Gutenberg School of Management and Economics

& Research Unit “Interdisciplinary Public Policy”

Discussion Paper Series

Does the internet increase the job finding rate? Evidence from a period of internet expansion

Manuel Denzer, Thorsten Schank, Richard Upward

August 2018

Discussion paper number 1807

Johannes Gutenberg University Mainz
Gutenberg School of Management and Economics
Jakob-Welder-Weg 9
55128 Mainz
Germany
wiwi.uni-mainz.de

Contact Details:

Manuel Denzer
Chair of Statistics and Applied Econometrics
Johannes Gutenberg-University
Jakob-Welder-Weg 4, 55128 Mainz
Germany
manuel.denzer@uni-mainz.de

Thorsten Schank
Chair of Statistics and Applied Econometrics
Johannes Gutenberg-University
Jakob-Welder-Weg 4, 55128 Mainz
Germany
schank@uni-mainz.de

Richard Upward
School of Economics
Sir Clive Granger Building University Park
NG7 2RD Nottingham
Great Britain
richard.upward@nottingham.ac.uk

Does the internet increase the job finding rate? Evidence from a period of internet expansion*

Manuel Denzer†
Johannes Gutenberg-University Mainz

Thorsten Schank‡
Johannes Gutenberg-University Mainz, IWH and IZA

Richard Upward§
University of Nottingham, IWH

August 20, 2018

Abstract

We examine the impact of household access to the internet on job finding rates in Germany during a period (2006–2009) in which internet access increased rapidly, and job-seekers increased their use of the internet as a search tool. During this period, household access to the internet was almost completely dependent on connection to a particular technology (DSL). We therefore exploit the variation in connection rates across municipalities as an instrument for household access to the internet. OLS estimates which control for differences in individual and local area characteristics suggest a job-finding advantage of about five percentage points. The IV estimates are substantially larger, but much less precisely estimated. However, we cannot reject the hypothesis that, conditional on observables, residential computer access with internet was as good as randomly assigned with respect to the job-finding rate. The hypothesis that residential internet access helped job-seekers find work because of its effect on the job search process is supported by the finding that residential internet access greatly increased the use of the internet as a search method. We find some evidence that household access to the internet reduced the use of traditional job search methods, but this effect is outweighed by the increase in internet-based search methods.

JEL classification: J64, C26, L86

Keywords: Job search, unemployment, job finding rate, internet, DSL

---

*We are very thankful to Mark Trappmann and his department to give us on-site access to the PASS data at the Institute for Employment Research (IAB) and to Stefan Schwarz for running our do-files. We also thank Oliver Falck and Andreas Mazat for providing us their data-set on broadband access by municipality. We gratefully acknowledge comments on our paper by Maya Bacache, Oliver Falck, Konstantin Wacker and Reyn van Ewijk as well as further comments received during presentations at an IfO workshop on the Economics of Digitization (2017, Munich), at the 10th Paris Conference on Digital Economics and at seminars at the Universities of Mainz and Tübingen.

†Gutenberg School of Management and Economics, Jakob-Welder-Weg 4, 55128 Mainz, ✉ manuel.denzer@uni-mainz.de

‡Gutenberg School of Management and Economics, Jakob-Welder-Weg 4, 55128 Mainz, ✉ schank@uni-mainz.de (corresponding author)

§School of Economics, Sir Clive Granger Building University Park, NG7 2RD Nottingham, ✉ richard.upward@nottingham.ac.uk

1 Introduction

Since the late 1990s, the internet has transformed the ways in which job-seekers look for work and the ways in which they contact potential employers. It has also changed the ways in which employers advertise positions, search for and screen suitable applicants. During the 2000s in Germany (the setting for this paper) the proportion of households with high-speed internet access increased from less than 10% to over 80%.[1] Survey evidence shows that over this period job-seekers and employers both increased their use of online search technologies.[2] The internet seems to offer a number of significant advantages as a search and matching technology (Autor, 2001). It allows job-seekers to search more quickly for a larger number of vacancies over a wider geographical area, while also allowing them to search and screen for vacancies which meet certain characteristics. It allows applicants to contact employers and make multiple applications more quickly and at much lower cost. It also allows the creation of information networks which enable job-seekers to broadcast their skills and availability to potential employers. In an environment where not everyone has access to this new technology (as in the 2000s in Germany), we expect that job-seekers who have access will have advantages and better job search outcomes compared to those who do not. Better job search outcomes will imply shorter unemployment durations if the benefits of the new technology do not increase reservation wages sufficiently to outweigh the increased rate at which job opportunities can be located.

A number of empirical studies have examined whether searching for a job on the internet is more effective than traditional job search methods. We review these studies in Section 2. A key issue is the endogeneity of the choice of search method. More recent papers in this literature have attempted to solve the endogeneity problem by using the timing and location of internet availability as an instrument for the use of the internet as a search method. In this paper we also use the process of internet expansion to measure the causal impact of the internet on the job-finding rate of the unemployed. We use a relatively new survey of unemployed job-seekers in Germany which provides information on individual access to the internet, job search methods and job search outcomes. But, in contrast to other papers in this literature, we ask a simpler but distinct question: does having access to the internet at home increase the job finding rate?

There are a number of reasons why focussing on this question is interesting: if we were to allocate a computer with internet access to a group of unemployed job-seekers, would those allocated a computer have a higher job finding rate than those not allocated a computer? In contrast, it is difficult to imagine a policy which allocated a search method: by definition, search methods will be chosen on the basis of their expected costs and benefits which makes the average treatment effect on the treated (ATT) a less interesting value, since further expansion of the technology will tend to impact on those with lower benefits. The second advantage is that we use a very straightforward survey question with a simple answer less likely to be affected by

[1] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_h&lang=en, accessed on May 24th 2018.

[2] Own calculations of job-seekers' search methods based on the German Socio Economic Panel (GSOEP) and counts of establishments' search methods obtained from http://fdz.iab.de/en/FDZ_Establishment_Data/IAB_Job_Vacancy_Survey.aspx, accessed on May 24th 2018.

measurement error. Instead of requiring survey respondents to recall what methods they used to search for a job, and whether they used the internet to do so, the question we use is just "do you have a computer at home with internet access?" The third advantage of focusing on computer access with an internet connection rather than search methods is that search methods may be complementary with internet access, as noted by Kuhn and Skuterud (2004, p. 223). For example, traditional search methods such as "contacting employers directly" or "answering advertisements in newspapers" may be made more effective with internet access.[3] Since we wish to measure the total benefit of internet access on search outcomes, it seems natural to consider internet access as our treatment and particular search methods as intermediate outcomes which are themselves affected by internet access.[4]

Although our research question has advantages, our results do require a different interpretation. First, our estimates should be interpreted as the "intention to treat" effect of having a computer with internet access: it seems likely that some of those who have a computer will not actually use it for job search, either because they are unable to or because it offers no actual benefit. Second, having a computer with internet access may help job-seekers find a job through mechanisms other than job search channels. For example, computer users may learn skills which are valued in the workplace, or internet access may be used as a signal of increased productivity by employers (Bertrand & Mullainathan, 2004). Our research question is also inherently partial equilibrium in nature. Finding that job-seekers with internet access have better job search outcomes than those without does not necessarily imply that a labour market with internet access has a higher matching rate than one without. In the extreme case, if the new technology does not increase the aggregate matching efficiency, but merely re-allocates which job seekers are successful in finding matches, access to the new technology will be beneficial to those that have it only insofar as others do not have access (Fountain, 2005). Finding that there is an individual effect is a necessary but not sufficient condition for establishing that the technology increases the matching rate overall.[5]

Figure 1 shows the key technological developments which occurred in Germany in the 2000s which we exploit in our analysis. In panel (a) we plot the share of households in Germany with a broadband internet connection, which increased from about 10% in 2003 to nearly 80% in 2010. During this period, access to broadband internet was essentially only possible via a technology called *Digital Subscriber Line* (DSL), which was first made available to subscribers in Germany in 1999 (Kopf, 2012). In panel (b) we plot the number of broadband subscriptions which shows

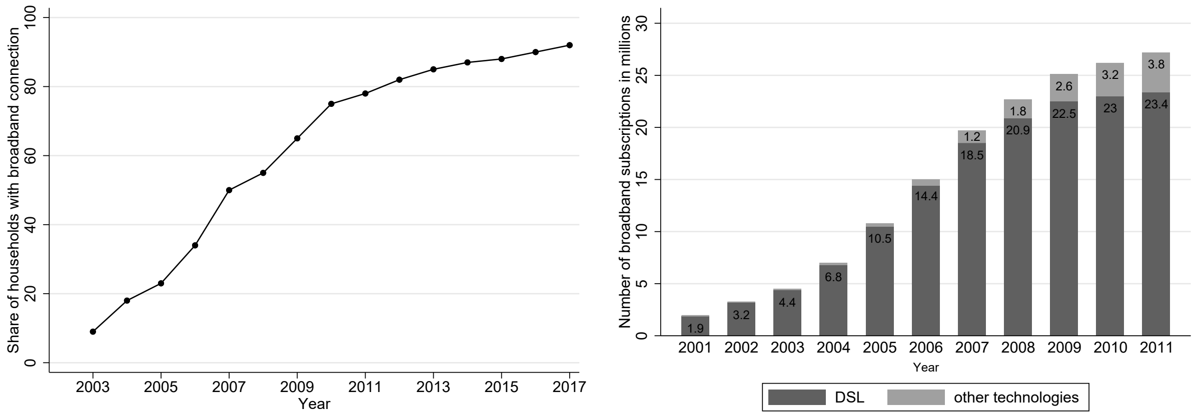
[3] Stevenson (2009, Table 2.4) shows that internet penetration in the US was associated with increases in all types of job search activity of the unemployed.

[4] Stevenson (2009, p. 81) argues that "An additional benefit of comparing Internet users with nonusers is that it captures the total net effect of using the Internet on . . . flows, regardless of whether a worker perceives him- or herself to be actively searching online."

