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SOCIAL TIES FOR LABOR MARKET ACCESS – LESSONS FROM THE MIGRATION OF EAST GERMAN INVENTORS

Abstract

We study the impact of social ties on the migration of inventors from East to West Germany, using the fall of the Iron Curtain and German reunification as a natural experiment. We identify East German inventors via their patenting track records prior to 1990 and their social security records in the German labor market after reunification. Modeling inventor migration to West German regions after 1990, we find that Western regions with stronger historically determined social ties across the former East-West border attracted more inventors after the fall of the Iron Curtain than regions without such ties. However, mobility decisions made by inventors with outstanding patenting track records (star inventors) were not impacted by social ties. We conclude that social ties support labor market access for migrant inventors and determine regional choices while dependence on these ties is substantially reduced for star performers.

JEL Classification: J60, O30, P20, R23

Keywords: inventors, migration, social ties, networks, East Germany, transition

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1. Introduction

Theoretically and empirically, social ties have been shown to facilitate labor market access for migrants as well as well as investment and trade decisions.[1] These effects are thought to be caused by individuals pledging “social collateral” for other individuals they are tied with or by facilitating communication and thus reducing informational frictions. Analyses of social ties and networks provide a novel and presumably realistic depiction of economic transactions and their antecedents, and they complement theories of anonymous exchange with a relationship-based view of economic transactions. Studies of this kind therefore perform an extremely important function in providing a justification for or – in some cases – a qualification and extension of widely used micro-economic models of economic transactions.

Despite extensive prior work, causality is a thorny issue in studies of social ties and networks. Individuals may actively invest in social relationships and network positions to enjoy the aforementioned positive effects. In particular, agents will seek to establish relationships to those network members who are particularly productive, well connected, or trustworthy. Hence, social ties are rarely determined exogenously (Manski 1993; Glaeser et al. 2002). Demonstrating causal effects of social ties and exploring their underlying mechanisms is therefore an important objective for economics and social sciences research in general.

This paper analyzes the importance of social ties for labor market access and the role of heterogeneity among agents. We argue that social ties will be particularly valuable to individuals whose performance is not readily observable. Conversely, workers whose performance is easily visible can be matched with future employers without having to overcome major informational asymmetries. Thus, they will be less dependent on social ties as an access mechanism. Hence, an important aspect of our research is to distinguish empirically between

1 Karlan et al. (2009) provide a general theoretical model. Burchardi and Hassan (2013) present a study of the impact of information flows via social ties on investment and entrepreneurial decisions. We discuss the literature in more detail in section 2.

two types of employees: for the first, publicly observable performance measures counteract asymmetric information and render the use of social ties unnecessary; for the second, asymmetric information prevails and “pledge capital” and information dissemination via social ties become important.

We use the fall of the Iron Curtain and subsequent German reunification as the backdrop for a study of East German inventors and their East-to-West migration decisions. Data from pre-unification patenting activities in the German Democratic Republic (GDR) allow us to identify inventors and their performance, and to control for the heterogeneity among them. We are able to exploit a natural experiment – the fall of the Iron Curtain – and analyze the role of social ties and of publicly observable performance indicators for the migration decision of these knowledge workers. Given that the fall of the Iron Curtain and the subsequent reunification were not anticipated, neither labor market activities in the East nor investments in social networks were determined by such expectations. Prior to 1989, East German inventors were active in a socialist system where incentives and individual rewards for patenting strongly differed from the market economy system in the Western Federal Republic of Germany (FRG). However, the GDR patent system and the requirements for filing a patent complied with international standards. Despite harsh political separation, patented inventions of East Germans were visible within the international patent system and were cited by Western examiners and patent-holders, making individual patenting activities an (unintended) performance indicator to be used later by West German employers.

Our identification strategy relies on two assumptions: First, past inventor productivity in the GDR was not meant to boost attractiveness for the West German labor market and thus was exogenous to the needs of particular Western employers when inventors most to the West. Second, social ties between East Germans and regions in West Germany had developed historically for idiosyncratic reasons. When the Iron Curtain came down, these ties were exogenous conditions for the job-seeking East Germans. To safeguard against a variety of econometric issues, we employ an instrumentation strategy in which the emergence of social ties is impacted by World War II (WW II) destruction of West German cities.

Using East German patent records for about 102,000 patents, we identify East German inventors, their locations, and productivity.[2] We obtain data on their invention track records prior to the demise of the GDR, using data on patent status and type as well as citations these patents received. We successfully match and disambiguate the inventor-patent records of 21,935 inventors with labor market biographies from the social security system. The linked data allow us to locate inventors in East Germany prior to German reunification (via the patent records) and to trace inventor migration to West Germany as of January 1st 1990 with great precision (via the social security records).

Consistent with other studies we find that migration was substantial – about a quarter of the inventors in our sample migrated to West Germany. Hazard-rate estimates reported in the appendix confirm a positive selection mechanism of migrants found in prior studies. The results point to a higher rate of migration among the most able inventors with the presumably most valuable inventive skills.[3]

We show that the (historic) social tie intensity between Western regions and the East had a statistically significant and strong effect on the level of inventor inflows into Western regions. This finding is in line with prior studies that highlight the importance of social ties in the migration of knowledge workers.[4] Regions with more intense social ties constitute locations with reduced informational frictions. In such regions, labor market entry by migrants has been easier than in regions without (or with weaker) ties after the fall of the Iron Curtain.

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2 We are not the first to use East German patent data. Kogut and Zander (2000) compare the patenting activities of Zeiss Jena and Zeiss Oberkochen, which became two independent firms with similar focus after WW II. The authors exploit the reorganization of the two companies after the reunification to analyze the outcomes of macro-level radical changes on organizations. See also Cook and Ivanyna (2015) who study patenting in East Germany before and after the Moscow Olympic Games in 1980.

3 See, e.g., Hunt (2006), Brücker and Trübswetter (2007) or Fuchs-Schündeln and Schündeln (2009).

4 See, e.g., Dahl and Sorenson (2010) or Miguélez and Moreno (2014).

Moreover, our results also shed light on the question under which circumstances social ties are being used, and how publicly observable information on performance might interact with social ties. Ties appear to be important for inventors with average track records. For the flow of "star inventors" who had been particularly productive and visible to West German firms due to the disclosure of patent documents, the impact of ties is considerably smaller than for "average inventors" or even statistically indistinguishable from zero. We conclude from our results that tapping into networks offered East German inventors access to employment, but that individuals with a highly visible and outstanding track record were not dependent on social ties. In the remainder of the paper, we first summarize prior studies and discuss our research question. In section 3 we describe the institutional background for inventors in the GDR as well as the transition of East Germany from a socialist to a market-based economy. Section 4 describes the datasets used. In Section 5 we investigate the migration of East German inventors to West Germany. Section 6 concludes.

2. Theory and Prior Studies

Over the past years, networks and social ties have received considerable attention from economists, both in theoretical and empirical work. Karlan et al. (2009) provide a very generic theoretical model of network-based trust. They use their model to conduct empirical tests for i) the impact of social ties on information provision, ii) hiring by employers based on trusted recommendations, and iii) informal borrowing. In each of the three cases they find results that are consistent with the notion that networks allow individuals to profit from social ties. Helsley and Zenou (2014) also develop a model in which social ties facilitate economic transactions. They study the relationship between an agent's position in the social network and her geographic location, pointing to another possibly important endogenous relationship between spatial sorting and social position of economic agents. Ambrus et al. (2010) develop a theory of risk-sharing in social networks where the network is taken as given, and social ties function as collateral for insurance. See also Bramoulle and Kranton (2007) for a study focusing on insurance. Further work on informal borrowing and risk-sharing in networks has been put forth by Fafchamps and Lund (2003), De Weerdt and Dercon (2006), and Fafchamps and Gubert (2007). There is also robust evidence that job access via social networks, e.g., by means of job referrals, is related to particularly good matches because informational deficits of labor markets are resolved via social ties (Topa 2011; Dustmann et al. 2016).

A number of papers point to heterogeneous effects of social ties and networks. Neubecker et al. (2015) study the effects of migrant networks on the skill structure of migration. Their results are consistent with the view that high-skilled individuals have lower effective migration costs than low-skilled individuals (see also Chiswick 1999). Similarly, Dahl and Sorenson (2010) study knowledge worker mobility in Denmark. They show that these workers – trained scientists and engineers – make mobility choices which are correlated with proximity to their current residence, proximity to their parents, the number of high school classmates in a region, the number of college classmates in a region, as well as proximity to places where they had lived in the past. Miguélez and Moreno (2014) confirm the importance of physical proximity, job opportunities, social networks, as well as other relational variables in determining inventor mobility across European regions.

While heterogeneity is not a completely new issue in this line of research[5], none of the papers above identifies individuals according to observable performance. Hence, the relationship of earlier results to economic theories remains somewhat tenuous. Information on an agent's performance is the cornerstone of economic models in the neo-classical tradition. Vice versa, social ties presumably resolve problems of asymmetric information, which emerge when such information is not available. To show that this characterization is correct, one would have to estimate the causal effect of social ties for employees who belong or do not belong to the group

[5] A survey of related studies is provided by Topa (2011).

with outstanding performance. We do so by distinguishing between "star inventors" who have had outstanding performance in terms of patent quantity and quality, and individuals with average track records who were active as inventors in East Germany, but without the outstanding success of the first group. [6] The latter group may to tap into social ties for labor market access, albeit at some cost (e.g. the expectation of reciprocal behavior in the future).

Assuming that social ties help overcome barriers caused by asymmetric information, actors with outstanding performance will be less dependent on social networks than actors not being able to document such a performance. We therefore postulate that the effects of social ties are likely to be important for individuals whose past performance is not easily observed. In the context of labor market moves, social ties will allow job seekers to access job market opportunities in those regions in which capital pledged via social ties is available. Thus, their moves will reflect the existence of regionally limited social ties.

In order to overcome various complications from endogeneity, our paper extends work by Burchardi and Hassan (2013; henceforth abbreviated as BH). In their spirit, we use regional variations in social ties between West German regions and East Germany, which evolved for idiosyncratic reasons prior to the demise of the GDR system. In fact, during the time of harsh separation, i.e., between 1961 and 1989, the initiation of professional or social ties by East Germans across the Iron Curtain was hardly possible given the restrictions in travelling and communication for GDR citizens.[7] Even the active preservation of social relationships established prior to the construction of the Iron Curtain was subject to threats of severe penalties

6 We refer here to objective information on an agent's past productivity from which employers may deduce future performance potential. We argue that the number of patents produced and the number of citations received prior to the fall of the Iron Curtain represent such information. Since patent quantity and citations follow highly skew distributions, only very few inventors have truly outstanding records and can be called "star inventors". Inventors not in this group may or may not be good choices for employers, given that reasons for their average performance are unclear. Average performance may be due to average talent as an inventor, or due to having mixed inventive activities with managerial or other tasks. The performance information would be unambiguous only for the "star inventors".

