0.0439)
(b) Suitable applicants via PEA (2005 - 2008)				
suit. appl. via PEA (log)	-0.1185**	0.0361	-0.0019	-0.1468**
	(0.0354)	(0.0776)	(0.0252)	(0.0469)
appl. via PEA (log)	0.0115	-0.0357	-0.0172	0.0364
	(0.0278)	(0.0570)	(0.0205)	(0.0364)
suitable applicants (log)	-0.0931*	-0.0026	-0.0404	-0.0844
	(0.0416)	(0.0965)	(0.0287)	(0.0541)
applicants (log)	0.1809**	0.0936	0.0742**	0.0932**
	(0.0321)	(0.0666)	(0.0239)	(0.0406)

Source: German Job Vacancy Survey (a) 2014, (b) 2005-2008.
Robust standard errors in brackets. ** indicates $p < 0.01$; * $p < 0.05$.

In part (a) the coefficient for using the PEA is positive and marginally significant for the sub-sample of vacancies, which hired before the intended starting date and becomes negative but insignificant for the vacancies, which hired in time or after the intended starting date. This is in line with the results found on the hazard rate. Also interesting in part (a) are the coefficients for the number of applicants and the number of suitable applicants. The positive sign associated with the number of applicants indicates that a higher number of applicants increases the time needed to screen applicants. The

negative sign of the coefficient on the number of suitable applicants indicates that a higher number of suitable applicants decreases search duration and thus suggests that intermediaries sending suitable applicants can indeed reduce search frictions. Part (b) provides the respective evidence by looking at the number of (suitable) applicant coming via the PEA conditional on the overall number of (suitable) applicants. The number of suitable applicants send by the PEA has a clear positive effect by decreasing the search duration of vacancies, which are most likely to fail to hire, because they did not hire before or around the intended starting date. Note, that this effect is conditional on the overall number of suitable applicants. These results strongly supports our hypothesis that the intermediation services provided by the PEA are able to reduce coordination frictions and help to avoid that firms fail to hire.

4.6 Worker suitability and match quality

The results above indicate that the PEA reduces coordination frictions and the risk of failing to hire. In this section we ask the question of whether suitable applicants arriving through the PEA are as good as matches formed with 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.

We use information on the fraction of firms using the PEA as hiring channel as indirect measure for the quality of suitable applicants coming via the PEA compared to the private market. If suitable applicants coming via the PEA are 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). By comparing these fractions we can test the hypothesis whether suitable applicants coming via the PEA are regarded by firms as equally "suitable" as suitable applicants coming via the private market.

In our sample of registered vacancies 45.6% hire an applicant, whom they meet through the PEA. Taking the same sample of firms the fraction of suitable applicants coming via the PEA among all suitable applicants is equal to 48.3%. The respective results are shown in Table 8. The difference is with 2.7 percentage points small. This indicates that the suitability of suitable applicants coming via the PEA is almost as high as the suitability of suitable applicants coming via the private market. Although the difference is small, it is still significantly different from zero at a 1% level. Splitting the sample into vacancies, which hired an applicant before, in time, or after the intended starting date, reveals that the difference is with 3.9 (3.5) percentage points high for vacancies, which hired before and around the intended starting date. For vacancies, which hired after the intended starting date, the difference is with 0.7 percentage points very small and statistically insignificant.

These results suggest that while on average suitable applicants coming via the PEA are regarded as sightly less "suitable" than suitable applicants coming via the private market, for vacancies, which hire after the intended starting date, the differences between the suitable applicants coming via the PEA and

Table 8: **Difference between fraction of vacancies hiring through the PEA and fraction of suitable applicants coming via the PEA**

	all vacancies	before	in time	after
		... intended starting date		
frac. hiring through PEA	0.4564	0.3940	0.5331	0.3968
	(0.0070)	(0.0135)	(0.0106)	(0.0127)
frac. of suit. appl. via PEA	0.4839	0.4327	0.5678	0.4037
	(0.0059)	(0.0112)	(0.0089)	(0.0108)
difference	-0.0275**	-0.0387**	-0.0347**	-0.0069
	(0.0061)	(0.0122)	(0.0091)	(0.0112)