[5] The availability of massively more information about job-seekers and job vacancies may not necessarily increase aggregate matching efficiency. In a non-online market, the matching friction may primarily be the result of the difficulty in finding out about the existence of potential matches e.g. a job may be available but the job-seeker is unaware of it. In an online market the job-seeker may be able to find all potential partners very easily; the friction then relates to the problem of being able to select a suitable match from a greatly increased pool of applicants. Autor (2001) notes that *excess applications* may be an issue, and provides some anecdotal evidence that pools of job-seekers on online job matching services may be negatively selected.

Figure 1: Access to the internet in Germany increased rapidly in the 2000s

(a) Share of households with broadband connection **(b)** Number of broadband subscriptions in millions



Source: Eurostat

Source: Breitbandatlas Deutschland

that almost all access to broadband was via DSL. At the same time period, the proportion of job-seekers using the internet as a job-search method increased considerably.[6]

The crucial feature of DSL we exploit is the fact that this technology was not available to all households at the same time. We use data on availability of DSL at the municipality level as an instrument for household access to a computer with internet.[7] As noted by Falck et al. (2014, p. 2245), key features which determined DSL availability included technological peculiarities such as the location of buildings which were determined in the 1960s during the roll-out of public switched telephone network. We show that DSL availability is a strong predictor of whether a household has a computer with internet access, and we argue that DSL availability is also plausibly exogenous with respect to the job-finding rate of unemployed job-seekers since we control for a set of observable local area characteristics like the employment rate, the unemployment rate and its change, the density of firms, population density, surface area, pupil shares by education level and GDP per capita.

A further distinguishing feature of our study is that we consider the job-finding behaviour of a group of relatively disadvantaged job-seekers. The survey we use (described fully in Section 4) oversamples job-seekers who have exhausted all savings, assets and other state transfers (such as insurance based unemployment benefit) and who are eligible for minimal means-tested benefits.[8] In this sample, job-finding rates are very low: only 30% of the sample interviewed in year t are in employment a year later.[9]

Nevertheless, we find that there are large differences in employment rates between those who have a computer with internet access and those who do not. Those who have the internet at home

[6]Own calculations based on the GSOEP and the PASS show that the (weighted) share of (unemployed) job-seekers using the internet for job search increased from 33% in 2003 to 73% in 2015.

[7]This data was previously used by Falck, Gold, and Heblich (2014).

[8]These benefits are known as "UB II"; see Trappmann, Beste, Bethmann, and Müller (2013).

[9]Calculations using the GSOEP for Germany over the same period suggest that the annual job-finding rate of all unemployed job-seekers is 41%.

have a job finding rate some nine percentage points larger than those who do not. OLS estimates which control for differences in observable individual and local area characteristics suggest a job-finding advantage of about five percentage points. The IV estimates are substantially larger, but much less precisely estimated. However, we cannot reject the hypothesis that, conditional on observables, individual computer access was as good as randomly assigned with respect to the job-finding rate. To relate our results back to the conventional question considered in the literature, we show that having a computer at home is indeed strongly related to the use the internet as a search method. This reassures us that having a computer at home with internet access is an important tool for internet job search.

In Section 2 we review the existing empirical literature on the effect of the internet on individual job search outcomes. In Section 3 we explain the methods we use, and in Section 4 we describe our data and provide some descriptive statistics. Our results are reported in Section 5 and Section 6 concludes.

2 Literature

Empirical studies on the effect of the internet on job search can be divided into two groups. The first group typically tries to estimate the effect of "using the internet to search for a job" on individual employment outcomes. The second group estimates the effect of "internet availability" on employment rates at some aggregated geographical level. In this review we focus on the estimation of individual employment outcomes, but it is worth noting that the second group of studies fails to consistently find a positive effect of internet availability on the matching rate or the employment rate.[10] In fact, there seems to be little evidence of any increase in matching efficiency over the 2000s, a period during which online job search became widespread. Hall and Schulhofer-Wohl (2015), for example, find that there has actually been some decline in matching efficiency for the US over the period 2001–2013 after taking into account changes in the composition of job-seekers.

A series of papers from the United States use the Current Population Survey (CPS) from the late 1990s and early 2000s (Kuhn & Skuterud, 2004; Fountain, 2005; Stevenson, 2009; Choi, 2011; Dettling, 2017). The CPS *Computer and Internet Use Supplements* ask job-seekers to report various different "traditional" search methods and in addition, respondents are asked whether they regularly use the internet to search for jobs. These papers typically consider a sample of individuals who are unemployed at the time of the survey and estimate the probability of employment in subsequent surveys. Kuhn and Skuterud and Fountain find small positive effects of internet search use on the probability of employment (Kuhn and Skuterud's estimates range from 3 to 6 percentage points), but they are not significantly different from zero.[11] Kuhn and Skuterud also

[10] The second group of studies include Gillett, Lehr, Osorio, and Sirbu (2006), Crandall, Lehr, and Litan (2007), Atasoy (2013) and Kroft and Pope (2014) for the US and Fabritz (2013), Czernich (2014) and Gürtzgen, Nolte, Pohlan, and van den Berg (2018) for Germany.

[11] Fountain splits the sample between two different years and finds a strong positive effect in 1998 but a strong negative effect in 2000. She argues that this is consistent with the theory that internet search becomes less

estimate duration models and find that, after controlling for observable characteristics, internet search is actually associated with longer unemployment durations. Kuhn and Mansour (2014) revisited Kuhn and Skuterud's findings using a later period (2005–2008) and a different data set, the National Longitudinal Survey of Youth. They find that the earlier positive relationship between internet search use and unemployment duration is reversed in the later period and argue that internet search use became more effective over time. Stevenson (2009) uses the same CPS supplements, but instead estimates employment outcomes for employed job-seekers. She finds that employed job-seekers who used the internet to find their current job are 15 percent more likely to change their employer in the following month.

As has been widely noted in this literature, these estimates may be biased if the choice of search method is related to unobserved determinants of the job finding rate. Choi (2011) constructs an instrument based on computer use at the occupation level.[12] Using this instrument increases the estimated size of the treatment effect, but the estimates are even less precise and again not significantly different from zero. The most recent paper to use the CPS is Dettling (2017). In contrast to the earlier literature, Dettling estimates the effect of "internet availability in the home" on the labour force participation rate. She instruments internet availability with pre-existing state-level housing structure, on the basis that the roll-out of high-speed internet was substantially cheaper to multiple-dwelling units (MDUs). She is able to show that MDUs had no effect on labour supply in the pre-internet period, giving some credence to the idea that MDUs only affected labour supply via their effect on internet availability. Dettling finds no effect of high speed internet availability on labour force participation overall, but does find a positive effect for women of about 3.5 percentage points.

There are four relevant papers which consider the case of Germany, three of which use the German Socio Economic Panel (SOEP). Thomsen and Wittich (2010) and Suvankulov, Lau, and Chau (2012) both use samples of unemployed job-seekers and estimate the effect of internet search on the probability of employment in the following year. In contrast to the US studies, the measure of internet job search used is one of six possible job search channels.[13] These papers therefore estimate what Kuhn and Skuterud call the "direct effect" i.e. the effect of internet job search holding other search methods constant. This may be considerably smaller than the total effect if the internet is complementary to traditional search methods. Nevertheless, their results are consistent with the findings from the US: those who use internet to search for jobs have a slightly higher re-employment probability (by about 4 percentage points), but the estimate is imprecise and the null of no effect cannot be rejected. Suvankulov et al. also estimate a model in which internet use is instrumented with its within-person deviation (i.e. a Hausman-Taylor estimator). Using this method increases the estimate to about 7 percentage points, and also increases the significance level at which the null can be rejected. Mang (2012) is the third German study, but considers as an outcome match quality rather than the probability of employment. Mang considers recent job-changers, and finds that those who reported using the internet to

effective as it becomes more widely used.

[12] However, it is not made clear exactly how unemployed job-seekers are associated with particular occupations.

[13] The other five are "traditional" job search channels such as personal contacts and direct applications.

find their new job have significantly higher self-reported job satisfaction measures. However, the measurement of search methods in this paper is quite different to that used in the rest of the literature, because those who have found a job recently are asked "How did you find out about your new job" and are required to choose one method only. Most recently, Gürtzgen et al. (2018) use the Labour Market and Social Security Panel Study (PASS) survey to show that availability of the internet at home increases online job search.

To summarise, we are still lacking clear evidence on the effectiveness of the internet as a job-finding tool. The bulk of the evidence for the US comes from a single survey which has rather small samples of job-seekers, and does not allow for the likely endogeneity of search method. The results we have for both the US and Germany are consistent with a small positive effect, but these estimates are imprecise. Furthermore, the existing German evidence from the SOEP does not allow one to disentangle the overall effect of internet availability from the partial effect of using the internet as a search method, holding other search methods fixed. Finally, there is some ambiguity about the relationship between the internet as a search method and the availability of the internet. Kuhn and Skuterud argue that internet access in itself does not have a causal effect on the job-finding rate, and suggest that it should instead be treated as a control variable. In contrast, it seems possible that access to the internet can have a causal effect on the job-finding rate because it is a well-defined tool which allows job-seekers to use a range of search methods more effectively, and which may also change job-seekers' productivity and preferences.

3 Concepts and methods

In this paper, we wish to measure the causal effect of residential internet access on job finding rates. As explained in the introduction, in contrast to most of the earlier work discussed in the previous section, our focus is on the effect of access to the internet at home rather than on the effect of particular job search methods. We do this because the thought experiment and policy implication are clearer, the data are more likely to be accurate, and the result is more likely to capture the "total" effect of internet access to the individual.

There are two further practical reasons for focusing on the effect of access to the internet at home. The first is that the survey we use does not unambiguously distinguish between search methods which actually use the internet and those which do not. For example, a search method such as "reading advertisements in a newspaper" might possibly include the use of newspaper websites, or responding to newspaper advertisements using email or forms on a website.[14] The second practical advantage is that only those who are actually unemployed and currently searching for employment are asked about methods of search. However, it seems plausible that the availability of the internet might also change the search behaviour of a wider group, including those who are not employed but who at the time of the survey are not actively looking for work or whose current search activity is not known.