7 Burchardi and Hassan (2013) argue that variation in the regional intensity of social ties to East Germany across West Germany is related to the settlement patterns of expellees coming from historical German territories in Eastern Europe around the end of WW II as well as subsequent migrants of East Germans who had migrated to the West from the GDR prior to the construction of the Iron Curtain.

by the regime. From the perspective of West Germans, ties across the border had been maintained for social reasons (e.g., to maintain contact to relatives or friends[8]), and not for economic benefit. In November 1989, the harsh East-West separation came to an end unexpectedly and quickly. Only one year later, in October 1990, German was officially reunified.

BH employ the setting of East-to-West relationships to show that households in West German regions with comparatively strong social ties to East Germany experienced an above-average increase in income post-1989 and an above-average growth in entrepreneurship. In the commercial gold rush that occurred during the privatization of the East German capital stock, agents in such regions had stronger than average investment activities in East Germany, and, looking at the aggregate effects, higher income growth at the regional level. BH argue that their results are likely to be caused by preferred access to information about demand conditions in the East for those agents in West German regions who had relatively strong social ties to the East. Such information allowed these agents to tap into the new economic opportunities in the East more rapidly and more precisely than other less well-connected and thus less well-informed agents.

We build on this view, but expand it in one important way: we consider those regions with strong historical ties across the border as preferred landing spots for migrants from the East. Our research questions are thus: i) how do social ties impact flows of mobile individuals, and ii) how do mobility patterns differ between individuals with highly visible, outstanding performance and those with more moderate achievements. In terms of identification, we follow earlier work in using historical data on war destruction as an instrument for the social ties variable.

8 In our analysis of the GSOEP we find that social ties across the border are dominated by relationships to relatives, while friendships account for a smaller fraction of our social tie intensity measure.

3. Institutional Background and the Reunification Process

3.1 The GDR Patent System

The Office for Inventions and Patents of the German Democratic Republic (*Amt für Erfindungs- und Patentwesen der DDR*) was established in 1950. Its duty was to grant and administer industrial property rights (patents, trademarks, and designs, IPR) and to provide information on industrial property rights effective in the GDR (Wießner 2015).

The legal frameworks for the protection of intellectual property in both parts of Germany, the Federal Republic of Germany (FRG) and the GDR, were almost identical. Both were members of the Paris Convention, one of the first international IPR treaties, signed in 1883, which established a uniform protection of IPR as regards national treatment, right of priority, and common rules.[9] However, contrary to the West German patent system the GDR patent system distinguished between two different types of patents. Exclusion patents (*Ausschliessungspatente*) corresponded to patents granted in the FRG and other western patent systems. In particular, these patents – which were granted for a limited time period – assigned their owners the right to exclude others from using or selling the invention.[10] Inventions protected by the second type of patents, so-called economic patents (*Wirtschaftspatente*), could be utilized by all people-owned operations (*Volkseigener Betrieb*, VEB) or government institutions. The user had to pay a license fee to the owner of the patent. Hence, they constituted a kind of compulsory licensing system.[11]

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9 The GDR became member of the Paris Convention on June 20th 1968 and its accession entered into force in April 1970. See http://www.wipo.int/treaties/en/ip/paris/summary_paris.html, accessed on March 18th 2015. To be patentable, inventions had to be new, involve an inventive step, and be commercially applicable.

10 See http://www.wipo.int/export/sites/www/about-ip/en/iprm/pdf/ch2.pdf, accessed on January 23rd 2014.

11 Economic patents could be transformed into exclusion patents. In case they had not been examined at the time of transferal, later examination was required (Curter 2001). Whereas exclusion patents had to be examined to be effective, economic patents were effective even without examination. Generally, applicants were given a choice between filing an exclusion patent or an economic patent. However, in case the invention was made while the inventors were employed with a VEB, a government research organization or any other public institution, it was only possible to file an economic patent. Exclusion patents were usually filed to protect knowledge also relevant in capitalist foreign countries (Legien 1957). In these cases patent protection was typically also sought in the FRG or other foreign countries. For 6.9% of all exclusion patents filed between 1981 and 1990, international patent protection for at least one foreign country was pursued, with the FRG (6.7%) being the by far most frequently chosen country for IP protection (Fendt 1992).

After the reunification, the GDR Patent Office merged with the German Patent and Trademark Office (GPTO) of the FRG.[12] IPR (including patents, utility models, semiconductor topographies, and trademarks) and related applications were extended to the territory of unified Germany, while maintaining priorities. For patents, which had not been examined at the time of the extension, the owner of the patent or any other person could request examination at the German Patent and Trademark Office (GPTO). The GPTO also took over the examination proceedings of all patent applications of the GDR Patent Office with a pending examination at the time of reunification.[13] After the Extension Law was enacted, exclusion patents that had been granted by the GDR patent office were treated like any other granted German patent.[14]

3.2 Economic Transformation of East Germany

Soon after the fall of the Berlin Wall on November 9th 1989 and the breakdown of the Iron Curtain in the subsequent months, the transition of East Germany to a market economy system commenced. Freedom of travel was granted to all GDR citizens. This enabled East Germans immediately – after three decades of being barred from traveling to the West – to migrate to West Germany and other countries.

Prior to political reunification, an economic union, including a currency reform, was implemented on July 1st 1990. For East German citizens the currency reform represented a substantial increase in wages and in purchasing power. For East German firms, however, monetary union dramatically reduced competitiveness. On the demand side, East German

[12] The treatment of GDR patents as well as other GDR IPR was laid down in the Law on the Extension of Industrial Property Rights (*Erstreckungsgesetz*) as of April 23rd 1992. See http://www.wipo.int/wipolex/en/text.jsp?file_id=126205, accessed on January 22nd 2014, and Wießner (2015).

[13] Mediation (remuneration disputes w.r.t. the German Employee Invention Act), appeal, and revocation proceedings were transferred in their current status to the arbitration board of the GPTO or the Federal Patent Court (§§ 50, 51 Extension Law). In case the GPTO confirmed or granted a former GDR patent, opposition could be filed with the GPTO up to July 31st 1992 (§12 Extension Law). The right to file an opposition also applied to extended patents for which the opposition term had already expired.

[14] Some economic patents were, on request and after a regular examination, converted into exclusion patents. The extended economic patents were considered as “patents for which a declaration of willingness to grant license (Section 23(1) German Patent Law) has been given” (§7(1) Extension Law). However, the owner of an examined patent could withdraw the declaration of willingness to license at any time.

producers also had to cope with the loss of their traditional export markets in Eastern Europe. In the course of the unification process, the majority of people owned operations, which – in times of the GDR – had employed about 90% of the East German workforce, became subject to substantial industrial restructuring and privatization (Windolf et al. 1999).[15] As a part of the political reunification, which became effective on October 3rd 1990, all pillars of the West German social security system (health, pension, and unemployment) were implemented in East Germany.

Overall, the transition of East Germany from a centrally planned to a marked-based economy led to a stunning and rapid loss of firms and jobs in East German regions.[16] In addition to the massive labor market-related structural changes, the lack of regional amenities, the mainly antiquated infrastructure, a decaying stock of housing, and severe environmental problems in many industrial agglomerations became further push factors for migration, despite the adjustment of wage levels by means of the currency reform in 1990 (Wagner 1992; Burda and Hunt 2001; Hunt 2006). By January 1992 about the equivalent of 5% of the whole population or 10% of the total GDR labor force, accounting for roughly 870,000 East Germans, had actually migrated to the Western states of Germany (Burda 1993). By the end of the decade, more than 2.4 million East Germans, representing the equivalent of 14.7% of the whole GDR population in 1988, had migrated to West Germany (Burda and Hunt 2001).

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[15] The transition of the East German economy to the market system was largely driven by the work of the governmental trust agency (*Treuhandanstalt*, THA). The THA had the purpose of providing East German firms with business knowledge, capital and technology from the West to facilitate market access in reunified Germany. Public research institutes that had been pursued patenting in specific areas related to the technology focus of their people-owned operations had also been subject to the substantial restructuring policies of the THA.

[16] A comprehensive analysis of the economics of German reunification is Burda and Hunt (2001).

4. Data and Descriptive Statistics

4.1 Data Collection

Our study uses comprehensive biography data of East German inventors compiled from different data sources. The inventor sample is based on patent track records of East German inventors who had been listed on patents between 1980 and 1990. We link the individual patent accounts with detailed labor market biographies as recorded in the social security data of the unified Germany between 1990 and 2012. Using these linked data, we are able to study transitions of East German inventors into the market economy of post-unification Germany.

All inventors listed on patent applications at the former GDR patent office between 1980 and 1990 represent the sampling frame for our population. All patent applications at the GDR patent office after the introduction of an electronic register in 1980 – in sum 102,281 patents – were drawn from ESPACENET, a database of the European Office, which comprises 90 million patent documents.

The social security data are taken from the Integrated Employment Biographies (IEB) of the Institute for Employment Research (IAB). The IEB is the largest administrative micro dataset on employment in Germany, and it comprises biographical data on more than 80% of the active workforce, excluding only civil servants or self-employed individuals. It includes a comprehensive set of socio-demographic characteristics as well as full information on episodes of employment, unemployment, or job search. For all employment episodes the data records a set of job characteristics including type of job, occupation, and (gross) wages as well as employer related information such as industry codes in the NACE classification system, establishment size, and most importantly for our study, the exact location of the employer.[17]

The administrative labor market data starts to record the full population of East German employees, i.e., those employees who work for an establishment located in East Germany as of

[17] For a description of a subsample of IEB, the so-called Sample of Integrated Employment Biographies (SIAB), see Dorner et al. (2010).

January 1992, whereas East Germans who migrate to the West before 1992 are represented in the data from the first day of their employment. This enables us to observe the complete labor market biography of inventor migrants identified in the patent data and matched to the administrative labor market data.[18]

We have linked the two data sets via record linkage techniques by using the first and the last name of the GDR inventor and by comparing them with the names in the administrative IAB data.[19] Our final set of linked inventor-employee matches comprises data on 24,418 unique individuals with a complete employment biography in the IEB data.[20] Since there is no evidence about a systematic relationship between common names and individual labor market outcomes for German names[21], we consider this sub-sample of matched inventors a random draw from and representative for the whole population of GDR inventors. We use this linked employer-employee biography data on East German inventors to determine their migration patterns. The location information of the employer (municipality level) enables us to determine the precise work location of each inventor in West Germany from the first day employed at any establishment in the pan-German labor market as of January 1st 1990.

[18] The administrative labor market data of the IAB in general does not record the origin (e.g., residential or work location abroad) of entrants, i.e., individuals who appear in the data for the first time. Therefore, we are not able to identify (former) East Germans directly from the information recorded at the IAB. To obtain an adequate matching population for East German inventors we restricted the full sample of entrants in the pan-German labor market in the years after 1990 using entry age of inventors and their employment status. As potential matches for East German inventors, we kept only entrants with an age of at least 25 years at their time of entry and furthermore excluded employees recorded as trainees. To link the first and the last names of the GDR inventors with employees in the social security data base comprised of new entrants we use exact (deterministic) matching as well as additional probabilistic methods to address spelling errors in the matching keys (see, e.g, Christen 2012).