Source: German Job Vacancy Survey 2005-2008. The sample size is 5,022 in total, 1,307 for those hiring before, 2,223 for those hiring in time, and 1,492 for those hiring after the intended starting date.
Robust standard errors in brackets. ** indicates $p < 0.01$; * $p < 0.05$.

the private market vanishes. This can have two reasons. First, vacancies, which hire after the intended starting date, could have been unlucky and received only a few applications from suitable applicants from the private market, and second, it could be that these vacancies lowered their requirements and hired applicants coming via the PEA although they are not quite as good as applicants coming via the private market. This interpretation is in line with evidence provided by Ehrenfried and Holzner (2018), who use the same data-set. They show that firms, which are unable to hire a worker until the intended starting date, are willing to make more concessions in terms of the qualification and experience required by the hired person.

Another common way to measure match quality is by looking at wages. Holzner and Watanabe (2018) show – using the same data-set – that registered vacancies do not pay differently if the hired worker applied through the PEA or the private market.[12] Given our evidence and the evidence provided in Holzner and Watanabe (2018) we conclude that the differences in the suitability of applicants and the quality of matches with suitable applicants coming via the PEA compared to the private market are small.

5 Conclusion

We analyze empirically the effect of the intermediation services provided by the PEA on the labor market. Using a unique vacancy-level data-set on the number of (suitable) applicants, we find positive

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[12]Holzner and Watanabe (2018) show that wages paid by registered vacancies are on average 3.2 to 4.2 percentage points lower than wages paid by unregistered vacancies. However, since our analysis is based on registered vacancies only, not the effect of using the "PEA search channel" matters but the effect of "PEA hiring channel". And the latter coefficient is insignificant in the Holzner and Watanabe (2018).

effects of the intermediation services on mitigating search frictions. In particular, the number of (suitable) applications, which firms received via the PEA, are more evenly distributed than the number of (suitable) applications, which firms received via the private market. Thus, the intermediaton services provided by the PEA coordinate job applications more than other search channels. We can also show that the number of suitable applicants coming via the PEA are postively associated with shorter search duration for firms, which are most at risk of not hiring.

References

[1] Abbring, J. H., Berg, G. J., and J. C. Ours, (2005), The effect of unemployment insurance sanctions on the transition rate from unemployment to employment, *The Economic Journal*, 115(505), 602-630.

[2] Addison, J.T. and P. Portugal, (2002), Job search methods and outcomes, *Oxford Economic Papers*, 54, 505-533.

[3] Albrecht, J., Gautier, P. A., and S. Vroman, (2006), Equilibrium directed search with multiple applications, *The Review of Economic Studies*, 73(4), 869-891.

[4] Belot, M., P. Kircher, and P. Muller, (2015), Providing advice to job seekers at low cost: An experimental study on online advice, *mimeo*.

[5] Behncke, S., Frlich, M., and M. Lechner, (2010), Unemployed and their caseworkers: should they be friends or foes? *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 173(1), 67-92.

[6] Bendel, R. B., Higgins, S. S., Teberg, J. E., and D. A. Pyke, (1989), Comparison of skewness coefficient, coefficient of variation, and Gini coefficient as inequality measures within populations, *Oecologia*, 78(3), 394-400.

[7] Blau, D.M., and P.K. Robins, (1990), Job search outcomes for the employed and unemployed, *Journal of Political Economy*, 98 (3), 637-655.

[8] Bradley, J., and A. Kugler, (2017), Labor Market Reforms: An Evaluation of the Hartz Policies in Germany, *mimeo*.

[9] Burdett, K., Shi, S., and R. Wright, (2001), Pricing and matching with frictions, *Journal of Political Economy*, 109(5), 1060-1085.