[14] The various search methods reported in the PASS data are described in Section 4.

Conceptually, the thought experiment is very simple: if we randomly allocate a computer with internet access to a group of individuals, is the job-finding rate of those who receive a computer higher than those who do not receive a computer? This thought experiment is an "intention to treat" effect, because (as mentioned in the previous paragraph) we do not have precise information on whether the job-seekers are actually using the internet to search for a job since several of the listed methods might involve the internet. Nevertheless, we can check the plausibility of our results by examining the relationship between the intention to treat and the different search methods.

We therefore estimate, for a sample of non-employed persons observed at year t, a linear model of the probability of having job in year $t+1$:

$$\Pr(\text{job}_{it+1} = 1 \mid \text{job}_{it} = 0) = \beta_0 + \beta_1 \text{internet}_{it} + \mathbf{x}'_{it}\boldsymbol{\beta}_2 + \mathbf{z}'_{m(it)}\boldsymbol{\beta}_3 \tag{1}$$

where internet_{it} is a dummy variable taking the value 1 if individual i has internet access at home in year t, and 0 otherwise. The vector $\mathbf{x}_{it}$ comprises a set of personal characteristics which determine the job finding rate and which may also be correlated with the probability of having the internet at home. $\mathbf{z}_{m(i)}$ is a vector of observable characteristics of municipality m in which individual i lives which may also influence the job finding rate. The full list of $\mathbf{x}$ and $\mathbf{z}$ variables is provided in Section 4.

A key problem we face is that having a computer at home with internet access may not be randomly allocated, even after conditioning on observable characteristics. Instead, it seems likely that those who have internet access at home are systematically different in their job finding rates in two ways. First, they may have different pre-existing characteristics. Those who get the internet at home might be more productive, for example. Second, the effect of the internet on the job finding rate might differ across individuals, and those who have a larger positive effect will be more likely to select into the treatment group. We therefore require an instrument which explains whether a person has a computer with internet access at home but which has no direct effect on the job finding rate. Our instrument is the share of households at the municipality level who *could* technically access DSL broadband, reported by the telecommunication operators.[15] As shown in Section 1, at the time under investigation in Germany almost all access to broadband was via DSL; and therefore the share of households with (potential) broadband access is a strong predictor for having a computer at home with internet access.

There are two threats to identification. The first is that DSL availability is not randomly allocated with respect to the baseline job-finding rate in each municipality. This might occur because DSL providers roll out the technology non-randomly. For example, as noted by Falck et al. (2014, p. 2239), it may be more profitable to increase DSL availability in areas with a richer or more highly-educated population. It might also occur if job-seekers choose to relocate on the basis of DSL availability. To deal with this problem of non-randomness, we include as controls a set of municipality and district-level covariates which may have affected the distribution of DSL

[15] Note that this rate is higher than the share of households who actually do have access to DSL broadband, because not every household subscribed to the service.

and the job finding rate as well as (as a robustness check) a dummy variable indicating whether the household moved between years $t-1$ and t.[16] The second threat is that DSL might have direct effects on the job finding rate, for example because availability of DSL increases the job creation rate in a municipality. Our solution to this problem is to additionally control for the change in the municipality level unemployment rate between $t+1$ and t.[17]

4 Data and descriptives

In order to determine the effect of residential internet access on the individual job finding rate, we combine information on households' access to a computer with internet, individuals' job-finding outcomes, the availability of broadband internet in the local area and other characteristics at the individual or the municipality level.

Information on households' access to a computer at home and individuals' job finding outcomes come from the PASS survey provided by the Institute for Employment Research (IAB) of the German Federal Employment Agency. The PASS was established in 2006 to evaluate the so-called Hartz reforms. It allows one to investigate diverse topics related to unemployment, deprivation and poverty (Trappmann, Gundert, Wenzig, & Gebhardt, 2010). It has a "dual-frame" sampling design with two subsamples. The first is a random sample of households containing at least one individual receiving unemployment benefits (UB II) in 2006. These are means tested benefits which are received only when insurance-based unemployment benefit has been exhausted, which typically occurs only after 12 months of unemployment. This sample is refreshed each year to include new entries into UB II (i.e. households with at least one benefit unit on the reference date of the current wave and no benefit unit on any of the previous reference dates). The second subsample consists of households drawn from the general population residing in Germany with an oversampling of low social status areas.[18] Once interviewed, each individual is followed regardless of household membership. Both subsamples were replenished in wave 5 to account for panel attrition. Each year around 10,000 households and therefore approximately 15,000 individuals are interviewed (Trappmann et al., 2013).

We select observations from wave t if the individual is at the time of the interview non-employed, between 16 and 65 years old and not in education. This group comprises (a) those who are unemployed according to the ILO definition (i.e. non-employed persons who have been actively searching for a job within the last four weeks and who are able and willing to take up an offered job within the next two weeks); (b) those unemployed job-seekers who are not available to take up a job in the next two weeks; (c) those non-employed who are not searching (i.e. the "inactive") and (d) those for whom we do not know whether they search for a job or not. We

[16] We cannot control for municipality fixed effects since the within-variation of our instrument is not sufficient and would lead to very imprecise estimates.

[17] An alternative solution for the first threat is to rely on an instrument which uses the "historical peculiarities" of the telephone network (Falck et al., 2014, p. 2239). However, our sample of job-seekers is heavily weighted towards larger municipalities for which the variation in these historical features is limited.

[18] See Achatz et al. (2007) on how low social status has been identified.

look primarily at group (a), but we also consider all non-employed, i.e. all groups (a)–(d). For this composite group, we expect a smaller treatment effect on the job finding rate because not everyone in this group is actively searching for work. However, it might still be the case that future labour supply (and consequently also the probability to have a job in $t + 1$) depends on whether a currently inactive person has a computer at home with internet.

Our treatment indicator is obtained from the question *If you think of your household, which of the following items do you have? ... Do you have a computer with internet access?* Those respondents who answered that they were actively searching for a job during the last four weeks were also asked *From where have you gathered information on jobs during the past four weeks?* Responses to this question provide us with a set of search methods for each individual. Figure 2 shows the use of each of these search methods between 2007 and 2016. There are two search methods which unambiguously require the internet, which are the *employment agency's online job market* shown in panel (b) and *other internet sources* shown in panel (c).[19] It is apparent that searching *other internet sources* is the only method which has been increasing during our period of investigation, albeit moderately. As we noted in the introduction, the use of these different search methods as "treatments" which might affect job search outcomes is problematic because any of these search methods might be complementary with (or might actually use) internet access.[20] Hence, we focus on "having a computer at home with internet access" as our main treatment variable. To test the plausibility of our results we also examine the effect of having a computer at home with internet access on the choice of different search methods.

Given the sampling frame described above, our unemployment sample is not representative of all job-seekers. UB II recipients are over-represented, while individuals receiving unemployment insurance are under-represented.[21] In addition, longer spells of unemployment are also oversampled given the nature of a stock sample. This explains why the job finding rate in our sample is low: only 30 percent of the sample who are unemployed at t are in employment a year later. However, Figure 3 shows that the raw effect of the internet access at home on the job finding rate of the unemployed is large (9 percentage points). Although Kuhn and Skuterud (2004) find a similar raw effect of 11.3 percentage points, in their case it implies an increase in the job finding rate from 53.3 to 64.6 percent, so the elasticity in our sample is much larger. As expected, the overall job finding rate of the group of all non-employed is lower (21 percent), but the raw effect of having internet access at home is of similar magnitude (8 percentage points) as for the unemployed.

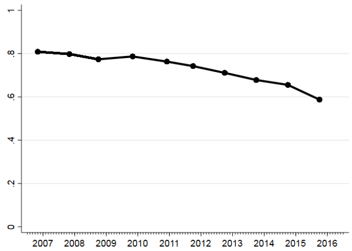
Our instrument is provided by the local provision of broadband infrastructure, which during our period of observation varied across local areas and over time. The source of this information

[19] See https://jobboerse.arbeitsagentur.de/vamJB/anmeldung.html for the current online job portal of the employment agency. About 40 percent of all unemployed job-seekers have used both, the employment agency's online job market and other internet search methods.

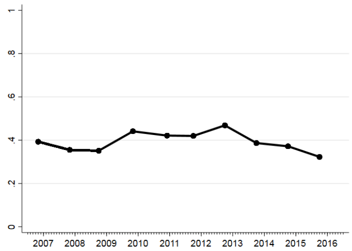
[20] The US NLSY97 survey used by Kuhn and Mansour (2014) asks respondents for search methods in a first step and in a second step for each of them if they used the internet. In contrast, the PASS survey does not make this differentiation explicit.

[21] Unemployment insurance depend on the level of the previous income and are paid (depending on the length of the previous employment) up to one year (which is gradually extended up to 24 months if the person is beyond 50, 55 or 58 years of age).