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[20] These inventors contributed to 52% of the patents in our initial (patent) data base. Further details on the linkage are available from the authors.

[21] Silberzahn et al. (2014) analyze German name data and document that there is no systematic evidence for a higher likelihood of getting promoted into management positions, conditional on having a traditional noble name as opposed to other common names. We assume that this finding is also robust to other labor market outcomes and inventive performance.

The linked patent-social security data at the level of the individual inventor allow us to trace inventors in the GDR patent register data and to generate patenting track records for each inventor between 1980 and 1990. To determine the location of inventors and the patent applicants prior to German reunification we used address data either available from the patent registers of the GPTO or which had been scraped from the original front pages of the GDR patent documents. City names and zip codes, extracted from these two sources, were cleaned, geocoded, and mapped into the areal units matching the territorial structure in the post-reunification data. From this information, we generated a variable that records the last location prior to the demise of the GDR in 1989 for each of the inventors.

The linked inventor biography data comprises data on 24,418 individuals. This number is further reduced due to some data restrictions: we dropped records on inventors who are i) recorded with an entry date in the social security register after December 31st 1994, and those who ii) had only episodes of unemployment listed in the IEB data.[22] Finally, iii) we dropped all inventor records without reliable location information prior to German reunification according to their patent account.

The resulting sample comprises data on 21,935 East German inventors with complete employment records. For all inventors in the sample, we define a common starting point on January 1st 1990 as the time when each inventor is (for the first time) at risk of migrating to the West.

4.2 Description of Variables

Inventor level variables prior to 1990

We derived a set of inventor-specific variables from records in the GDR patent register data that capture inventive performance in the GDR until December 31st 1989, both in terms of patent quantity and quality. The quantity indicator is based on a count of patents filings. On

[22] Reasons for inventors entering the labor market after the first five years may result from periods of self-employed, further education, living abroad, or from inactivity.

average, each inventor in our analysis sample has contributed to 3.4 (std. dev. 6.2) GDR patents during our full observation period. Additionally, we compute a fractional count of patents that normalizes inventor contributions to patents by the number of inventors listed on the respective patent.[23] In order to take the timing of patenting activities in the GDR into account we construct two indicators from the patent counts. First, we count patenting activities of inventors in the last three years prior to the collapse of the GDR (1987, 1988 and 1989). These patents are presumably most relevant when considering patent filings as a performance indicator, since they are based on the inventor's most recent work. Second, to account for patenting prior to 1987, we compute an additional binary indicator, which takes the value of one if inventors have patented only prior to 1987 and zero if not. The distribution of the quality of patents is highly skewed. The quality indicator we use throughout our analysis is the citation status of patents. In general citations are a well-established indicator for the commercial value and the technological impact of a patent (Harhoff et al. 1999). We use a count of the number of citations inventors have received to their patents until December 31st 1989 and a binary indicator equal to one if any citations were received, and zero otherwise. [24]

We define two inventor groups in order to distinguish between highly productive inventors and average inventors: i) inventors with at least one cited patent, henceforth-called star inventors, and ii) those inventors without citations who had presumably contributed to less relevant inventions (called non-star inventors). Star inventors account for 12% of our sample.

[23] Patent fractions are standardized by the number of co-inventors who are listed on each patent. We assume that inventors listed on the patent documents contribute equally to the patent filing.

[24] Other quality indicators for an inventor's patent portfolio were generated. A second indicator was derived from the examination status of GDR patents, i.e., we exploit the differences between exclusion and economic patents in terms of their examination requirements. Exclusion patents presumably are of higher quality due to the obligatory examination process. Additionally, we are able to infer whether a patent is part of a patent family, i.e., that the patent filed at GDR patent office has also been registered in countries other than the GDR. These patents will tend to be more valuable, since they require additional investments, but also provide a more comprehensive protection of the invention in terms of geographical scope. Binary variables indicating whether an inventor had contributed to exclusion patents or patent families were tested. Results are available from the authors upon request.

In our sample, 89% of the inventors are male and 56% of them hold an academic degree[25]. The mean inventor age as of 1990 is 43.7 years.

Migrant inventors

We identify migrant inventors based on the IEB data, which records employment spells of inventors in West German firms as of January 1st 1990. A subset of 16,818 (76.7%) inventors did not migrate to the West (in the following referred to as non-migrants). We identify migrant inventors (migrants*)* as those individuals who started working for an establishment located in West Germany at some point after January 1st 1990. Detailed summary statistics and t-tests for differences between the sub-groups of East German inventors (star vs. non-star and migrant vs. non-migrant inventors, respectively) are provided in Table A1.

Social ties to East Germany and regional characteristics

We compile a regional data set comprising all – in terms of geography – possible destinations in the West German labor market at the level of planning regions (*Raumordnungsregionen*, regions).[26] These regions represent aggregates of cities respectively counties at the NUTS 3 level. The territorial structure of regions approximates travel to work areas.

Our main goal is to analyze the impact of social ties and observable indicators of outstanding productivity on the migration of inventors. To build our social tie indicator, we use GSOEP survey data (Wagner et al. 2007) collected in 1991 from households located in West Germany. Each household was asked in 1991 whether in 1989 (i.e., prior to the fall of the Iron Curtain) any household member had had either relatives or friends living in the GDR. This household level measure of pre-unification socials has been used by other researchers to study correlations between migration and social ties (Fuchs-Schündeln and Schündeln 2009; Rainer and Siedler

[25] Education is a variable reported by the employer. We determine the highest level of education for each inventor by using the mode of education in all employment episodes to construct the indicator. This procedure resembles imputation algorithms frequently used for IAB employment biography data to correct inconsistencies arising from reporting behaviors of different employers over time (Fitzenberger et al. 2006).

[26] We only exclude the city of Berlin and its western part, which we assign to East Germany. This approach is in line with Burda and Hunt (2001), Fuchs-Schündeln and Schündeln (2009), and Rainer and Siedler (2009).

2009). We use the household level data to compute the share of households in each of the 74 West German regions reporting relatives living in the GDR prior to the fall of the Iron Curtain in 1989. The share approximates the intensity of social networks between any West German region and East Germany at the time of German reunification. Following BH, we exploit this indicator as a measure for the social network intensity of individuals in West German regions towards potential East German inventors, e.g., to provide job-related information or job referrals.

In our empirical analysis, we further control for a set of variables from various data sources that account for heterogeneity across the 74 West German regional labor markets and regional innovation systems. Regional indicators are measured for the year 1989 in order to reduce potential endogeneity bias. Sources of information, summary statistics, and a correlation matrix of the regional indicators are reported in Table 1 and Table A3.

[Table 1 about here]

4.3 Descriptive Results

Focusing on the spatial distribution of patenting in the GDR, Figure 1 visualizes the number of inventors across 21 East German regions.

[Figure 1 about here]

Figure 1 shows that the capital city *East Berlin* and *Oberes Elbtal/Osterzgebirge* with its main urban center, the city of Dresden, had been the hot-spots of inventive activities in the GDR. Their outstanding role in the geography of innovation of East Germany was linked to the presence of the National Academy of Science (*Akademie der Wissenschaften*), of several technical universities and research-intensive people owned operations. Major cities such as Leipzig (*Westsachsen*), Halle/Saale (*Halle/S.*), Magdeburg (*Magdeburg*), and Rostock (*Mittleres Mecklenburg/Rostock*) were also locations of substantive inventive activities, which were mostly concentrated at the local universities. As a result of the detailed planning of industrial activities and top-down location decisions made by the East German government, there had been several small but highly specialized towns in rural areas that were both socially and economically dominated by one firm.

Of the 21,935 former GDR inventors included in our sample, we observe 23.3% (5,117) migrating to the West after January 1st 1990. The annual incidence of labor market entries in West Germany is presented in Figure 2.

[Figure 2 about here]

The migration of inventors set in very quickly after the collapse of the Berlin Wall, and the majority of moves occurred already in years from 1990 to 1992. By the end of 1992, almost 55% of all migrants had moved to West Germany. By December 31st 1994, the respective cumulative share of migrants amounted to 61%. The temporal pattern of star inventor migration over time is very similar to the full population of inventors. By the end of 1994, 62% of the star inventors had moved to the West.

Using Cox proportional hazard models we have modelled the timing and the determinants of migration from East to West Germany.[27] The estimates provide robust evidence that the "best went west" (Brücker and Trübswetter 2007), i.e., after holding important socio-demographic characteristics constant and controlling for geographical location, GDR inventors with larger patent portfolios had a higher risk of moving to the West German labor market than less productive East German inventors. Besides patent quantity effects, we also find that patent quality matters in the sense that inventors who had received citations to their patents prior to 1990 (the star inventors) had a significantly higher risk of migrating.

We now turn to the destination regions in West Germany and the impact of the intensity of social ties to East on migration. We computed the aggregate inflow of East German inventors to West Germany and map the heterogeneity across regions (see Figure 3a).

[Figures 3a and 3b about here]

[27] Detailed results are presented in the appendix (Table A2).

The most important destination regions are characterized by the presence of large urban agglomerations. Figure 3b visualizes the spatial distribution of social ties to East Germany across western regions. At the region average, 17% of households reported having social ties to the East. In the region of *Goettingen,* about 48% of households reported social ties to the GDR while, at the bottom of the ranking, the share of the households with ties to the GDR does not exceed 2%.

[Figures 4a and 4b about here]

The scatterplot in Figure 4a shows that social ties intensity and the inflow of East German inventors are positively correlated (ρ= 0.119).[28] However, outliers representing agglomerations such as the regions *Rhein/Main* (Frankfurt/Main), *Stuttgart,* or *Munich* distort the correlation. We also find that both social tie intensity (ρ= -0.575) and inventor inflows (ρ= -0.094) are negatively correlated with the distance of a West German region to the (former) inner German border (Figure 4b).

5. Multivariate Results

5.1 Migration Patterns between East Germany and West German Regions

We now investigate in more detail the relevance of social ties for inventor migration and the (causal) interrelationship with observable performance indicators. Towards this objective, we analyze flows and the spatial pattern of East German inventor migration into West Germany and test the relevance of social ties for inventor migration flows between East Germany and West German regions. We consider inflows of inventors and their determinants across 74 regions in West Germany over the first five years after German reunification, i.e., in the years from 1990 to 1994. We regress annual regional inflows of all inventors, as well as sample splits

[28] Figure A1 shows scatterplots separately for star and non-star inventors. Both graphs indicate a positive correlation between social ties and inflows of inventors. However, the relationship appears to be stronger for non-star inventors.

for the groups of star inventors and non-star inventors, on the social tie intensity to East Germany measured at the level of West German regions and additional control variables.

We estimate the following equation:

$$y_{rt} = \beta_0 + \beta_1 dist_r + \beta_2\, tie_{r,1989} + X_{r,1989} + D_t + \varepsilon_{rt}$$

To explain the annual inventor inflows in region r in year t (y_{rt}) we control for time invariant shortest distance to the former border ($dist_r$) and a comprehensive set of regional characteristics referring to the year 1989 ($X_{r,1989}$). Our core variable of interest is the social tie intensity of West German regions to East Germany ($tie_{r,1989}$).