[10] Butters, G. R., (1977), Equilibrium Distributions of Sales and Advertising Prices, Review of Economic Studies 44, pp.465–91.

[11] Couch, K.A., (1992), New Evidence on the Long-Term Effects of Employment Training Programs, *Journal of Labour Economics*, 10, 380388.

[12] Cowell, F. A., and E. Flachaire, (2007), Income distribution and inequality measurement: The problem of extreme values, *Journal of Econometrics*, 141(2), 1044-1072.

[13] Ehrenfried, F, and C. Holzner, (2018), Dynamics and endogeneity of firms' recruitment behaviour, *mimeo*.

[14] Felbermayr, G., G. Impullitti and J. Prat, (2016), Firm Dynamics and Residual Inequality in Open Economies, *mimeo*.

[15] Fougère, D., J. Pradel, and M. Roger, (2009), Does the public employment service affect search effort and outcomes?, *European Economic Review* 53, 846-869.

[16] Galenianos, M., and P. Kircher, (2009), Directed search with multiple job applications, *Journal of Economic Theory*, 144(2), 445-471.

[17] Gartner, H., and C.L. Holzner, (2015), Wage Posting as a Positive Selection Device: Theory and Empirical Evidence, *CESifo Working Paper No. 5494*.

[18] Gautier, P. A., Rosholm, M., Svarer, M., and B. van der Klaauw, (2014), Estimating equilibrium effects of job search assistance, *mimeo*.

[19] Graversen, B. K., and J. C. Van Ours, (2008), How to help unemployed find jobs quickly: Experimental evidence from a mandatory activation program, *Journal of Public Economics*, 92(10), 2020-2035.

[20] Gregg, P., and J. Wadsworth, (1996), How effective are state employment agencies? Jobcentre use and job matching in Britain, *Oxford Bulletin of Economics and Statistics*, 58 (3), 442-467.

[21] Hainmueller, J., Hofmann, B., and K. Wolf, (2016), Do Lower Caseloads Improve the Performance of Public Employment Services? New Evidence from German Employment Offices, *The Scandinavian Journal of Economics*, 118(4), 941-974.

[22] Heckman, J., R. LaLonde, and J. Smith, (1999), The Economics and Econometrics of Active Labor Market Programs, *In Handbook of Labour Economics*, edited by O. Ashenfelter, and D. Card, Vol. 3, Amsterdam , North-Holland , 18652097.

[23] Holzer, H.J., (1988), Search method by use by unemployed youth, *Journal of Labor Economics*,6, 1-20.

[24] Holzner, C.L., and M. Watanabe, (2018), Understanding the Role of the Public Employment Agency, *mimeo*.

[25] Hunt, J. (1995), The effect of unemployment compensation on unemployment duration in Germany, *Journal of Labor Economics*, 88-120.

[26] Katz, L. F., and B. D.Meyer, (1990), The impact of the potential duration of unemployment benefits on the duration of unemployment, *Journal of Public Economics*, 41(1), 45-72.

[27] Krause, M. U., and H. Uhlig, (2012), Transitions in the German labor market: Structure and crisis, *Journal of Monetary Economics*, 59(1), 64-79.

[28] Krebs, T. and M. Scheffel, (2013), Macroeconomic Evaluation of Labor Market Reform in Germany, *IMF Economic Review* 61 (2013), 664701.

[29] Lalive, R. (2007), Unemployment benefits, unemployment duration, and post-unemployment jobs: A regression discontinuity approach, *The American Economic Review*, 97(2), 108-112.

[30] Lalive, R., and J. Zweimüller, (2004), Benefit entitlement and unemployment duration: The role of policy endogeneity, *Journal of Public Economics*, 88(12), 2587-2616.

[31] Lalive, R., Ours, J. C., and J. Zweimüller, (2005), The effect of benefit sanctions on the duration of unemployment, *Journal of the European Economic Association*, 3(6), 1386-1417.

[32] Lalive, R., Landais, C., and J. Zweimüller, (2015), Market externalities of large unemployment insurance extension programs, *The American Economic Review*, 105(12), 3564-3596.