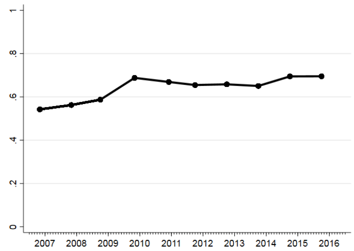
Figure 2: Use of single search methods for the unemployed



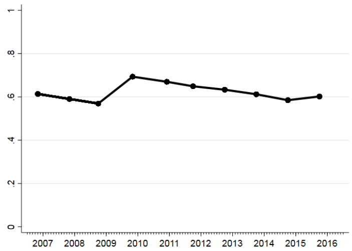
(a) Advertisements in newspapers



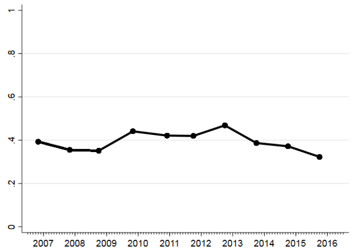
(b) EAs online job market



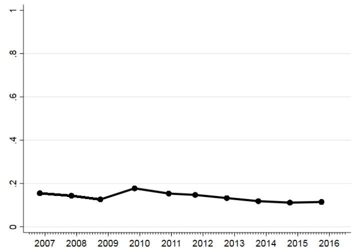
(c) Other internet sources



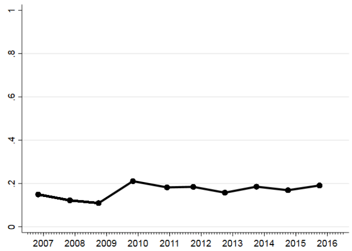
(d) Friends and family



(e) Placement officer at EA

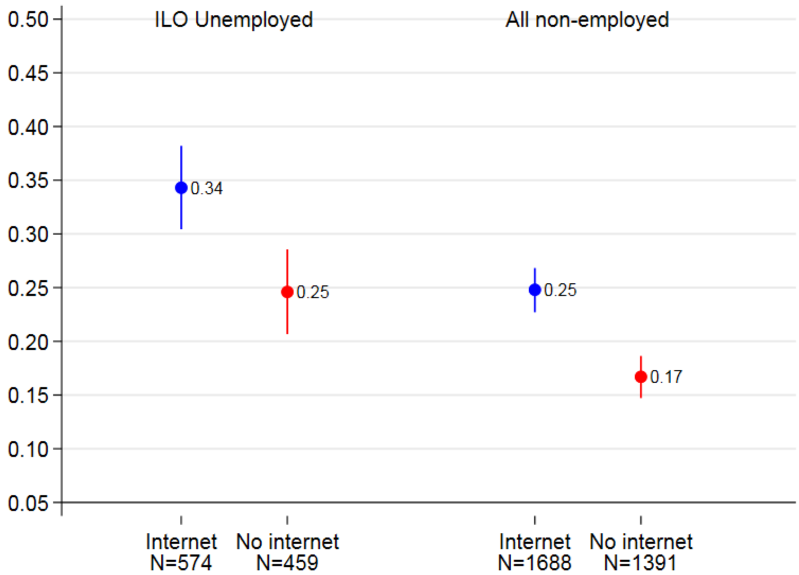


(f) Private job placement services



(g) Others

Figure 3: Probability of employment at $t+1$ conditional on unemployment and non-employment at t



is the *Breitbandatlas Deutschland* published by the Federal Ministry of Transport and Digital Infrastructure (former: Federal Ministry of Economics and Technology). It contains self-reported information by national telecommunication operators on the extent of broadband access[22] via Digital Subscriber Line (DSL) per municipality (*Gemeinde*).[23] There are about 12,300 municipalities in Germany during the years of interest. From this data we have a measure of the fraction of households in each municipality who are able to access the internet via DSL (irrespective of whether or not they actually have subscribed to a DSL connection).[24] The DSL rate can vary between municipalities for two reasons. First, only those who live within a distance of approx. 4.2 km from a main distribution frame (MDF) can in practice gain access to DSL.[25] Second, *Deutsche Telekom* must have upgraded the relevant MDF to provide DSL to connected households. We check whether the fraction of households with potential DSL access in a municipality does indeed increase over time. If the fraction of households with potential DSL access in a municipality decreases by more than 5% between year t and $t+1$, we regard this decrease as unreliable and clean the data by dropping information from that municipality from year t onwards.[26]

Figure 4 plots the distribution of DSL access across municipalities and shows how the distribution develops over the years of interest. A small (declining) fraction of municipalities had no DSL access at all, while the mean proportion of households with access increased from 80% to 90% over this period. The relevance of DSL availability as an instrument for internet access at home is shown in Figure 5, which plots the fraction of households in the PASS survey who report having a computer at home with internet access against percentiles of DSL availability in that household's municipality. The relatively small size of the PASS means that the sample size in each percentile is relatively small, so there is substantial variation across municipalities with the same value for DSL availability. Still, there is strong positive correlation. Unsurprisingly, households in municipalities with low DSL availability are less likely to have a computer at home with internet access.

The availability of broadband infrastructure varies systematically across municipalities with respect to their size and economic characteristics. We therefore also control for a detailed set of municipality or district-level characteristics: the employment rate, the unemployment rate and its change, population density, surface area, pupil shares by education level, the density of firms and GDP per capita. These data come from the *Gemeindeverzeichnis*, the *Statistik Lokal* database and the *Regionalatlas* provided by the German Federal Statistical Office.[27]

[22]Broadband access in this context is defined by the *Breitbandatlas Deutschland* as the possibility of a minimum downstream data transfer rate of 384 kb/s. We believe that this rate was sufficient to use the internet without major time delay given that, at this time, web pages were not particularly sophisticated. This motivates the relevance of our instrument.

[23]Municipality is the lowest level of official territorial division in Germany, ranking after state (*Bundesland*) and district (*Kreis*). Some states also include *Regierungsbezirke* above districts.

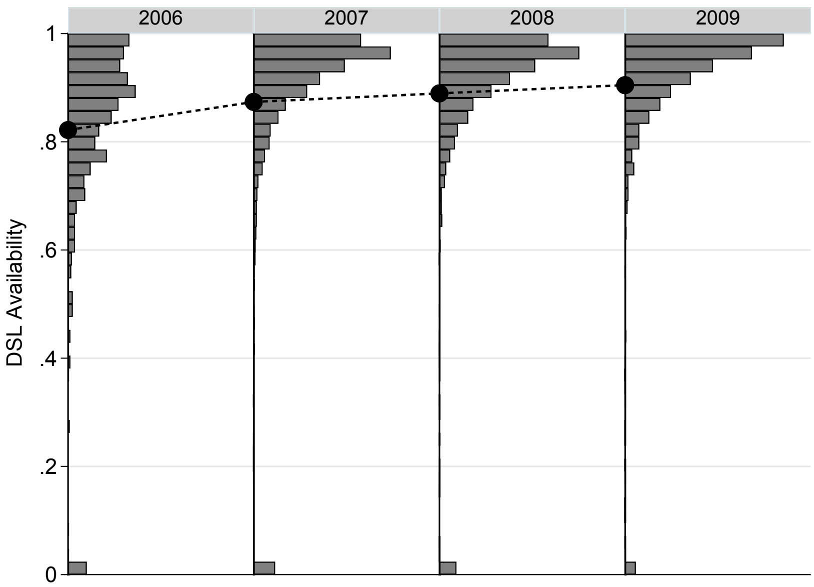
[24]Data for the years 2006–2008 stem from (Falck et al., 2014) and can be downloaded from https://www.aeaweb.org/articles?id=10.1257/aer.104.7.2238; the information for 2009 was provided to us directly by Oliver Falck and Andreas Mazat.

[25]This is due to the technical features of the copper lines used for the "last mile" during the period of interest by the Deutsche Telekom, for instance the diameter. See Falck et al. (2014, p. 2246) for a detailed explanation.

[26]We also check whether the results are robust to cut-offs being at 2% or 10%.

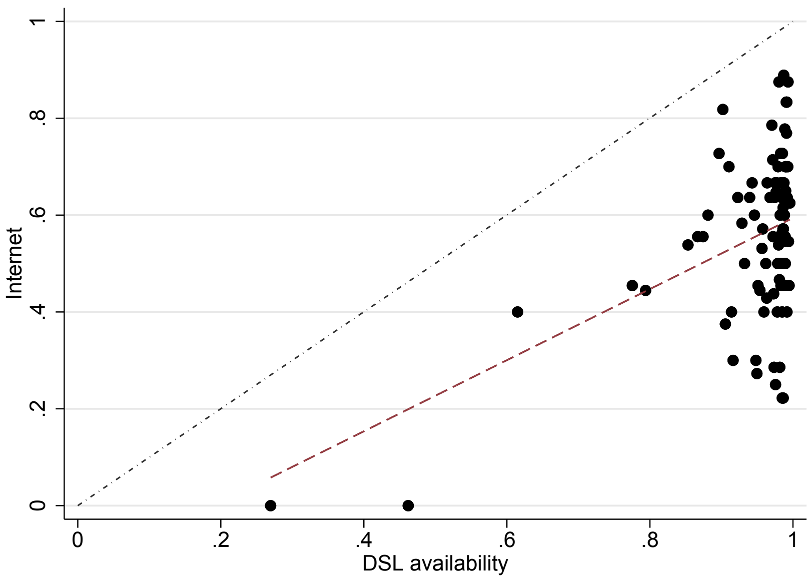
[27]Due to data availability, the data on pupil shares by education level, the density of firms and GDP per capita

Figure 4: Distribution of DSL availability by municipality 2005–2009



The dotted line connects the population-weighted mean availability for each year. This is a modified version of Figure 1 in Falck et al. (2014).

Figure 5: Proportion of households (of unemployed persons) with a computer at home with internet access by percentiles of DSL availability



We merge the PASS data and the municipality-level information on DSL availability and economic characteristics into an individual-level panel from 2006 (when the PASS was carried out for the first time) to 2009 (the last year before there was a break in the measurement of our DSL availability rate).[28] We restrict our sample to observations from municipalities which were not affected by territorial changes at the municipality level over the sample period. After dropping observations with missing values in our instrument (the DSL availability rate), in the covariates and in the dependent variable (which occur if somebody is not observed in the next year) our final regression sample contains 3,079 observations for the non-employed sample and 1,033 observations for unemployed sample. The number of observations which are lost in each step are reported in the Table A1 in the Appendix.[29]

Table 1 provides descriptive statistics of the regression samples. For each sample we report the sample mean and the difference in that mean between those who have access to the internet at home and those who do not. As shown in Figure 3, the mean job-finding rate in both samples is relatively low, but there is a large and significant difference between those with and without a computer of 8–10 percentage points. The second row shows that during the sample period, 55% of both samples have access to the internet at home. The third row gives some indication of the relevance of our instrument. The PASS sample is weighted towards larger urban areas, and so mean DSL availability is high (95%), but there is a significant difference of between 2 and 4 percentage points between those who have a computer at home and those who do not. In rows 4 and 5 we report the proportion of the sample who search using the internet and who use the employment agency's online job market (this information is only available for the unemployed sample). There is a very large difference in these proportions between those who have a computer at home with internet access and those who do not, which supports our claim that having a computer at home does enable online search. Note that online job search is undertaken by some of those who do not have a computer at home, which presumably reflects the fact that the internet can be used outside the household.