We also include (annual) time fixed effects (D_t). In our preferred specification, we further interact a binary indicator variable taking the value of one for the years 1992, 1993 and 1994 and zero for the years 1990 and 1991 with the social tie intensity in order to capture some depreciation of the social tie effect over time after German reunification. The distribution of the error term (ε_{rt}) follows standard assumptions. All specifications are estimated using (pooled) OLS.[29] We use robust standard errors.[30] The dependent variable (y_{rt}) is log transformed to cope with nonlinearities in the skewed distribution of inflows. We also transform all regressors to logs.[31]

Using the full sample, we find that social tie intensity has a positive effect on the inventor inflow into West German regions, controlling for time fixed effects and several regional characteristics. Table 2 presents the OLS regression results for the star and non-star inventor inflows.[32]

[Table 2 about here]

29 Alternative specifications of the OLS inflow models using count data estimators yield very similar results, which are available from the authors upon request.

30 The statistical significance of the OLS results does not change substantially if we account for autocorrelation of regional characteristics by clustering the standard errors at the level of regions. The results are available from the authors upon request.

31 In the presence of variables having zero values (e.g., star inventor inflow from East Germany in region *r* and in year *t*) we shifted the value of the variable by adding one to avoid missing values in the logarithm.

32 Results for the two groups combined are reported in the appendix (Table A4).

We had argued that inventors with average productivity are dependent on social ties, while star inventors are not. We therefore expect a positive correlation between the social tie intensity of the region and the number of non-star inventors who had chosen this destination. The estimate for regional social tie intensity in the model neglecting time fixed effects amounts to 0.171 (column Ia) and is sustained in terms of magnitude once we include annual year dummies (column IIa) and an additional interaction term between social tie intensity and the years 1992/1993/1994 (column IIIa) as regressors. With this interaction, we account for the fact that the effect of social ties might differ between the period until the survey in 1991 and later years when the relative importance of historical ties might have decreased with the German integration. We find that the positive and significant effect measured for the early period is still positive and comparable with the effects reported in columns Ia and IIa, while the interaction term has a slightly negative and insignificant effect. The joint F-test nevertheless indicates that the total effect of social tie intensity is still significantly different from zero ($p<0.05$). The other estimates point into the expected directions, and their magnitude and significance is sustained over the different specifications.

Turning to the star-inventors, we hypothesized that if commonly observable productivity measures are a valid channel facilitating labor market access, the effect of social ties should be considerably smaller or even neutralized for star inventors. For star inventor inflows, we do not find any significant effect of the social tie intensity. The results are therefore consistent with our expectations.

These estimates are obtained after controlling for a number of potential confounders such as the distance to the border capturing the costs of migration, as well as regional characteristics acting as controls for regional heterogeneity. For the estimates on regional distance to the border, population, and the share of high skilled workers, the relationships with inflows point in the same direction and are comparable in terms of statistical significance.

Differences in the magnitude of both coefficients indicate that star inventors appear to be less sensitive to migration costs, as indicated by distance, and to the potential benefits of larger labor markets.[33] The non-star inventor flows are further directed to regions with lower levels of unemployment and are particularly attracted by a higher share of academic workers on regional labor markets. Although pointing in the same direction, both characteristics of regional labor markets do not impact star inventor inflows. However, we find that regional wage differentials are marginally significant ($p<0.1$) as determinants of migration patterns of star inventors, but not of the group of non-star inventors.

5.2 Instrumental Variable Results

We measure the social tie intensity of West German regions to East Germany using survey data collected in 1991, and hence based on a retrospective survey item. Therefore our estimates for social ties might be subject to endogeneity due to measurement errors. Possible sources of measurement error might be misunderstandings of the question by the respondents, memory errors of the respondents, a lack of geographical literacy that would affect the location of the tie. Moreover, the sampling of the GSOEP is not adjusted for the territorial structure used in this paper. Essentially, these issues result in a classical measurement error in variables problem, which leads to downward biased OLS estimates (attenuation bias). To account for potential endogeneity in this core variable, we re-estimate our main models using an instrumental variable approach.

Our instrumental variable is the share of destroyed dwellings in 1946 relative to the stock in 1939 at the regional level (for convenience, we use the term war destruction in the following, when we refer to our instrument). War destruction is derived from data on the share of war destruction in 177 German cities and population data of the cities documented in Hohn (1991).

[33] Further tests show that the marginal effects of the social tie intensity are unequal ($p<0.01$) between the star and the non-star inventor sample.

The regional level of war destruction is computed as the population weighted average over all cities with data on war destruction in a region. The aggregation of the data only yields valid information for a subset of 72 regions, since we do not observe any city level data point within two regions. A graphical representation of the war destruction variable is given in Figure A2 in the appendix. The average war destruction at the regional level amounts to 28% of the stock of dwellings (std. dev. 19.97). The maximum of war destruction was 75% in the region of *Wuerzburg*. Three regions had virtually no war destruction according to the destruction levels documented in the regional cities and therefore take on the destruction value of zero.

To be a valid instrument, the instrument (Z) needs to fulfil two criteria: exogeneity and relevance. Our first assumption is fulfilled if the instrument is uncorrelated with the error term of the model, i.e., Cov($Z; \varepsilon$)= 0 or E($\varepsilon|Z$) =0. Hence it is assumed that there is no variable, other than the ones we control for, that relates to both our instrument and the inflow of inventors to West German regions after 1990. Following the arguments developed by BH, we argue that the social ties across the inner German border had developed for idiosyncratic reasons. More precisely, social ties are related to refugee settlement patterns directly after WW II. Refugees were displaced from the Eastern parts of the former *Deutsches Reich*. Many of the refugees settled in East Germany, but a substantial share of them moved to West Germany in the years between 1945 and the erection of the Berlin Wall in 1961. Due to the origin of the newly located refugees they were likely to have ties with family members who remained in East Germany, i.e., in the newly constituted GDR. In general, settlement patterns of these refugees were largely determined by the extent of war destruction and thus available housing.[34] This historical development creates a link between social ties of West German regions to East Germany and

[34] Mobility of the households across West German regions, which would confound our link between the level of war destruction and refugees settlements, was low during this period. In addition, there was no strategic bombing during time the when the most of the housing was destroyed in WW II (see Brakman et al. 2004), which would dilute the exogeneity of the instrument.

the level of (exogenously given) war destruction, which we exploit for identification of our causal effect.

The relevance of the instrument can be directly inferred from the first-stage relationship. The first stage results for overall inventor flows are documented in the appendix (Table A5). War destruction has a partial effect of -0.117 on the regional intensity of social ties to East Germany. The effect is significant at the level of $p<0.01$. The F-test on excluded instruments in the first stage regression confirms that our IV strategy is justified as the critical value is exceeded (first stage F-Value = 24.045, $p<0.01$). Durbin-Wu-Hausman tests furthermore confirm that, given the presence of endogeneity, the instrumental variable approach is appropriate.[35]

Our main results obtained from the two stage least squares regression (2SLS) are presented in Table 3 separately for the star and the non-star inventors. Full results including coefficient estimates for all regressors are given in Table A6.

[Table 3 about here]

For brevity, the coefficients of controls are omitted, but the specifications use the same set of variables as in Table 2 (columns Ia, Ib). Column I of Table 3 presents the compact results from the pooled OLS specification in the main results (see also Table 2, column Ia, Ib). Column II is the respective pooled OLS estimate that is based on the restricted sample of 72 regions for which we have valid information for our instrument variable. Column III shows the main estimate obtained from the second stage in the 2SLS estimation. The main estimates for the non-star inventor migration inflows are reported in Panel A of Table 3. Column I and column II both show a positive and significant effect of social ties on the regional flow of non-star inventors. Both the positive sign and the significance of the effect are also retained when

[35] Durbin-Wu-Hausman test statistics: non-star inventor model: $F(1,349) = 2.568$; $p = 0.110$; star inventor model: $F(1,349) = 3.473$; $p = 0.063$.

applying the instrumental variable approach. The magnitude of the effect, however, is three times larger in the 2SLS estimation.

In quantitative terms, an increase in the social tie intensity of a region by one percentage point would cause the inflow of non-star inventors to rise by 0.67 percentage points. A standard deviation change in the regional social tie intensity would increase the inflow of non-stars by about 5.5 percentage points (i.e., the average region would receive two additional inventors). Results based on the star inventor sample and for the same specifications as above are reported in Panel B of Table 3. In accordance with the results obtained from the OLS estimations, we do not find any significant effect of the regional social ties intensity on the inflow of star inventor migrants. Due to less efficient identification in the IV regression and the marginal validity of the instrument for the sample (Durbin-Wu-Hausman statistic: $F(1,349) = 3.484$; $p = 0.063$), the sign of the estimated effect changes, but the effect remains insignificant. In general, our model for the star inventor sample does not perform as well as for the non-stars sample as the goodness of fit statistics indicates. However, this is to be expected if star inventors can afford to follow idiosyncratic preferences which are not adequately captured in our aggregate data.

5.3 Robustness Tests

Our main results on the interrelationship between social ties and patenting performance are robust to a set of tests that address potential issues with our main variables and identification strategy (see Table A7). We first used alternative definitions of (non-)star inventors to construct migration flows, i.e., we tested whether the arbitrary choice of star inventors being identified by having at least one cited patent prior to 1990 in their portfolio is determining our findings (Table A7 – Panel A). In line with earlier studies (e.g., Moretti and Wilson 2015) we define the sample split at the 90^{th} percentile in the distribution of the number of patent filings of East German inventors. This new split into subsamples accounts for problems that might arise from the censoring of citations for patents filed just before the reunification. With respect to the number of stars and non-stars, the split yields sub-sample sizes similar to the split used in our main results. Our regressions using the alternative sample split yield very similar regression results in general and again robust point estimates of the social tie effect. This holds both for the pooled OLS as well as the IV regressions.

The second test splits the inventor sample into a group of inventors who are reported to have an academic degree according to their employers in West Germany and those who did not obtain such a degree (Table A7 – Panel B). With this sample split we test whether formal productivity information such as school education certificates may be used as a substitute of social ties in the presence of asymmetric information. Since our inventors (average age 43 years of age in 1990) had all passed through the GDR education system, we can reliably infer the effect of standardized certificates. The share of academic inventors among the migrants amounts to 59%, leading to a more equal size of the groups. Running the same regressions as for the star- and non-star inventors we do not find statistically significant results of social ties intensity neither for the academic nor on the non-academic inventors. This result is consistent with the view that patents are a verifiable productivity indicator, while country specific (and partly obsolete) GDR education certificates are not.

Our third robustness test explores whether a less restrictive measurement of the social tie intensity variable affects our results (Table A7 – Panel C). Towards this objective we computed the social tie intensity of a West German region to East Germany based on all reported cross border ties in the GSOEP, i.e., by counting households with friends in addition to those with family relatives, divided again by the number of responding households in the region. This extended definition of social ties now comprises strong ties, represented by relatives, and weak ties, represented by friends. For the latter, we expect endogeneity concerns in terms of measurement error to be more relevant than for relatives. The social tie measure based on relatives and the combined indictor are highly correlated (ρ= 0.832), indicating that households with relatives in the East were also more likely to have access to further social relationships across the border. This is in line with our general hypothesis relating to the function of social networks as bridges to information. Re-estimating our regressions using the alternative social tie indicator yields similar results for our main effect. Including weak (friendship) ties in our social ties measure yields a social tie effect that is even stronger for non-star inventor migration than in our earlier results, but only marginally significant. Again, we obtain an insignificant effect for star inventors.