[33] Launov, A., and K. Wälde (2016), The employment effects of reforming a public employment agency, *European Economic Review*, 84 (2016), 140164.

[34] Lechner, M., and C. Wunsch, (2009), Are training programs more effective when unemployment is high?, *Journal of Labor Economics*, 27(4), 653-692.

[35] Lechner, M., Miquel, R., and C. Wunsch, (2011), Longrun effects of public sector sponsored training in West Germany, *Journal of the European Economic Association*, 9(4), 742-784.

[36] McAfee, (1993), Mechanism design by competing sellers, *Econometrica* 61-6, 1281-1312.

[37] Narendranathan, W., Nickell, S., and J. Stern, (1985), Unemployment benefits revisited, *The Economic Journal*, 95(378), 307-329.

[38] Nickell, S., and R. Layard, (1999), Labor market institutions and economic performance, *Handbook of Labor Economics*, 3, 3029-3084.

[39] Osberg, L., (1993), Fishing in different pools: Job-search strategies and job finding success in Canada in the Early 1980s, *Journal of Labor Economics*, 11, 348-386.

[40] Petrongolo, B., and C. A. Pissarides, (1999), Looking into the Black Box: A Survey of the Matching Function, *Journal of Economic Literature*, 39, 390–31.

[41] Peters, M. and Severinov, (1997), Competition among sellers who offer auctions instead of prices, *Journal of Economic Theory*, vol.75, pp. 141-179.

[42] Pissarides, C., (1979), Job Matching with State Employment Agencies and Random Search, *The Economic Journal*, 89, 818-833.

[43] Satterthwaite M. and A. Shneyerov, (2007), Dynamic Matching, Two-Sided Incomplete Information, and Participation Costs: Existence and Convergence to Perfect Competition, *Econometrica*, 75-1,pp 155-200

[44] Shimer, R., (2005), The assignment of workers to jobs in an economy with coordination frictions, *Journal of Political Economy*, 113(5), 996-1025.

[45] Svarer, M., (2011), The effect of sanctions on exit from unemployment: Evidence from Denmark, *Economica*, 78(312), 751-778.

[46] Van den Berg, G. J., Van der Klaauw, B., and J. C. Van Ours, (2004), Punitive sanctions and the transition rate from welfare to work, *Journal of Labor Economics*, 22(1), 211-241.

[47] Weber, A., and H. Mahringer, (2002), Choice and success of job search methods, *Empirical Economics*, 35, 153-178.

[48] Wielgosz, J.B., and S. Carpenter (1987), The effectiveness of alternative methods of searching for jobs and finding them: An exploratory analysis of the data bearing upon the ways of coping with joblessness, *American Journal of Economics and Sociology*, 46 (2), 151-164.

A Appendix: Tables

Table A.1: **Reverse causality check for inequality measures**

	Private Market (1)	PEA (2)	Difference / Ratio (3)
	Gini coefficients		
absolute number of			
applicants	0.5309 (0.0051)	0.4532 (0.0074)	0.0777**
suitable applicants	0.5500 (0.0098)	0.4554 (0.0146)	0.0946**
residual number of			
applicants	0.4669 (0.0081)	0.3783 (0.0073)	0.0886**
suitable applicants	0.4084 (0.0104)	0.3181 (0.0081)	0.0904**
	Variance of logs		
absolute number of			
applicants	1.2590	0.7222	1.7434**
suitable applicants	0.9147	0.5778	1.5829**
residual number of			
applicants	0.8045	0.4960	1.6222**
suitable applicants	0.5202	0.3143	1.6553**
	Coefficient of variation		
absolute number of			
applicants	1.5881	1.0290	1.5433**
suitable applicants	1.2231	0.8844	1.3829**
residual number of			
applicants	1.1116	0.8013	1.3873**
suitable applicants	0.8261	0.6077	1.3594**

Source: German Job Vacancy Survey 2005-2008.
The sub-sample contains 2,012 (1,224) observations for the absolute number of (suitable) applicants and 1,443 (905) observations for the residual number of (suitable) applicants. The t-test (H_0: Difference = 0) is based on the standard error, which are provided in the parentheses. Variance-ratio-test (H_0: Ratio = 1) is based on the F-statistic with the degree of freedom given by the respective number of observations minus 1. ** indicates $p < 0.01$; * $p < 0.05$.