The remaining rows in Table 1 report individual and municipality-level characteristics. Unemployed job-seekers who have access to the internet at home are significantly more likely to be married, to be migrants; to live in Western Germany; to own their own home; to have a university degree and are less likely to be unskilled (to have neither an apprenticeship nor a university degree). Those with access to a computer at home also have significantly shorter elapsed unemployment duration at the time of the interview. Note that the mean unemployment duration is over 3 years, confirming that this is a sample which over-represents disadvantaged job-seekers. Municipality characteristics also differ between those with internet access at home and those without. Those with internet access live in more densely populated municipalities with a higher GDP per capita and a lower unemployment rate. On average the unemployment rate is reducing

are at the district (*Kreis*) level. The remaining local area controls are at the municipality level.

[28] To be more precise, there was a change in the method and the executive field institute of the *Breitbandatlas Deutschland* in 2010. Therefore, it is impossible to use data on broadband availability stemming from this data source from both sides of the cutoff at the same time.

[29] Technical notice: Since the municipality identifier for the PASS observations is confidential, the individual panel data set can only be accessed on-site at the IAB in Nuremberg.

Table 1: Sample means and sample mean differences between subgroups of households with and without internet access by labor force groups

Labor force group	Unemployed		All non-employed	
	Mean ($\bar{x}$)	Difference: $\bar{x}(internet = 1)$ - $\bar{x}(internet = 0)$	Mean ($\bar{x}$)	Difference: $\bar{x}(internet = 1)$ - $\bar{x}(internet = 0)$
Variables of interest				
Employed in $t+1$ (dummy:1=yes)	0.300	0.097***	0.211	0.081***
Internet (dummy:1=yes)	0.556	1.000	0.548	1.000
DSL availability	0.946	0.036***	0.952	0.020***
Search via other internet sources (dummy:1=yes)	0.590	0.418***		
Search via empl. agency's onl. job market (dummy:1=yes)	0.547	0.228***		
Individual characteristics				
Female (dummy:1=yes)	0.484	−0.023	0.595	0.070***
Cohabitation (incl. marriage) (dummy:1=yes)	0.264	0.158***	0.376	0.179***
Children with Age: 0-5 (dummy:1=yes)	0.058	0.026*	0.084	0.030***
Children with Age: 6-14 (dummy:1=yes)	0.238	0.135***	0.268	0.175***
Children with Age: 15-17 (dummy:1=yes)	0.081	0.029*	0.092	0.059***
Migration background (dummy:1=yes)	0.272	0.046*	0.304	0.003
Disabled (dummy:1=yes)	0.154	0.010	0.183	−0.070***
East (incl. Berlin) (dummy:1=yes)	0.156	−0.068***	0.117	−0.057***
Home owner (dummy:1=yes)	0.112	0.057***	0.150	0.106***
Age	42.216	−1.960***	43.753	−4.216***
Unskilled (dummy:1=yes)	0.230	−0.064**	0.304	−0.066***
Apprenticeship (dummy:1=yes)	0.712	0.014	0.635	0.011
University degree (dummy:1=yes)	0.058	0.050***	0.060	0.055***
Duration of unemployment (in years)	3.068	−0.523***		
Regional characteristics				
Unemployment rate (in %)	7.177	−0.445***	6.973	−0.415***
Change in unemployment rate $t-(t-1)$	−0.668	0.134**	−0.643	0.174***
Change in unemployment rate $(t+1)-t$	−0.352	0.065	−0.334	0.084***
Employment rate (in %)	49.334	−0.749	49.581	−1.142*
% of pupils w/o any degree	0.083	−0.003**	0.081	−0.004***
% of pupils w. second. educ. degree	0.632	0.002	0.633	0.005*
% of pupils w. univers. entrace degree	0.266	−0.001	0.265	−0.003
Population density (per km^2)	1274.333	132.582*	1275.323	−11.464
Surface area (in km^2)	184.840	8.751	172.899	−4.968
Number of firms per 1000 inhabitants	36.460	0.022	37.085	−0.917*
GDP per capita	30429.164	1783.667**	31382.591	842.366*
Time controls				
Year 2006 (dummy:1=yes)	0.023	0.003	0.019	−0.003
Year 2007 (dummy:1=yes)	0.338	−0.094***	0.340	−0.089***
Year 2008 (dummy:1=yes)	0.333	0.007	0.321	0.008
Year 2009 (dummy:1=yes)	0.306	0.084***	0.320	0.085***
Month duration between interviews	11.938	0.010	11.915	0.032
Observations	1033		3079	
Number of individuals	828		2052	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Migration background is defined such that either the observed individual itself or one of his/her parents or grandparents migrated to Germany. Disabled means the the observed individual has at least one officially recognized handicap or applied for a corresponding recognition. An individual is defined as unskilled if he/she neither completed an apprenticeship nor holds a university degree.

over time, but at a slightly lower rate for those with internet access at home. Differences in mean characteristics are generally similar for the sample of all non-employed, with the exception that non-employed who have access to the internet are significantly more likely to be female, significantly less likely to be disabled and considerably younger.

5 Results

In Table 2 we report our main results, which are estimates of β_1 from Equation (1) for the samples of unemployed job-seekers and all non-employed. Estimates of the coefficients $\boldsymbol{\beta}_2$ and $\boldsymbol{\beta}_3$ for the control variables are reported in Table A2 in the Appendix. For each sample we report the OLS estimate and the 2SLS estimate which uses the availability of DSL at the municipality level as an instrument. Compared to the raw difference shown in Figure 3, the inclusion of control variables reduces the estimated treatment effect from 0.097 to 0.059 for the unemployed sample, consistent with the view that characteristics associated with higher job-finding rates are also positively associated with having access to the internet at home. Hence, the OLS estimate is consistent with the earlier finding for the US from Kuhn and Skuterud (2004), although their estimates had wider confidence intervals which included zero. Our estimate is also consistent with the more recent studies from Germany (Thomsen & Wittich, 2010; Suvankulov et al., 2012). Note, however, that all three of these previous results are estimates of the effect of internet search on employment outcomes, rather than access to the internet at home. The estimated treatment effect for the larger sample of all non-employed is very similar but more precisely estimated. Of the control variables $\mathbf{x}_{it}$ (shown in Table A2) we find that females, younger workers and workers with shorter unemployment durations at t are significantly more likely to find employment by $t+1$. Of the municipality-level variables $\mathbf{z}_{m(it)}$ the level and change in the unemployment rate has a significant negative association with the job-finding rate, as expected.

Table 2: Effects of having internet at home in t on being employed in $t+1$

LABOR FORCE GROUP	Unemployed			All non-employed		
	OLS	**2SLS**		**OLS**	**2SLS**	
		Second stage	**First stage**		**Second stage**	**First stage**
Internet (dummy:1=yes)	0.059** (0.030)	0.313 (0.260)		0.052*** (0.016)	0.196 (0.203)	
DSL availability			0.686*** (0.143)			0.558*** (0.121)
Observations		1033			3079	
R^2	0.089			0.064		
Kleibergen-Paap Wald F statistic			22.927			21.332
Durbin-Hausman-Wu test p-value	0.396			0.502		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Standard errors reported in parentheses are clustered at the household level for OLS and at the municipality level for IV. Individual characteristics in t, regional characteristics in t as well as month dummies for $t+1$ indicating when the interview took place are included in all regressions. See Table A2 for the complete regression table.

We now turn to the IV estimates. If access to the internet at home were entirely dependent on DSL availability, and if all those with DSL availability chose to use it, then this first-stage coefficient would be equal to one. The first stage coefficient on DSL availability is large (between 0.6 and 0.7) but significantly less than one, and has an F-statistic over 20. The estimated treatment effect from the 2SLS model is much larger than the OLS estimate, but also much less precisely estimated (the standard error is nine times larger), meaning that we cannot rule out that the true effect lies within the OLS confidence interval. At the bottom of Table 2 we report the results of the Durbin-Wu-Hausman regression-based test of the exogeneity of the treatment. We cannot reject the null, which is indicative of the imprecision of the IV estimate. The IV results for the larger sample of all non-employed are very similar. The first-stage coefficient is large and highly significant, the second-stage estimate is much larger than the OLS estimate but again imprecisely estimated and we cannot reject the null that, conditional on the control variables, access to the internet at home is exogenous.

We now consider whether the effect of internet access at home on the job-finding rate is driven by choice of job search methods. As noted in the introduction, having a computer at home with internet access may also help job-seekers because it increases their productivity or because it signals higher productivity. To test whether those with a computer at home with internet access do use different job search methods, we estimate Equation (1) but use as a dependent variable indicators for each of the two search methods which unambiguously require the internet, namely accessing the employment agency's online job market and other internet sources (see Figure 2). Note that these indicators are only available for the unemployed sample.

Results are shown in Table 3. The OLS estimate suggests that having a computer at home with internet access increases the use of the search method other internet sources by 39 percentage points. The sample means in Table 1 imply that 36% of those who do not have a computer at home report using the internet as a job search channel, compared to 78% of those who do have a computer at home. This reflects the fact that access to the internet was possible outside the home, for example in libraries or job centres. Instrumenting internet at home with DSL availability increases the estimated effect, but again we cannot reject the null that the treatment is exogenous.[30] The effect of internet at home on the use of the employment agency's online search channel is smaller (about 20 percentage points) but remains highly significant in the OLS specification.

Table 3 is consistent with the argument that having a computer with internet access increases the job finding rate at least partly because of its effect on choice of search methods. A related question is whether access to a computer is beneficial because it changes the type of search methods chosen, or because it increases the total number of search methods. Some evidence on this is provided by Stevenson (2009), who shows that the number of job search methods chosen increases with a state's internet penetration rate. In Table 4 we report estimates of Equation (1) where the dependent variable is replaced with a count of the number of "traditional" job search methods i.e. search methods which do not explicitly mention the internet.

[30] These results are similar to those obtained by Gürtzgen et al. (2018), who use the same data-set, but make use of a bigger sample.