In our fourth robustness test we exchange social tie intensity computed from GSOEP data by an alternative indicator derived from West German census data in 1961 (Table A7 – Panel D). These data report also expellees from territories that were part of Germany until 1945. Expellees who arrived in the West via East Germany are only one group of migrants constituting potential social ties. Former East Germans who also migrated to the West without being expellees are not recorded separately in the census. Since expellees and other migrants from East Germany arrived at the same time in the West, they faced similar constraints with respect to the availability of housing and socio-economic integration. Thus, we argue that census data on expellee settlement patterns in the West give us a good approximation of the geographical distribution of social ties to East Germany (Burchardi and Hassan 2013). We use the share of expellees who arrived via East Germany in each region as an alternative social tie indicator to model migrant inflows in West German regions. Our main findings about the use of social ties remain robust to this alternative specification. However, social ties indicated by expellees represent only a fraction of the actual social ties and therefore constitute rather a lower bound estimate. Social ties obtained from the GSOEP provide us with a more accurate estimate of the effect of interest.

Our fifth robustness test checks whether our migration measure is prone to problems resulting from commuting into West German border regions (Table A7 – Panel E). Identification of migration in our case is solely based on the inventors' place of work, since we lack data on their place of residence after 1990. Commuting might therefore be a substitute to migration, and we would overestimate the amount of migrants in border regions. Indeed, commuting was an important part of early economic integration of East and West Germany and had important implications for migration patterns (Burda and Hunt 2001). Since border regions tend to have higher social tie intensity, this effect might partially drive our results. To rule this out we estimate our models excluding the ten destination regions sharing a border with East Germany. Due to the size of the regions and their travel to work nature, the amount of commuters should be negligible after this adjustment. Our findings based on the reduced sample of 64 West German regions are very similar to the results obtained from the full sample, which indicates that (potential) commuting does not affect bias our results.

Finally, we have tested whether citations to GDR patents prior to 1990 are substitutes for social ties (Table A8). West German regions that hosted many inventors and firms that had recognized and heavily cited[36] GDR patented inventions prior to 1990 might be more inclined to hire inventors familiar with these technologies. To test for this alternative cross border tie, we pooled all citations to GDR patent filings originating from the 74 West German regions over the years from 1987 to 1989 and constructed this alternative measure of an East-to-West tie. The region average of citations to GDR patents amounted to 18.18 (std. dev. 22.57). Inventors in two regions (*Emsland* and *Süd-West Schleswig-Holstein*) did not cite any GDR patent between 1987 and 1989. Despite patent citations being an imperfect measure for knowledge spillovers, their use here provides us with a reasonable approximation of markets for technologies in West Germany, and regional heterogeneity in the potential demand for East German inventors related to specific technologies of relevance in the GDR. Substituting the social tie intensity with this alternative citation-based indicator in the pooled OLS models yields only statistically

[36] Note, that we are not able to distinguish between actual citations made by the inventors or citations that were added in the process of patent examination by the examiner.

insignificant coefficients (positive sign for star and negative sign for non-star inventors). We conclude from this test that labor market access of inventors in West Germany did not benefit from potential demand side effects that can be traced by patent citations from West German regions to GDR patents.

5.4 Labor Market Outcomes

A final check concerns labor market outcomes. Our results imply that migrant star inventors were able to find attractive employment opportunities without making use of social ties. For this result to be incentive-compatible, labor market outcomes for stars should dominate outcomes of non-star inventors. We confirm that this implication is indeed supported by the data.

[Table 4 about here]

In Table 4, we report a set of labor market outcomes for all migrant inventors who moved from East Germany to the West between 1990 and 1994, and for the two subgroups. Star inventors were more successful in terms of their first job in the West: their deflated gross daily wage of 93.4 Euros was significantly higher than the wage of non-star inventors (88.8 Euros). Moreover, the share of star inventors with wages above the social security limit was higher than the respective share of non-star inventors (Panel A). We also consider how labor market outcomes evolved over time (Panel B). While we do not find significant differences between cumulative employment durations, cumulative gross wages remain significantly higher for star-inventors. Star inventors were apparently able to achieve favourable labor market outcomes without resorting to social ties for forging their first employment relationship in the West German labor market.

6. Conclusions

The role of social ties has been emphasized in many recent social sciences studies and in economic modeling. In quasi-experimental settings, a number of authors have found support for the notion that social ties facilitate investment and information flows related to migration decisions, employment, borrowing, and insurance. However, the exact mechanisms at work are still largely unclear and deserve more attention. Moreover, providing evidence that social ties cause improvements in economic transactions is challenging given the endogenous nature of social tie formation. Finally, it is unclear whether social ties are used by all agents or predominantly by particular groups, i.e., agents who are particularly dependent on others for the pledge of social capital or on information flows via networks. Empirical results supporting the latter would also provide indirect support for the notion that social ties are more relevant to economic agents in the presence of asymmetric information.

This paper supplies such evidence. We study the role of social ties when some agents have access to publicly observable quality indicators which attest to outstanding achievements. We use the migration of East German inventors to Western Germany after the fall of the Iron Curtain as our empirical setting, thus exploiting the German reunification process as a natural experiment. We construct a unique data set combining GDR patent track records at the inventor level with very precise German social security data for the post-unification employment careers of inventors. These unique data enable us to characterize East German inventors in detail and track their migration to the West accurately in terms of timing and geographical scope. The harsh separation between the East and West German economies provides us with an ideal setting in which we can study the migration of inventors whose track record of patent contributions is observable both by West German employers and by us. Given that the GDR operated a patent system, which was comparable with the West German system in the requirements and procedures of obtaining patent protection, we identify a group of star inventors and less visible inventors. We use this differentiation to test for differences in the dependence on social ties.

Our empirical analysis shows that the likelihood and timing of a migration decision, i.e., labor market entry of an inventor in West Germany after reunification is subject to substantial selection effects. We show that inventor demographics are important for understanding migration of East German inventors but also that one selection mechanism is directly related the publicly-observed productivity of the inventor. We demonstrate that inventors that are more productive were more likely to migrate to the West after the Iron Curtain vanished. More importantly, we show that social ties which can reduce informational frictions and provide access to important job-related networks in potential destination regions have a significant and positive impact on aggregate migration flows. We conclude that social ties matter for explaining migration patterns, but apparently only for the (non-star) inventors who do not have publicly observable quality information at their avail. Using an instrumental variables approach based on the spatial variation in historical war destruction across regions in West Germany, we show that our results hold up when the social ties variable is instrumented. While we find a consistent positive effect of social tie intensity and cross-border networks on the inflows non-star inventors in 2SLS estimates, no such effect is found for the flows of star inventors. We argue that this result is due to the lower dependence of these highly visible stars on social networks in the labor market access.

Finally, our results are complementary to Burchardi and Hassan (2013) who argue that in the economic Gold-rush starting in 1990, West German entrepreneurs and investors in regions with particularly strong social ties to the East were advantaged and had superior information for their own entrepreneurial and investment decisions targeted towards East Germany. While we have no reason to question this potential mechanism, our results point to another possible channel: the information needed for making the particularly profitable decisions may have been supplied by the inflow of East Germans carrying the information. Social ties may have facilitated the mobility of these individuals, but social ties may not have been fully responsible for the direct transfer of information from the East to the West. We leave it to future studies using larger and less specific samples to distinguish more clearly between these alternative mechanisms. However, we consider our results as strong support for the notion that aggregate labor market mobility is impacted by the pre-existing social ties (Borjas and Bronars 1992; Wegge 1998).

Our contribution hopefully sheds new light on social ties and networks. Our results are consistent with the view that social ties are a substitute for meritocratic, publicly visible information and that they provide alternative channels of access to the labor market (e.g., via "pledged" social capital). In this function, social ties help to overcome the curse of asymmetric information and truly contribute to "democratize" labor markets and other institutions for the less outstanding individuals. Conversely, "stars" apparently do not strongly depend on the existence of social ties.

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Table 1 Summary statistics of regional level variables

	Data	Mean	Std. dev.	Min	Max
Total regional inflow					
- all inventors	IAB, DPMA	69.15	71.92	9	388
- non-star inventors		61.16	63.52	6	336
- star inventors		7.99	8.78	0	52
Total regional inflow, 1990-1994 only					
- all inventors	IAB, DPMA	42.04	43.90	5	231
- non-star inventors		37.11	38.70	2	196
- star inventors		4.93	5.69	0	35
Annual regional inflow, 1990-1994 only					
- all inventors	IAB, DPMA	8.41	11.64	0	72
- non-star inventors		7.42	10.30	0	58
- star inventors		0.99	1.69	0	14
Social tie intensity of region to East Germany	GSOEP	17.41	8.23	2.00	48.26
Distance to East Germany (km)	BKG	151.84	80.46	17.72	328.52
Residential population (in 1,000), 1989	Destatis	818.22	579.62	255.03	2905.53
Population density (pop. / km²), 1989	Destatis	318.46	363.01	73.40	2144.47
Wage differential to East Germany, 1989	IAB, GSOEP	3.37	0.23	2.96	3.85
Share of high skilled workers, 1989	IAB	4.60	1.74	2.08	10.92
Unemployment rate, 1989	FEA	7.09	2.60	3.40	12.46
Number of patents per 1,000 inhabitants, 1989	Patstat	85.02	62.66	9.85	382.79
Avg. number of citations per patent, 1989	Patstat	0.79	0.24	0.29	1.51

Note: 74 regions (*Raumordnungsregionen*) in West Germany; Berlin (East and West) as migration destination region excluded. Distance to East Germany: shortest distance in kilometers between a municipality centroid within a western region and municipality centroid in East Germany; Wage differential to East: median gross monthly wages of employees in West German regions (SIAB 7510) / median gross monthly wages in East Germany as reported to the GSOEP (Wave 1991); Avg. number of citations per patent is computed from total number of citations a focal patent in a region received within 3 years after the priority date from other patents.