Table A.2: **Measurement error check for inequality measures**

	Private Market	PEA	Difference / Ratio
	(1)	(2)	(3)
		Gini coefficients	
absolute number of			
applicants	0.5262	0.4626	0.0636**
	(0.0043)	(0.0087)	
suitable applicants	0.5558	0.4572	0.0986**
	(0.0082)	(0.0138)	
residual number of			
applicants	0.4728	0.4085	0.0643**
	(0.0059)	(0.0083)	
suitable applicants	0.4513	0.3507	0.1006**
	(0.0108)	(0.0085)	
		Variance of logs	
absolute number of			
applicants	1.2093	0.7504	1.6117**
suitable applicants	0.9478	0.5750	1.6482**
residual number of			
applicants	0.8731	0.5751	1.5181**
suitable applicants	0.6184	0.3683	1.6792**
		Coefficient of variation	
absolute number of			
applicants	1.5334	1.0572	1.4504**
suitable applicants	1.2570	0.8816	1.4258**
residual number of			
applicants	1.1808	0.8817	1.3393**
suitable applicants	0.9252	0.6673	1.3866**

Source: German Job Vacancy Survey 2005-2008.
The sub-sample contains 3,526 (2,017) observations for the absolute number of (suitable) applicants and 2,484 (1,463) observations for the residual number of (suitable) applicants. The t-test (H_0: Difference = 0) is based on the standard error, which are provided in the parentheses. Variance-ratio-test (H_0: Ratio = 1) is based on the F-statistic with the degree of freedom given by the respective number of observations minus 1. ** indicates $p < 0.01$; * $p < 0.05$.

Table A.3: **Hired workers' previous employment status and fraction of (suitable) applicants coming via the private market**

| | Probit: Marginal effects | | | |
| | fraction of applicants | | fraction of suitable applicants | |
	(1)	(2)	(3)	(4)
fraction of applicants	0.2662**	0.2529**		
	(0.0162)	(0.0167)		
number of applicants		0.0249**	0.0251**	0.0134
		(0.0067)	(0.0069)	(0.0100)
fraction of suit. applicants			0.2726**	0.2738**
			(0.0153)	(0.0153)
number of suitable applicants				0.0224
				(0.0136)
firm- and vacancy characteristics	yes	yes	yes	yes
year-, region-, occup.-, ind.-FE	yes	yes	yes	yes
(year x region)-FE	yes	yes	yes	yes
Pseudo R^2	0.2205	0.2224	0.2464	0.2468
N	4,937	4,937	4,456	4,456

Source: German Job Vacancy Survey 2005-2008.
Robust standard errors in brackets. ** indicates $p < 0.01$; * $p < 0.05$.

Table A.4: **Worker characteristics (descriptive statistics)**

	Characteristics of non-employed actively searching individuals		
	all	via the PEA	without the PEA
number of search channels	3.3	3.6	2.2
PEA (search channel)	75.5%	100%	0%
Job ads (search channel)	83.0%	85.5%	75.1%
Internet (search channel)	62.0%	64.9%	53.2%
Network (search channel)	72.4%	73.4%	69.3%
Speculative appl. (search channel)	35.1%	38.4%	24.8%
registered unemployed	85.8%	90.9%	70.2%
female	50.6%	47.8%	59.0%
age	38.3 yrs	38.0 yrs	39.4 yrs
work experience (full-time)	10.7 yrs	10.8 yrs	10.4 yrs
work experience (part-time)	1.6 yrs	1.5 yrs	1.8 yrs
unemployment experience	3.4 yrs	3.4 yrs	3.6 yrs
inadequate education	2.8%	2.8%	2.9%
general elementary	15.8%	15.6%	16.2%
middle vocational	55.7%	55.6%	56.2%
vocational & high school	4.3%	4.3%	4.4%
higher vocational	5.6%	6.5%	2.9%
higher education	12.2%	11.8%	13.4%

Source: German Job Vacancy Survey 2005-2007.
Weighted averages using sampling weights.