Table 3: Effects of having internet at home in t on researching via internet channels in t

Dependent variable	Other internet sources			Employment agency's online job market		
	OLS	2SLS		OLS	2SLS	
		Second stage	First stage		Second stage	First stage
Internet (dummy:1=yes)	0.389*** (0.032)	0.803*** (0.228)		0.195*** (0.034)	0.110 (0.274)	
DSL availability			0.704*** (0.140)			0.704*** (0.140)
Observations		1033			1033	
R^2	0.227			0.104		
Kleibergen-Paap Wald F statistic			25.245			25.245
Durbin-Hausman-Wu test p-value	0.197			0.743		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Standard errors reported in parentheses are clustered at the household level for OLS and at the municipality level for IV. Individual characteristics in t and regional characteristics in t are included in all regressions. See Table A3 for the complete regression table.

Table 4 shows that internet access at home is associated with a small decline in the number of traditional search methods, suggesting some substitution towards internet search methods. However, our results from Table 3 show that the increase in the use of internet search methods is larger than the decrease in the number of traditional search methods, implying that having a computer with internet access at home increases search intensity overall. IV estimates are similar to OLS, but imprecisely estimated. Appendix Table A5 reports the effect of having a computer at home with internet access on each traditional search method separately. According to the IV-estimates, search via friends and family becomes much less important when a job-seeker has a computer with internet access. Note that for this search method as the dependent variable, the validity of the OLS results is rejected. By contrast, the probability to search via a private job placement rises by 34 percentage points if a person has a computer with internet access. This might simply reflect, however, that the service of a private job agency can be accessed via the web.

Table 4: Effects of having internet at home in t on the number of traditional search methods used in t

	OLS	2SLS	
		Second stage	First stage
Internet (dummy:1=yes)	−0.129* (0.076)	−0.155 (0.349)	
DSL availability			0.704*** (0.140)
Observations		1033	
R^2	0.050		
Kleibergen-Paap Wald F statistic			25.245
Durbin-Hausman-Wu test p-value	0.940		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Standard errors reported in parentheses are clustered at the household level for OLS and at the municipality level for IV. Individual characteristics in t and regional characteristics in t are included in all regressions. See Table A4 for the complete regression table.

6 Conclusion

In this paper we consider whether access to a new technology, namely having a computer with internet access, helps job-seekers to find work. In contrast to much of the existing literature, we do not consider job search methods to be a "treatment", but instead consider how access to the technology changes the choice of search methods and the resulting job-finding rate. We use a detailed survey of disadvantaged job-seekers which covers a period in Germany when access to the internet was increasing rapidly. We apply OLS and IV methods which condition on both individual and local area characteristics which affect the job finding rate and which may be correlated with individuals' access to a computer with internet. To instrument individual computer access, we exploit the local area roll-out of a new broadband technology.

We find that there are large differences in job-finding rates between those who have a computer with internet access and those who do not. OLS estimates which control for differences in observable characteristics still suggest a job-finding advantage of about five percentage points. Our IV estimates show that the roll-out of broadband access was a significant determinant of individual computer access. The IV estimates are substantially larger than the OLS estimates, but much less precisely estimated. However, we cannot reject the hypothesis that, conditional on observables, individual access to the internet was as good as randomly assigned with respect to the job-finding rate. The hypothesis that residential internet access helped job-seekers find work because of its effect on the job search process is supported by the finding that household access to the internet greatly increased the use of the internet as a search method. We find some evidence that residential internet access reduced the use of traditional job search methods, but this effect was outweighed by the increase in internet-based search methods.

Our results indicate that during the period of internet expansion, having a computer with internet access increased the use of internet job search, and at the same time, increased the job-finding rate. In other recent evidence from Germany, Gürtzgen et al. (2018) find a modest positive effect (2%-3%) of internet expansion on the job-finding rate at the municipality level, which suggests that our estimated individual-level treatment effect does translate into an increase in the aggregate matching rate.

A question for future research is whether having a computer with internet access increased the job finding rate through channels other than increased search effectiveness, such as productivity or labour supply preferences. If so, one might expect that the benefit of residential internet access would have varied across groups of job-seekers depending on the productivity effects in their chosen occupations. A second question is whether the internet also changed the job-seeking behaviour of the employed. It seems plausible that internet access greatly reduced the time required to make job applications, in which case the benefits would have been greater for those who are already in employment. This effect would suggest an increase in job-to-job transitions. It also seems possible that internet access might have changed the quality of matches, which might have increased or decreased the job-to-job transition rate. To answer this second question would require data on the search methods of the employed. Further, for more recent years it would also be interesting to see whether the continued diffusion of new technologies such as mobile broadband access and the participation of individuals in social networks have impacted the job finding rate or match quality.

References

Achatz, J., Hirseland, A., Schnell, R., Helmut Rudolph, H., Trappmann, M., Wenzel, U., & Promberger, M. (2007). *Neue Daten für die Sozialstaatsforschung. Zur Konzeption der IAB-Panelerhebung Arbeitsmarkt und Soziale Sicherung* [IAB-Forschungsbericht 12/2007].

Atasoy, H. (2013). The Effects of Broadband Internet Expansion on Labor Market Outcomes. *Industrial & Labor Relations Review*, *66*(2), 315-345.

Autor, D. H. (2001). Wiring the labor market. *The Journal of Economic Perspectives*, *15*(1), 25–40.

Bertrand, M., & Mullainathan, S. (2004). Are Emily and Greg More Employable Than Lakisha and Jamal? A Field Experiment on Labor Market Discrimination. *The American Economic Review*, *94*(4), 991–1013.

Choi, E. J. (2011). *Does the internet help the Unemployed Find Jobs?* [Unpublished paper of the U.S. Bureau of Labor Statistics].

Crandall, R., Lehr, W., & Litan, R. (2007). The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data. *Issues in Economic Policy - The Brookings Institution*, *6*.

Czernich, N. (2014). Does broadband internet reduce the unemployment rate? Evidence for Germany. *Information Economics and Policy*, *29*(C), 32-45.

Dettling, L. (2017). Broadband in the Labor Market: The Impact of Residential High-Speed Internet on Married Women's Labor Force Participation. *ILR Review*, *70*(2), 451-482.

Fabritz, N. (2013). *The Impact of Broadband on Economic Activity in Rural Areas: Evidence from German Municipalities* (No. 166).

Falck, O., Gold, R., & Heblich, S. (2014). E-lections: Voting behavior and the internet. *American Economic Review*, *104*(7), 2238–2265.

Fountain, C. (2005). Finding a Job in the Internet Age. *Social Forces*, *83*(3), 1235-1262.

Gillett, S. E., Lehr, W. H., Osorio, C. A., & Sirbu, M. A. (2006). *Measuring the economic impact of broadband deployment* (Tech. Rep.). MIT. (Final Report Prepared for the U.S. Department of Commerce, Economic Development Administration)

Gürtzgen, N., Nolte, A., Pohlan, L., & van den Berg, G. J. (2018). *Do digital information technologies help Unemployed Job Seekers Find a Job? Evidence from the Broadband Internet Expansion in Germany* (IZA Discussion Paper No. 11555).

Hall, R. E., & Schulhofer-Wohl, S. (2015). *Measuring job-finding rates and matching efficiency with heterogeneous jobseekers* (National Bureau of Economic Research Working Paper Series No. 20939).

Kopf, W. (2012). Transitorische oder unendliche Regulierung? In M. Kurth & M. Schmoeckel (Eds.), *Regulierung im Telekommunikationssektor: Chancen und Risiken im historischen Prozess* (p. 127-141). Tübingen: Mohr Siebeck.

Kroft, K., & Pope, D. G. (2014). Does Online Search Crowd Out Traditional Search and Improve Matching Efficiency? Evidence from Craigslist. *Journal of Labor Economics*, *32*(2), 259 - 303.

Kuhn, P., & Mansour, H. (2014). Is Internet Job Search Still Ineffective? *The Economic Journal*, *124*(581), 1213–1233.

Kuhn, P., & Skuterud, M. (2004). Internet Job Search and Unemployment Durations. *American Economic Review*, *94*(1), 218-232.

Mang, C. (2012). *Online job search and matching quality* (Ifo Working Paper Series No. 147).

Stevenson, B. (2009). The Internet and Job Search. In *Studies of Labor Market Intermediation* (p. 67-86). National Bureau of Economic Research, Inc.

Suvankulov, F., Lau, M. C. K., & Chau, F. H. C. (2012). Job search on the internet and its outcome. *Internet Research*, *22*(3), 298-317.

Thomsen, S. L., & Wittich, M. (2010). Which One to Choose? Evidence on the Choice and Success of Job Search Methods. *Schmollers Jahrbuch*, *130*(4), 445-783.

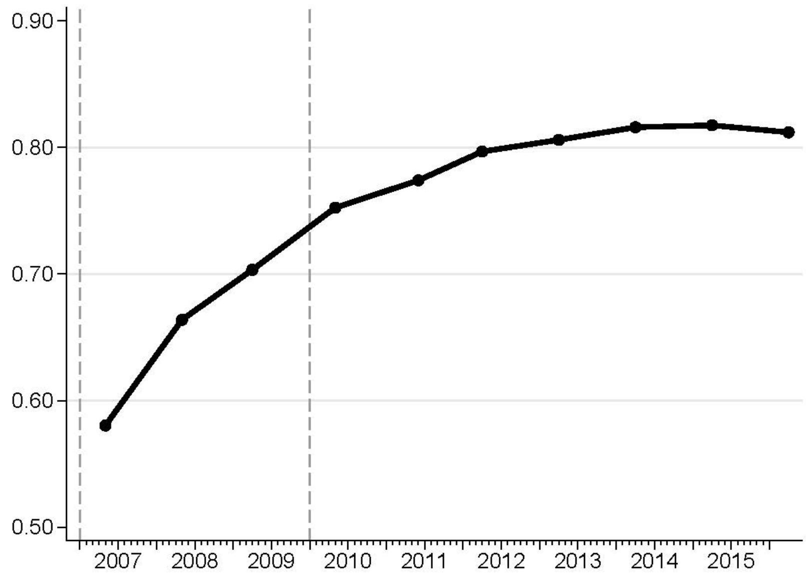
Trappmann, M., Beste, J., Bethmann, A., & Müller, G. (2013). The PASS panel survey after six waves. *Journal for Labour Market Research*, *46*(4), 275–281.