Table 2 Model of regional migrant inflows for non-star and star inventors

	Non-star inventors						Star inventors					
	(Ia)		(IIa)		(IIIa)		(Ib)		(IIb)		(IIIc)	
Social tie intensity	0.171	**	0.175	***	0.204	**	-0.059		-0.057		-0.031	
	(0.087)		(0.059)		(0.082)		(0.058)		(0.052)		(0.082)	
Social tie intensity # 1992, 1993, 1994 (d)	-		-		-0.049		-		-		-0.042	
					(0.096)						(0.086)	
Joint F-test (2,73)	-		-		4.410	**	-		-		0.880	
Distance to border (in km)	-0.365	***	-0.364	***	-0.364	***	-0.160	***	-0.159	***	-0.159	***
	(0.062)		(0.039)		(0.039)		(0.044)		(0.039)		(0.039)	
Residential population (in 1,000)	0.868	***	0.88	***	0.88	***	0.462	***	0.467	***	0.467	***
	(0.107)		(0.065)		(0.065)		(0.075)		(0.064)		(0.064)	
Population density	0.138		0.136	**	0.136	**	-0.078		-0.079		-0.079	
	(0.098)		(0.059)		(0.059)		(0.075)		(0.061)		(0.061)	
Wage differential to East Germany	0.115		0.341		0.34		1.187		1.287	*	1.286	*
	(1.249)		(0.878)		(0.877)		(0.806)		(0.712)		(0.712)	
Share of high skilled workers	0.317		0.322	**	0.322	**	0.222		0.224		0.224	
	(0.233)		(0.150)		(0.149)		(0.165)		(0.148)		(0.148)	
Unemployment rate	-0.42	***	-0.469	***	-0.469	***	-0.107		-0.129		-0.129	
	(0.159)		(0.108)		(0.108)		(0.122)		(0.110)		(0.110)	
Number of patents / 1,000 inhab.	0.134		0.08		0.08		0.02		-0.004		-0.004	
	(0.096)		(0.067)		(0.067)		(0.073)		(0.068)		(0.068)	
Avg. number of citations / patent	-0.375		-0.314		-0.314		0.005		0.033		0.033	
	(0.345)		(0.240)		(0.241)		(0.246)		(0.211)		(0.212)	
Constant	-4.231		-4.768		-4.846		-8.601	**	-8.785	**	-8.669	**
	(6.732)		(4.682)		(4.675)		(3.552)		(3.678)		(3.529)	
Year dummies	No		Yes		Yes		No		Yes		Yes	
Adjusted r-squared	0.481		0.771		0.770		0.286		0.446		0.445	
Number of obs. (regions x yrs.)	370		370		370		370		370		370	

Note: All regressors are log transformed and measured in 1989; robust standard errors in parentheses; statistical significance: * p<0.10, ** p<0.05, *** p<0.01.

Table 3 Instrumental variables estimates (2SLS) of regional migration inflows

Panel A – Non-star inventors

	POLS (Ia)		POLS (IIa)		2SLS (IIIa)	
Social tie intensity	0.175	**	0.190	**	0.676	**
	(0.087)		(0.090)		(0.324)	
IV: War destruction 1946 / 1939	No		No		Yes	
Regional characteristics	Yes		Yes		Yes	
Durbin-Wu-Hausman test: Chi² (1)					2.586	
F-test (1, 349)					2.621	
Adjusted r-squared	0.479		0.481		0.440	
Number of obs. (regions x yrs.)	370		360		360	

Panel B – Star inventors

	POLS (Ib)		POLS (IIb)		2SLS (IIIb)	
Social tie intensity	-0.056		-0.076		0.278	
	(0.058)		(0.060)		(0.207)	
IV: War destruction 1946 / 1939	No		No		Yes	
Regional characteristics	Yes		Yes		Yes	
Durbin-Wu-Hausman test: Chi² (1)					3.529	*
F-test (1, 349)					3.484	*
Adjusted r-squared	0.285		0.288		0.230	
Number of obs. (regions x yrs.)	370		360		360	

Note: All regressors are log transformed and measured in 1989; specifications IIa and IIb use sample of 72 regions with valid data on war destruction; full results including coefficient estimates for all regressors are given in Table A6; tests using the Stata command *suest* and stacked IV models show that the marginal effects of the social tie intensity are unequal (p<0.01) between the star and the non-star inventor sample; robust standard errors in parentheses; statistical significance: * p<0.10, ** p<0.05, *** p<0.01.

Table 4 Labor market outcomes of migrant inventors in West Germany

	All inventors (I)		Star inv. (II)		Non-star inv. (III)		t-test	
	Mean	SD	Mean	SD	Mean	SD	Diff. (II) - (III)	p-value
Panel A – First job in West Germany								
Full time job at entry (d)	0.97	0.17	0.98	0.13	0.97	0.17	0.01	[0.146]
Gross daily wage (Euros) at entry, full time jobs only	89.54	29.00	95.35	29.81	88.75	28.81	6.59	[0.000]
Wage above social security contribution limit at entry, full time jobs only (d)	0.11	0.32	0.21	0.41	0.10	0.30	0.11	[0.000]
Panel B – Cumulative experience and wage income								
Cumulative gross wage income (Euros): 12 months from entry	33,046	10,951	35,205	10,846	32,759	10,935	2,446	[0.000]
24 months from entry	66,314	21,752	70,344	21,557	65,778	21,726	4,567	[0.000]
36 months from entry	100,950	33,380	106,650	33,405	100,192	33,309	6,458	[0.001]
48 months from entry	135,736	45,753	143,005	45,802	134,769	45,668	8,236	[0.001]
Cumulative employment duration (months): 12 months from entry	11.83	0.89	11.83	0.80	11.83	0.90	0.00	[0.969]
24 months from entry	22.57	1.89	22.66	1.62	22.56	1.93	0.10	[0.339]
36 months from entry	34.14	3.30	34.29	3.20	34.12	3.31	0.18	[0.342]
48 months from entry	45.51	5.15	45.76	4.95	45.48	5.18	0.29	[0.320]
Job in entry establishment after 48 months (d)	0.27	0.45	0.24	0.43	0.28	0.45	-0.03	[0.189]
Number of establishments 48 months after entry	1.39	0.76	1.33	0.70	1.40	0.76	-0.07	[0.093]

Note: Only migrant inventors entering West Germany between 1990 and 1994 (N = 3,111); in Panel B: only inventors with employment records for at least 4 yrs. after migration date; wages in Euros, prices deflated to year 2000; wages in Panel A and cumulative gross wage income in Panel B are computed using censored wages; the social security contribution limit for annual gross earnings in West Germany varied between 38,660 EUR in 1990 and 50,300 EUR in 1997.

Figure 1 Regional distribution of East German inventors prior to German reunification