Table A.5: **The influence of the PEA search channel on search behavior**

	OLS	Probit Regressions: Marginal Effects			
	nr. of search channels	job ads	internet	personal network	speculative applications
All non-employed job seekers					
PEA (used as search channel)	1.2644** (0.0701)	0.0651 (0.0354)	0.0894** (0.0298)	0.0622 (0.0334)	0.0720* (0.0295)
registered unemployed	0.2521** (0.0936)	0.1290* (0.0591)	-0.0200 (0.0399)	0.0414 (0.0378)	0.1008** (0.0389)
female	-0.0211 (0.0670)	0.0268 (0.0263)	-0.0052 (0.0294)	-0.0320 (0.0300)	-0.0062 (0.0285)
age	0.0056 (0.0061)	0.0026 (0.0026)	-0.0039 (0.0029)	0.0054 (0.0031)	0.0011 (0.0028)
work experience (full-time)	-0.0062 (0.0063)	-0.0002 (0.0025)	-0.0016 (0.0029)	-0.0018 (0.0028)	-0.0024 (0.0029)
work experience (part-time)	0.0086 (0.0097)	0.0109 (0.0066)	0.0009 (0.0048)	0.0003 (0.0045)	0.0009 (0.0045)
unemployment experience	-0.0233* (0.0098)	-0.0055 (0.0045)	-0.0084 (0.0045)	0.0006 (0.0044)	-0.0109* (0.0044)
general elementary	0.1205 (0.1416)	-0.0131 (0.0472)	0.0472 (0.0580)	0.0062 (0.0557)	0.1008 (0.0594)
middle vocational	0.4238** (0.1290)	0.0874 (0.0564)	0.1614** (0.0529)	0.0637 (0.0550)	0.1148* (0.0547)
vocational & high school	0.6606** (0.1745)	0.1383 (0.0884)	0.4164** (0.0841)	-0.0420 (0.0734)	0.2034** (0.0756)
higher vocational	0.4810* (0.1866)	0.0501 (0.0708)	0.3405** (0.0804)	0.0039 (0.0744)	0.1038 (0.0778)
higher education	0.6948** (0.1571)	0.0870 (0.0663)	0.4273** (0.0667)	0.0593 (0.0666)	0.1653* (0.0655)
Non-employed, not-registered job seekers					
PEA (used as search channel)	1.2447** (0.2080)	0.0529 (0.0823)	0.1146 (0.0758)	0.0381 (0.0827)	0.0737 (0.0751)
female	-0.3411 (0.2543)	-0.0539 (0.0961)	-0.0705 (0.0983)	-0.0214 (0.0911)	-0.1808* (0.0810)
age	0.0058 (0.0151)	0.0062 (0.0072)	-0.0166** (0.0063)	0.0132 (0.0071)	0.0015 (0.0067)
work experience (full-time)	0.0038 (0.0194)	-0.0005 (0.0091)	0.0118 (0.0085)	-0.0003 (0.0090)	-0.0043 (0.0084)
work experience (part-time)	0.0159 (0.0267)	0.0059 (0.0128)	0.0118 (0.0108)	0.0046 (0.0103)	-0.0032 (0.0100)
unemployment experience	-0.0231 (0.0410)	-0.0036 (0.0188)	-0.0085 (0.0180)	-0.0099 (0.0207)	-0.0071 (0.0196)
general elementary	0.4760 (0.3811)	-0.0192 (0.1504)	0.4053** (0.1456)	0.0961 (0.1531)	0.1096 (0.1381)
middle vocational	0.6647 (0.3614)	0.1434 (0.1498)	0.4820** (0.1440)	0.0694 (0.1520)	0.1192 (0.1344)
vocational & high school	0.2933 (0.5493)	0.0486 (0.2179)	0.3088 (0.2163)	-0.1426 (0.2228)	0.1805 (0.1924)
higher vocational	0.0124 (0.6021)	-0.1239 (0.2243)	0.2853 (0.2195)	-0.0563 (0.2262)	0.0047 (0.2072)
higher education	0.5007 (0.5473)	-0.0075 (0.1932)	0.4887* (0.1909)	0.0813 (0.1998)	0.0761 (0.1787)
year-, occup.-FE	yes	yes	yes	yes	yes
R^2	0.3632	0.0793	0.0998	0.0496	0.0714
N (all non-employed)	1,579	1,347	1,413	1,442	1,454
N (non-empl., not reg.)	242	170	175	177	174