Trappmann, M., Gundert, S., Wenzig, C., & Gebhardt, D. (2010). PASS - A Household Panel Survey for Research on Unemployment and Poverty. *Schmollers Jahrbuch*, *130*(4), 609–622.

Appendix

Figures

Figure A1: Proportion of individuals with household access to the internet via computer



The dashed lines indicate the period of the study.

Tables:

Table A1: Genesis of the regression samples

	Number of obs.	Number of ind.
All PASS data 2006–2009	44880	23462
Aged 16-65; not in education	26887	15459
all non-employed	11984	7964
unemployed	5671	4376
Information on home internet access	26874	15455
all non-employed	11979	7961
unemployed	5669	4375
Living in municipalities free of territorial changes	21259	12426
all non-employed	9109	6224
unemployed	4126	3247
Information on DSL availability (municipality)[a]	19417	11458
all non-employed	8378	5761
unemployed	3758	2980
Full set of other covariates	12263	7509
all non-employed	5388	3768
unemployed	1788	1483
Employment information in the consecutive year	7592	4437
all non-employed	3079	2052
unemployed	1033	828

Note: Unemployed individuals are defined according to the ILO definition, i.e. non-employed persons who have been actively searching for a job within the last four weeks and who are able and willing to take up an offered job within the next two weeks.
[a]Reduction in observations due to (i) missing values in the *Breitbandbatlas* and (ii) data cleaning.

Table A2: Effects of having internet at home in t on being employed in $t+1$

Labor force group	Unemployed			All non-employed		
	OLS	2SLS		OLS	2SLS	
		Second stage	First stage		Second stage	First stage
Internet (dummy:1=yes)	0.059**	0.313		0.052***	0.196	
	(0.030)	(0.260)		(0.016)	(0.203)	
DSL availability			0.686***			0.558***
			(0.143)			(0.121)
Individual characteristics in t						
Female (dummy:1=yes)	0.071*	0.089**	−0.066	0.018	0.021	−0.017
	(0.037)	(0.041)	(0.046)	(0.021)	(0.021)	(0.032)
Cohabitation (incl. marriage) (dummy:1=yes)	0.041	0.016	0.095*	0.022	0.005	0.115***
	(0.050)	(0.054)	(0.055)	(0.028)	(0.035)	(0.038)
Female * Cohabitation	−0.085	−0.105	0.079	−0.094***	−0.100***	0.044
	(0.069)	(0.070)	(0.070)	(0.034)	(0.035)	(0.045)
Children with Age: 0-5 (dummy:1=yes)	0.049	0.020	0.117*	0.002	−0.004	0.046
	(0.074)	(0.074)	(0.060)	(0.035)	(0.033)	(0.040)
Children with Age: 6-14 (dummy:1=yes)	−0.010	−0.049	0.147***	0.000	−0.018	0.127***
	(0.043)	(0.057)	(0.043)	(0.024)	(0.033)	(0.029)
Children with Age: 15-17 (dummy:1=yes)	0.062	0.049	0.082	0.023	0.009	0.108***
	(0.059)	(0.063)	(0.064)	(0.030)	(0.038)	(0.034)
Migration background (dummy:1=yes)	0.002	−0.002	0.017	0.005	0.012	−0.046**
	(0.036)	(0.038)	(0.040)	(0.018)	(0.019)	(0.022)
Disabled (dummy:1=yes)	0.016	0.012	0.007	−0.054***	−0.046**	−0.058*
	(0.042)	(0.043)	(0.057)	(0.018)	(0.022)	(0.030)
East (incl. Berlin) (dummy:1=yes)	0.051	0.058	0.028	−0.012	−0.005	0.008
	(0.084)	(0.100)	(0.083)	(0.044)	(0.055)	(0.057)
Home owner (dummy:1=yes)	0.041	0.014	0.124**	0.046*	0.025	0.158***
	(0.052)	(0.062)	(0.054)	(0.027)	(0.045)	(0.032)
Age 26-35 (dummy:1=yes)	−0.034	−0.019	−0.056	0.041	0.054	−0.090**
	(0.071)	(0.079)	(0.072)	(0.037)	(0.045)	(0.041)
Age 36-45 (dummy:1=yes)	−0.062	−0.047	−0.045	0.040	0.058	−0.126***
	(0.070)	(0.074)	(0.069)	(0.038)	(0.047)	(0.046)
Age 46-55 (dummy:1=yes)	−0.158**	−0.118	−0.153*	−0.031	0.004	−0.244***
	(0.069)	(0.091)	(0.084)	(0.038)	(0.064)	(0.053)
Age 56-65 (dummy:1=yes)	−0.245***	−0.203**	−0.157	−0.126***	−0.077	−0.336***
	(0.073)	(0.091)	(0.103)	(0.039)	(0.079)	(0.055)
Apprenticeship (dummy:1=yes)	0.031	0.005	0.103***	0.058***	0.043	0.102***
	(0.037)	(0.043)	(0.039)	(0.018)	(0.027)	(0.021)
University degree (dummy:1=yes)	0.100	0.036	0.248***	0.111***	0.066	0.316***
	(0.074)	(0.095)	(0.061)	(0.037)	(0.076)	(0.039)
Duration of unemployment (in years)	−0.015***	−0.013**	−0.009			
	(0.006)	(0.006)	(0.007)			
Regional characteristics in t						
Unemployment rate (in %)	−0.015	−0.012	−0.007	−0.004	−0.004	0.002
	(0.010)	(0.012)	(0.010)	(0.005)	(0.006)	(0.007)
Change in unemployment rate $t-(t-1)$	−0.047*	−0.042	−0.015	−0.010	−0.011	0.005
	(0.027)	(0.029)	(0.029)	(0.015)	(0.018)	(0.017)
Change in unemployment rate $(t+1)-t$	−0.039**	−0.035*	−0.015	−0.009	−0.010	0.004
	(0.019)	(0.021)	(0.018)	(0.014)	(0.010)	(0.014)
Employment rate (in %)	0.002	0.002	−0.002*	0.000	0.001	−0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
% of pupils w/o any degree	1.036	1.622	−1.577	1.612**	1.973**	−2.053**
	(1.577)	(1.749)	(1.546)	(0.715)	(0.893)	(0.814)
% of pupils w. second. educ. degree	0.491	0.931	−1.577	1.052	1.232*	−1.130
	(1.476)	(1.629)	(1.482)	(0.648)	(0.704)	(0.761)
% of pupils w. univers. entrace degree	0.172	0.672	−1.810	0.985	1.184	−1.289

Continued on next page

Table A2 – continued from previous page

	OLS	2SLS		OLS	2SLS	
		Second stage	First stage		Second stage	First stage
	(1.719)	(1.872)	(1.705)	(0.744)	(0.809)	(0.857)
Population density (per km^2)	0.000	−0.000	0.000	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Surface area (in km^2)	−0.000	−0.000	0.000	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of firms per 1000 inhabitants	0.000	0.000	−0.000	−0.000	−0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
GDP per capita	0.000	−0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Time controls in t						
Year 2007 (dummy:1=yes)	−0.243**	−0.204	−0.134	−0.225***	−0.218***	−0.046
	(0.118)	(0.126)	(0.119)	(0.071)	(0.079)	(0.073)
Year 2008 (dummy:1=yes)	−0.160	−0.146	−0.032	−0.223***	−0.224***	0.018
	(0.121)	(0.122)	(0.113)	(0.072)	(0.080)	(0.070)
Year 2009 (dummy:1=yes)	−0.156	−0.154	0.009	−0.222***	−0.233***	0.083
	(0.131)	(0.139)	(0.129)	(0.075)	(0.087)	(0.072)
Month duration between interviews	0.017**	0.017**	0.001	0.013***	0.013***	−0.002
	(0.007)	(0.008)	(0.009)	(0.004)	(0.004)	(0.005)
Observations		1033			3079	
R^2	0.089			0.064		
Kleibergen-Paap Wald F statistic			22.927			21.332
Durbin-Wu-Hausman p-value	0.396			0.502		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Standard errors reported in parentheses are clustered at the household level for OLS and at the municipality level for IV. Month Dummies for $t + 1$ indicating when the interview took place are included in all regressions.

Table A3: Effects of having internet at home in t on researching via internet channels in t