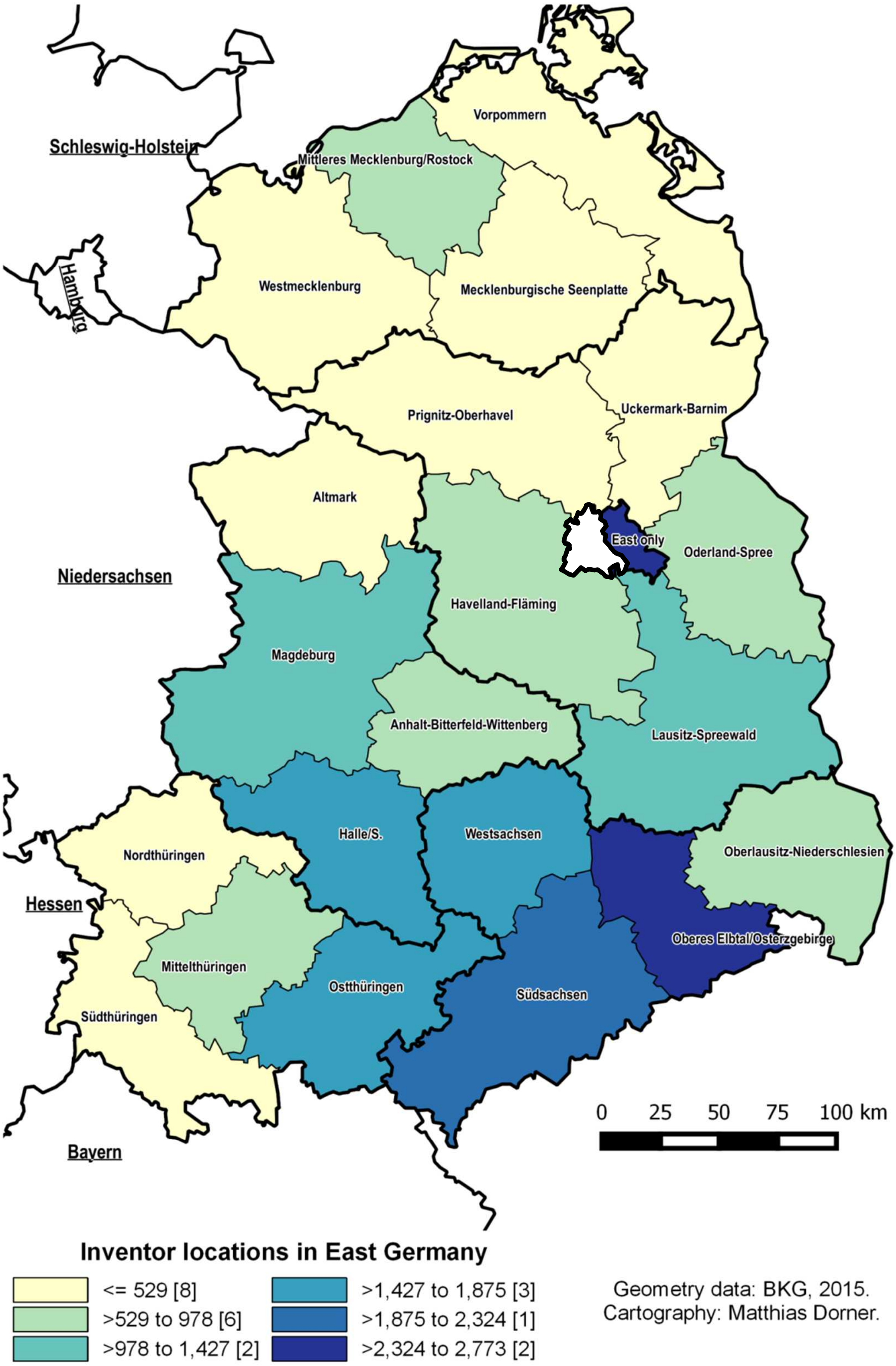


Figure 2 Annual incidence of East to West inventor migration

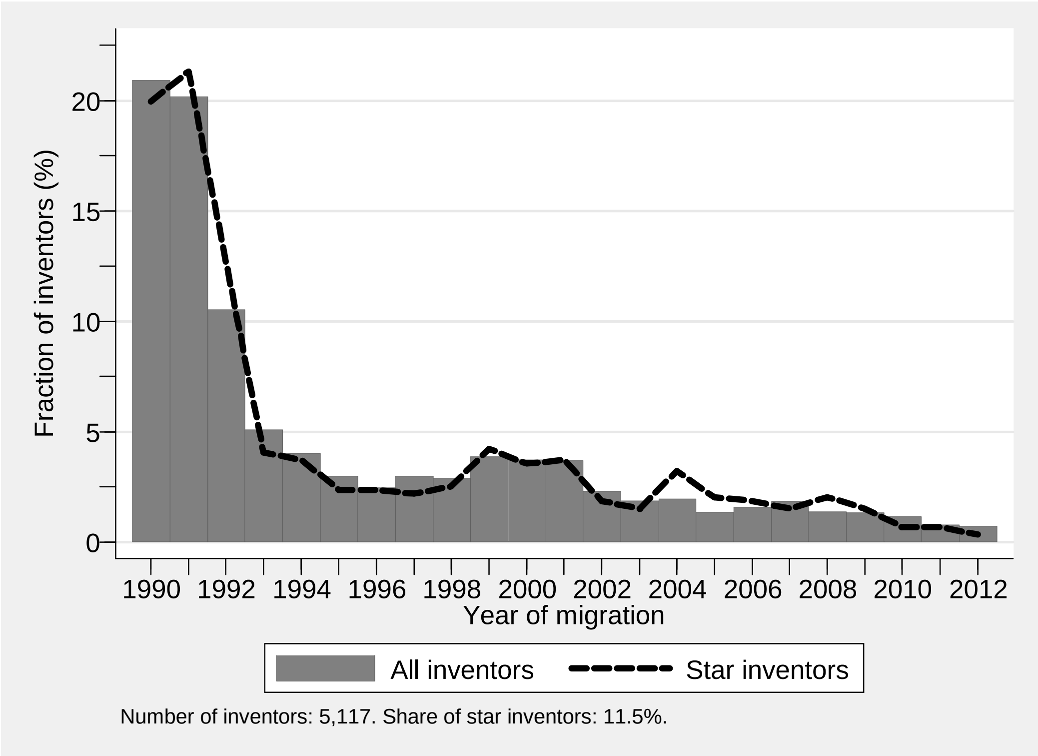
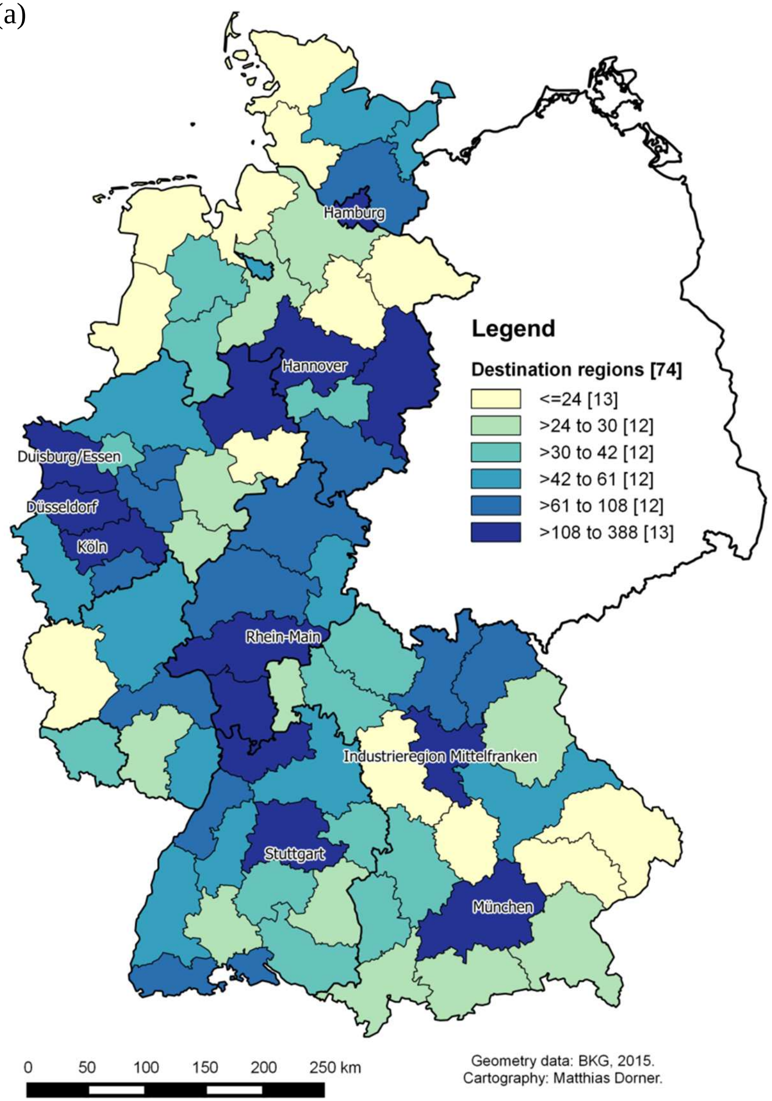


Figure 3 Inventors inflows in West German regions and intensity of social ties to East Germany

(a)



(b)

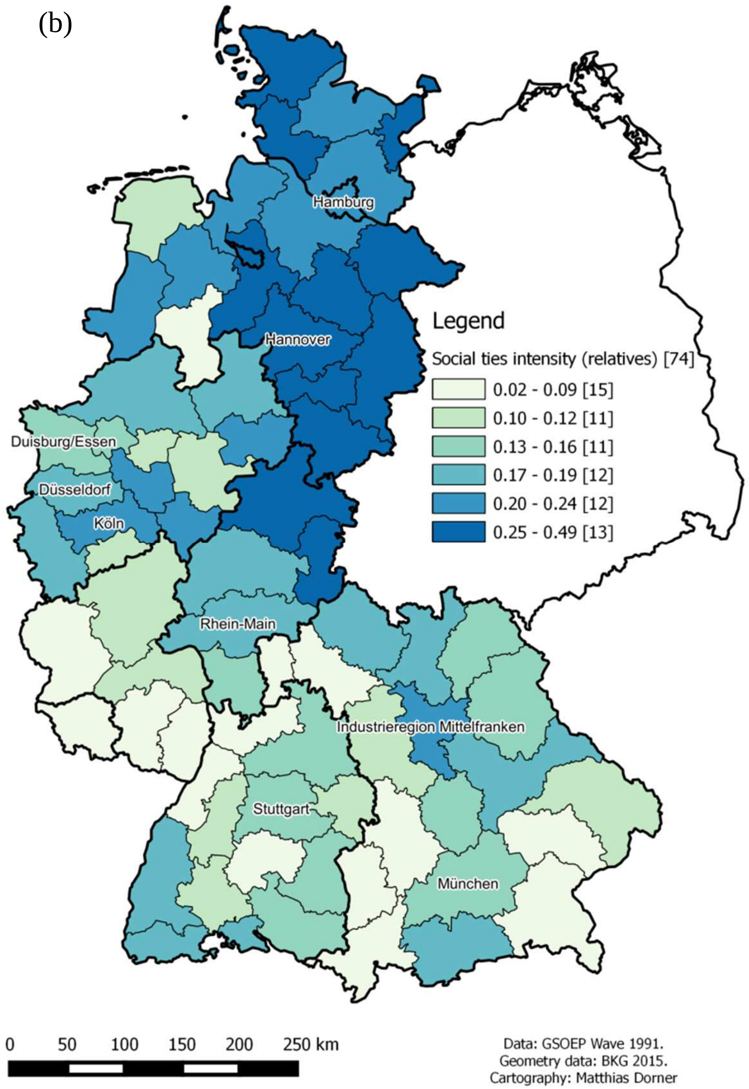
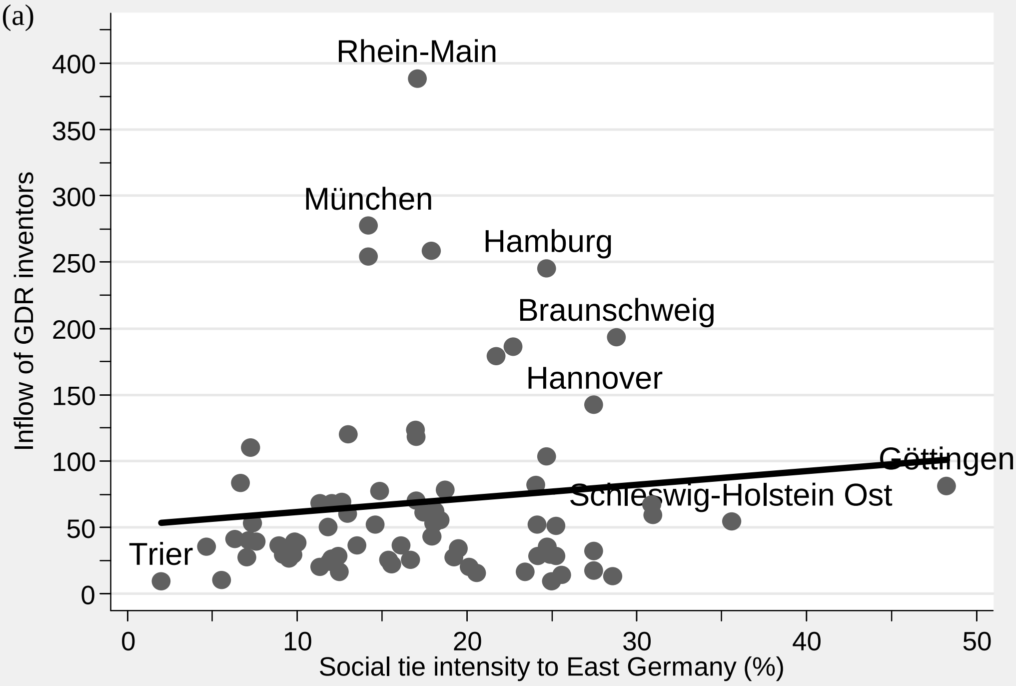


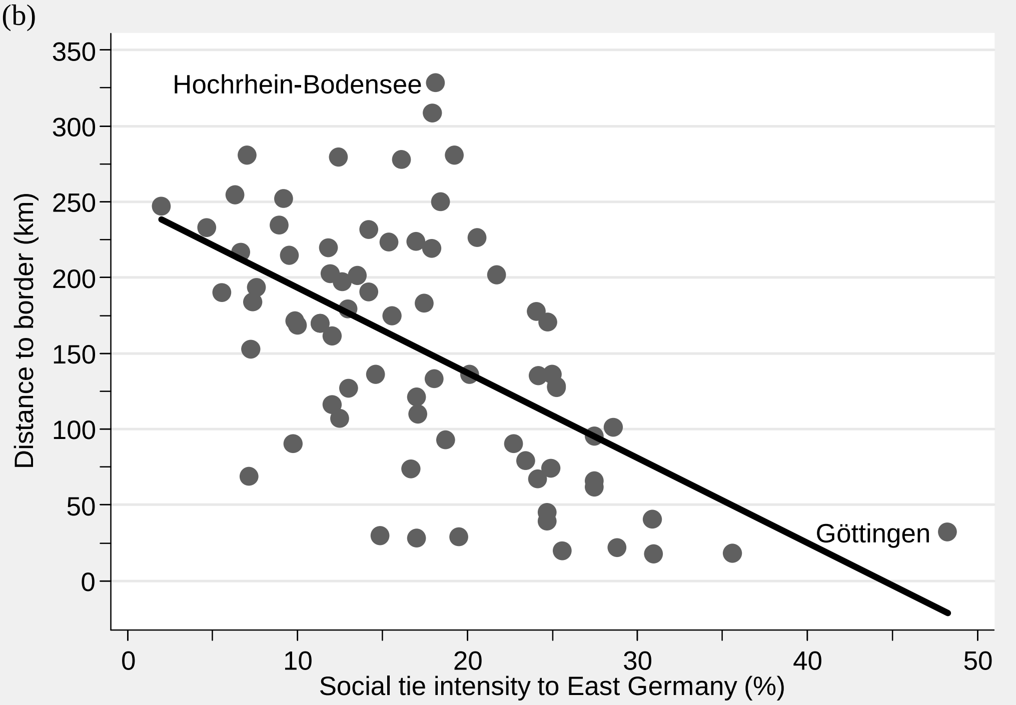
Figure 4 Scatterplots of social tie intensity with inventor inflows and distance to border

(a)



Number of regions ('Raumordnungsregionen') = 74.