Source: German Socio Economic Panel 2005-2007.
Robust standard errors in brackets. ** indicates $p < 0.01$; * $p < 0.05$.

Table A.6: **The effect of using the PEA on the hazard of hiring a worker**

| | Cox-Proportional Hazard Model: Hazard ratios | | | |
| | Time-constant PEA effect | | Time-varying PEA effect | |
	(1)	(2)	(3)	(4)
PEA (time-constant)	1.0239	(0.0342)		
PEA (15 to 11 weeks prior)			0.8536	(0.1759)
PEA (11 to 7 weeks prior)			0.9492	(0.1286)
PEA (7 to 3 weeks prior)			0.9835	(0.0740)
PEA (3 prior to 1 week after)			0.9971	(0.0526)
PEA (1 to 5 weeks after)			1.0541	(0.0876)
PEA (5 to 9 weeks after)			1.3941*	(0.1906)
PEA (9 to 13 weeks after)			1.3964	(0.2785)
PEA (13 to 17 weeks after)			1.0732	(0.2536)
BLH (15 to 11 weeks prior)	0.2863**	(0.0362)	0.3296**	(0.0504)
BLH (11 to 7 weeks prior)	0.3879**	(0.0418)	0.4329**	(0.0570)
BLH (7 to 3 weeks prior)	0.8869	(0.0845)	0.9794	(0.1143)
BLH (3 prior to 1 week after)	2.0439**	(0.1872)	2.2477**	(0.2526)
BLH (1 to 5 weeks after)	1.4086**	(0.1343)	1.5143**	(0.1805)
BLH (5 to 9 weeks after)	0.9059	(0.0979)	0.8537	(0.1215)
BLH (9 to 13 weeks after)	0.7963	(0.1027)	0.7513	(0.1305)
BLH (13 to 17 weeks after)	0.7721	(0.1089)	0.8228	(0.1503)
low qualification	0.9949	(0.0537)	1.0013	(0.0541)
high qualification	0.8597**	(0.0373)	0.8599**	(0.0373)
occupation specific exp.	0.9794	(0.0364)	0.9794	(0.0364)
permanent	0.9537	(0.0317)	0.9481	(0.0316)
full-time	0.9413	(0.0420)	0.9432	(0.0421)
weekend-work	0.9634	(0.0468)	0.9625	(0.0468)
firm-size (log)	1.0204	(0.0130)	1.0211	(0.0130)
"financial constraints"	1.0182	(0.0834)	1.0204	(0.0836)
"low sales"	0.8961	(0.0508)	0.8970	(0.0508)
"skilled labor shortage"	0.6404**	(0.0291)	0.6396**	(0.0291)
industry-, region-FE	yes		yes	
N	4,041		4,041	

Source: German Job Vacancy Survey 2014.

"BLH" denotes the Hazard ratio of searching in the respective period. It can be interpreted as a baseline hazard around the initial starting date.

Robust standard errors in brackets. ** indicates $p < 0.01$; * $p < 0.05$ difference from 1.