Dependent variable	Other internet sources			Employment agency's online job market		
	OLS	**2SLS**		**OLS**	**2SLS**	
		Second stage	**First stage**		**Second stage**	**First stage**
Internet (dummy:1=yes)	0.389*** (0.032)	0.803*** (0.228)		0.195*** (0.034)	0.110 (0.274)	
DSL availability			0.704*** (0.140)			0.704*** (0.140)
Individual characteristics in t						
Female (dummy:1=yes)	0.002 (0.037)	0.030 (0.042)	−0.060 (0.046)	−0.033 (0.040)	−0.038 (0.040)	−0.060 (0.046)
Cohabitation (incl. marriage) (dummy:1=yes)	−0.029 (0.052)	−0.073 (0.061)	0.101* (0.056)	0.036 (0.055)	0.045 (0.060)	0.101* (0.056)
Female * Cohabitation	−0.024 (0.070)	−0.056 (0.076)	0.073 (0.069)	−0.028 (0.072)	−0.021 (0.075)	0.073 (0.069)
Children with Age: 0-5 (dummy:1=yes)	−0.028 (0.066)	−0.074 (0.079)	0.114* (0.061)	−0.047 (0.071)	−0.037 (0.076)	0.114* (0.061)
Children with Age: 6-14 (dummy:1=yes)	0.006 (0.041)	−0.056 (0.051)	0.140*** (0.043)	−0.013 (0.044)	−0.001 (0.064)	0.140*** (0.043)
Children with Age: 15-17 (dummy:1=yes)	0.000 (0.060)	−0.018 (0.071)	0.077 (0.064)	0.019 (0.059)	0.023 (0.054)	0.077 (0.064)
Migration background (dummy:1=yes)	−0.050 (0.036)	−0.057 (0.040)	0.018 (0.039)	−0.051 (0.039)	−0.049 (0.037)	0.018 (0.039)
Disabled (dummy:1=yes)	−0.025 (0.043)	−0.032 (0.049)	0.010 (0.057)	−0.053 (0.043)	−0.052 (0.043)	0.010 (0.057)
East (incl. Berlin) (dummy:1=yes)	−0.055 (0.079)	−0.044 (0.068)	0.031 (0.080)	−0.101 (0.087)	−0.104 (0.081)	0.031 (0.080)
Home owner (dummy:1=yes)	0.071 (0.050)	0.029 (0.064)	0.124** (0.055)	0.071 (0.054)	0.080 (0.055)	0.124** (0.055)
Age 26-35 (dummy:1=yes)	0.070 (0.064)	0.099 (0.067)	−0.062 (0.070)	0.032 (0.072)	0.026 (0.080)	−0.062 (0.070)
Age 36-45 (dummy:1=yes)	−0.032 (0.064)	−0.008 (0.071)	−0.044 (0.068)	−0.056 (0.073)	−0.061 (0.072)	−0.044 (0.068)
Age 46-55 (dummy:1=yes)	−0.091 (0.063)	−0.024 (0.078)	−0.158* (0.082)	−0.093 (0.074)	−0.107 (0.086)	−0.158* (0.082)
Age 56-65 (dummy:1=yes)	−0.147** (0.074)	−0.076 (0.097)	−0.162 (0.102)	−0.182** (0.081)	−0.197** (0.088)	−0.162 (0.102)
Apprenticeship (dummy:1=yes)	0.102*** (0.038)	0.059 (0.043)	0.106*** (0.039)	0.140*** (0.041)	0.149*** (0.047)	0.106*** (0.039)
University degree (dummy:1=yes)	0.182*** (0.063)	0.076 (0.081)	0.249*** (0.062)	0.230*** (0.073)	0.251*** (0.091)	0.249*** (0.062)
Duration of unemployment (in years)	0.004 (0.006)	0.007 (0.007)	−0.008 (0.007)	0.001 (0.006)	0.000 (0.006)	−0.008 (0.007)
Regional characteristics in t						
Unemployment rate (in %)	0.001 (0.010)	0.006 (0.010)	−0.006 (0.010)	0.010 (0.010)	0.009 (0.011)	−0.006 (0.010)
Change in unemployment rate $t-(t-1)$	0.042* (0.025)	0.046* (0.027)	−0.009 (0.027)	0.004 (0.032)	0.003 (0.035)	−0.009 (0.027)
Change in unemployment rate $(t+1)-t$	0.006 (0.018)	0.012 (0.020)	−0.015 (0.018)	−0.030 (0.022)	−0.031 (0.021)	−0.015 (0.018)
Employment rate (in %)	−0.000 (0.001)	0.000 (0.001)	−0.002* (0.001)	−0.001 (0.001)	−0.002 (0.001)	−0.002* (0.001)
% of pupils w/o any degree	1.152 (1.352)	2.117 (1.518)	−1.596 (1.546)	0.800 (1.409)	0.603 (1.439)	−1.596 (1.546)
% of pupils w. second. educ. degree	1.564 (1.235)	2.299* (1.234)	−1.621 (1.471)	1.256 (1.302)	1.106 (1.333)	−1.621 (1.471)

Continued on next page

Table A3 – continued from previous page

	OLS	2SLS		OLS	2SLS	
		Second stage	First stage		Second stage	First stage
% of pupils w. univers. entrace degree	1.898	2.738*	−1.875	1.230	1.058	−1.875
	(1.443)	(1.477)	(1.693)	(1.523)	(1.453)	(1.693)
Population density (per km^2)	−0.000	−0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Surface area (in km^2)	0.000*	0.000	0.000	−0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of firms per 1000 inhabitants	−0.003*	−0.003*	0.000	0.003	0.002	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
GDP per capita	0.000	0.000	0.000	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Time controls in t						
Year 2007 (dummy:1=yes)	−0.176*	−0.118	−0.128	−0.122	−0.134	−0.128
	(0.092)	(0.108)	(0.090)	(0.096)	(0.099)	(0.090)
Year 2008 (dummy:1=yes)	−0.189*	−0.175*	−0.013	−0.044	−0.047	−0.013
	(0.097)	(0.106)	(0.092)	(0.102)	(0.095)	(0.092)
Year 2009 (dummy:1=yes)	−0.175*	−0.184*	0.034	−0.030	−0.028	0.034
	(0.102)	(0.109)	(0.107)	(0.107)	(0.094)	(0.107)
Observations		1033			1033	
R^2	0.227			0.104		
Kleibergen-Paap Wald F statistic			25.245			25.245
Durbin-Wu-Hausman p-value	0.197			0.743		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: Standard errors reported in parentheses are clustered at the household level for OLS and at the municipality level for IV.

Table A4: Effects of having internet at home in t on the number of traditional search methods used in t

	OLS	2SLS	
		Second stage	First stage
Internet (dummy:1=yes)	−0.129* (0.076)	−0.155 (0.349)	
DSL availability			0.704*** (0.140)
Individual characteristics in t			
Female (dummy:1=yes)	0.072 (0.091)	0.071 (0.095)	−0.060 (0.046)
Cohabitation (incl. marriage) (dummy:1=yes)	0.110 (0.126)	0.113 (0.122)	0.101* (0.056)
Female * Cohabitation	−0.083 (0.169)	−0.081 (0.164)	0.073 (0.069)
Children with Age: 0-5 (dummy:1=yes)	−0.160 (0.164)	−0.157 (0.164)	0.114* (0.061)
Children with Age: 6-14 (dummy:1=yes)	−0.139 (0.097)	−0.135 (0.116)	0.140*** (0.043)
Children with Age: 15-17 (dummy:1=yes)	−0.025 (0.133)	−0.023 (0.142)	0.077 (0.064)
Migration background (dummy:1=yes)	−0.027 (0.084)	−0.026 (0.084)	0.018 (0.039)
Disabled (dummy:1=yes)	−0.157 (0.106)	−0.157 (0.101)	0.010 (0.057)
East (incl. Berlin) (dummy:1=yes)	0.086 (0.205)	0.085 (0.191)	0.031 (0.080)
Home owner (dummy:1=yes)	0.049 (0.131)	0.052 (0.134)	0.124** (0.055)
Age 26-35 (dummy:1=yes)	−0.069 (0.152)	−0.071 (0.157)	−0.062 (0.070)
Age 36-45 (dummy:1=yes)	−0.071 (0.151)	−0.072 (0.165)	−0.044 (0.068)
Age 46-55 (dummy:1=yes)	0.011 (0.155)	0.006 (0.174)	−0.158* (0.082)
Age 56-65 (dummy:1=yes)	−0.054 (0.184)	−0.058 (0.187)	−0.162 (0.102)
Apprenticeship (dummy:1=yes)	0.218** (0.089)	0.221** (0.099)	0.106*** (0.039)
University degree (dummy:1=yes)	0.036 (0.151)	0.043 (0.167)	0.249*** (0.062)
Duration of unemployment (in years)	−0.029** (0.011)	−0.029*** (0.011)	−0.008 (0.007)
Regional characteristics in t			
Unemployment rate (in %)	−0.010 (0.024)	−0.010 (0.025)	−0.006 (0.010)
Change in unemployment rate $t-(t-1)$	−0.023 (0.062)	−0.023 (0.057)	−0.009 (0.027)
Change in unemployment rate $(t+1)-t$	−0.123** (0.053)	−0.124*** (0.046)	−0.015 (0.018)
Employment rate (in %)	0.001 (0.003)	0.001 (0.003)	−0.002* (0.001)
% of pupils w/o any degree	−1.076 (3.799)	−1.137 (4.223)	−1.596 (1.546)
% of pupils w. second. educ. degree	−0.372 (3.527)	−0.418 (3.649)	−1.621 (1.471)
% of pupils w. univers. entrace degree	−2.462 (4.110)	−2.515 (4.052)	−1.875 (1.693)

Continued on next page

Table A4 – continued from previous page

	OLS	2SLS	
		Second stage	**First stage**
Population density (per km^2)	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)
Surface area (in km^2)	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Number of firms per 1000 inhabitants	0.003	0.003	0.000
	(0.005)	(0.004)	(0.002)
GDP per capita	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)
Time controls in t			
Year 2007 (dummy:1=yes)	−0.359	−0.362	−0.128
	(0.242)	(0.258)	(0.090)
Year 2008 (dummy:1=yes)	−0.162	−0.163	−0.013
	(0.252)	(0.243)	(0.092)
Year 2009 (dummy:1=yes)	−0.254	−0.254	0.034
	(0.268)	(0.253)	(0.107)
Observations		1033	
R^2	0.050		
Kleibergen-Paap Wald F statistic			25.245
Durbin-Wu-Hausman p-value		0.940	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: Standard errors reported in parentheses are clustered at the household level for OLS and at the municipality level for IV.

Table A5: Effects of having internet at home in t on researching via traditional search channels in t

	OLS	**2SLS** Second stage	Durbin-Wu-Hausman
INDEPENDENT VARIABLE:	Internet	Internet	p-values
DEPENDENT VARIABLE:			
Advertisements in newspapers	-0.051^{**} (0.021)	0.110 (0.203)	0.369
Friends or family	-0.020 (0.034)	-0.617^{**} (0.264)	0.009
Placement officer at empl. agency	-0.029 (0.035)	-0.085 (0.206)	0.778
Private job placement service	0.029 (0.025)	0.338^{**} (0.142)	0.057
Others	-0.059^{**} (0.022)	0.098 (0.102)	0.192
None	0.001 (0.005)	0.048 (0.037)	0.240

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Standard errors reported in parentheses are clustered at the household level for OLS and at the municipality level for IV. The set of covariates is the same as in Table A3 for all regressions. Number of observations: 1033, Coefficient & SE of First Stage: 0.704***(0.140), Kleibergen-Paap Wald F statistic: 25.245