(b)



Number of regions ('Raumordnungsregionen') = 74.

Appendix

Table A1 Summary statistics of migrant and star inventors

	Migrant inv.		Stayer inv.		t-test		Star inv.		Non-star inv.		t-test	
	Mean	SD	Mean	SD	Diff.	p-value	Mean	SD	Mean	SD	Diff.	p-value
Male (d)	0.908	0.289	0.879	0.326	0.029	[0.000]	0.907	0.291	0.908	0.289	0.001	[0.914]
Age in 1990 (yrs.)	39.096	7.844	45.046	8.864	-5.950	[0.000]	41.716	7.346	38.754	7.844	-2.962	[0.000]
Academic degree (d)	0.585	0.493	0.556	0.497	0.029	[0.000]	0.626	0.484	0.580	0.494	-0.047	[0.031]
DD patents, count	3.266	5.525	3.377	6.443	-0.111	[0.265]	8.369	11.865	2.600	3.509	-5.769	[0.000]
DD patents, fractional count	1.027	1.883	0.995	1.617	0.032	[0.231]	2.466	4.018	0.839	1.264	-1.627	[0.000]
DD patents 1987-1989, count	1.294	2.456	1.227	2.636	0.067	[0.105]	2.635	4.756	1.119	1.899	-1.515	[0.000]
DD patents 1987-1989, fractional count	0.401	0.927	0.352	0.715	0.050	[0.000]	0.770	1.873	0.353	0.702	-0.417	[0.000]
Patents prior to 1987 (d)	0.293	0.455	0.242	0.428	0.051	[0.000]	0.044	0.205	0.326	0.469	0.282	[0.000]
Citations to DD patents until 1989, count	0.186	0.660	0.214	0.972	-0.028	[0.054]	-	-	-	-	-	-
Citation to any DD patent until 1989 (d)	0.115	0.320	0.119	0.324	-0.004	[0.443]	-	-	-	-	-	-
Exclusion patents until 1988, count	0.203	0.817	0.224	0.851	-0.020	[0.131]	0.523	1.749	0.162	0.584	-0.361	[0.000]
Exclusion patents until 1988 (d)	0.122	0.327	0.134	0.341	-0.012	[0.028]	0.195	0.396	0.113	0.316	-0.082	[0.000]
Contribution to patent family (d)	0.019	0.138	0.019	0.135	0.001	[0.755]	0.076	0.265	0.012	0.109	-0.064	[0.000]
Last location in East Berlin (d)	0.127	0.333	0.126	0.332	0.001	[0.919]	0.110	0.313	0.129	0.335	0.019	[0.191]
Distance (in km) to border (log)	4.436	0.636	4.502	0.591	-0.066	[0.000]	4.410	0.636	4.440	0.636	0.030	[0.280]
Avg. number of co-inventors on DD patents	4.271	2.304	4.436	2.370	-0.164	[0.000]	4.555	2.214	4.234	2.314	-0.320	[0.001]
Number of inventors	N = 5,117		N = 16,818				N = 591		N = 4,526			
	23.3%		76.7%				11.5%		88.5%			

Note: Total number of inventors N = 21,935; levels of statistical significance * p<0.1; ** p<0.05; *** p <0.01; (d) indicates dummy variables; Distance (in km) to border: shortest distance between centroid of municipality of origin in East Germany and a municipality centroid in West Germany.

Table A2 Migration hazard estimates

	(I)		(II)	
Male (d)	1.745	***	1.745	***
	(0.087)		(0.087)	
Age in 1990 (log)	0.119	***	0.120	***
	(0.008)		(0.008)	
University degree (d)	0.937	**	0.939	**
	(0.028)		(0.028)	
Number of patents 1987-1989 (log)	1.115	***	-	
	(0.029)			
Patents prior to 1987 (d)	0.910	***	-	
	(0.032)			
Number of patents (fractional counts) 1987-1989 (log)	-		1.227	***
			(0.058)	
Patents prior to 1987 (d)	-		0.923	**
			(0.031)	
At least one exclusion patent until 12/1988 (d)	0.951		0.957	
	(0.045)		(0.044)	
Citation to at least one patent until 12/1989 (d)	1.108	**	1.108	**
	(0.052)		(0.052)	
Contribution to patent family (d)	1.040		1.041	
	(0.111)		(0.110)	
Origin East Berlin (d)	1.111	**	1.110	**
	(0.049)		(0.049)	
Distance (in km) to border (km, log)	0.856	***	0.857	***
	(0.021)		(0.021)	
Controls (incl. technology dummies)	Yes	***	Yes	***
Pseudo r-squared	0.011		0.011	
Log likelihood	-48810.85		-48809.97	
Number of failures (= migration)	5,117			
Number of inventors	21,935			

Note: Coefficients are hazard ratio estimates; controls include the average number co-inventors on GDR patents and 32 technology area dummies according to Schmoch (2008); robust std. errors in parentheses; statistical significance: * p<0.10, ** p<0.05, *** p<0.01.

Table A3 Correlation matrix of regional level variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	Social tie intensity	1.00								
(2)	Distance to border (km)	-0.52	1.00							
(3)	Residential population (in 1,000), 1989	0.06	0.15	1.00						
(4)	Population density, 1989	0.10	0.03	0.57	1.00					
(5)	Wage differential to East Germany, 1989	0.05	0.12	0.71	0.64	1.00				
(6)	Share of high skilled workers, 1989	0.07	0.12	0.66	0.53	0.80	1.00			
(7)	Unemployment rate, 1989	0.43	-0.31	0.11	0.31	0.02	-0.03	1.00		
(8)	Number of patents / 1,000 inhabitants, 1989	-0.22	0.30	0.42	0.14	0.60	0.51	-0.48	1.00	
(9)	Avg. number of citations per patent, 1989	-0.18	0.12	0.25	0.10	0.36	0.35	-0.43	0.54	1.00

Note: Number of regions N = 74.

Table A4 First stage regression of 2SLS estimator

	(I)	
Instrument variable: War Destruction 1946 /1939	-0.117	***
	(0.024)	
Distance to border (km)	-0.345	***
	(0.032)	
Residential population (in 1,000)	0.067	
	(0.049)	
Population density	-0.139	***
	(0.045)	
Wage differential to East Germany	1.984	***
	(0.623)	
Share of high skilled workers	0.259	***
	(0.094)	
Unemployment rate	0.547	***
	(0.075)	
Number of patents / 1,000 inhab.	0.011	
	(0.072)	
Avg. number of citations / patent	-0.072	
	(0.246)	
Constant	-7.922	**
	(3.369)	
F-test (1,350)	24.045	***
Adjusted r-squared	0.481	
Number of obs. (regions x yrs.)	360	

Note: All regressors log transformed and measured in 1989; instrument variable: share of destroyed housing 1946 / 1939; robust standard errors in parentheses; statistical significance: * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table A5 Models of regional migrant inflows for all inventors

	POLS (I)		POLS (II)		POLS (III)		2SLS (IV)	
Social tie intensity			0.118	**	0.129		0.582	*
			(0.058)		(0.094)		(0.330)	
Distance to border (km)	-0.418	***	-0.380	***	-0.376	***	-0.225	*
	(0.038)		(0.043)		(0.064)		(0.125)	
Residential population (in 1,000)	0.906	***	0.909	***	0.908	***	0.910	***
	(0.067)		(0.066)		(0.108)		(0.109)	
Population density	0.097	*	0.112	**	0.100		0.169	
	(0.057)		(0.055)		(0.101)		(0.114)	
Wage differential to East Germany	0.741		0.656		0.545		-0.218	
	(0.885)		(0.878)		(1.334)		(1.413)	
Share of high skilled workers	0.275	**	0.241	*	0.237		0.126	
	(0.134)		(0.133)		(0.191)		(0.217)	
Unemployment rate	-0.363	***	-0.426	***	-0.393	**	-0.631	**
	(0.096)		(0.096)		(0.164)		(0.256)	
Number of patents / 1,000 inhab.	0.104	*	0.093	*	0.111		0.104	
	(0.059)		(0.050)		(0.103)		(0.106)	
Avg. number of citations / patent	-0.368		-0.330		-0.299		-0.221	
	(0.226)		(0.220)		(0.372)		(0.388)	
Constant	-6.939		-6.859		-6.340		-3.642	
	(4.836)		(4.808)		(7.242)		(7.414)	
Year dummies	No		No		No		No	
Durbin-Wu-Hausman Test: Chi² (1)	-		-		-		2.129	
F-Test (1, 349)	-		-		-		2.143	
Adjusted r-squared	0.478		0.479		0.482		0.447	
Number of obs. (regions x yrs.)	370		370		360		360	

Note: All regressors are log transformed and measured in 1989; robust standard errors in parentheses; statistical significance: * p<0.10, ** p<0.05, *** p<0.01.

Table A6 Models of regional migrant inflows for non-star and star inventors – Full results

	Non-star inventors				Star inventors			
	POLS (Ia)	POLS (IIa)	POLS (IIIa)	2SLS (IVa)	POLS (Ib)	POLS (IIb)	POLS (IIIb)	2SLS (IVb)
Social tie intensity	0.175 ***	0.175 **	0.190 **	0.676 **	-0.056	-0.056	-0.076	0.278
	(0.058)	(0.087)	(0.090)	(0.324)	(0.057)	(0.058)	(0.060)	(0.207)
Distance to border (km)	-0.364 ***	-0.364 ***	-0.358 ***	-0.196	-0.159 ***	-0.159 ***	-0.170 ***	-0.052
	(0.044)	(0.062)	(0.063)	(0.120)	(0.031)	(0.044)	(0.045)	(0.078)
Residential population (in 1,000)	0.882 ***	0.882 ***	0.881 ***	0.883 ***	0.470 ***	0.470 ***	0.477 ***	0.478 ***
	(0.066)	(0.107)	(0.107)	(0.108)	(0.069)	(0.075)	(0.075)	(0.076)
Population density	0.138 **	0.138	0.127	0.200 *	-0.078	-0.078	-0.090	-0.036
	(0.058)	(0.098)	(0.099)	(0.112)	(0.055)	(0.075)	(0.076)	(0.085)
Wage differential to East Germany	0.340	0.340	0.174	-0.644	1.336 *	1.336	1.677 **	1.081
	(0.908)	(1.256)	(1.320)	(1.400)	(0.676)	(0.813)	(0.852)	(0.907)
Share of high skilled workers	0.259 *	0.259	0.256	0.138	0.165	0.165	0.153	0.066
	(0.142)	(0.192)	(0.192)	(0.217)	(0.104)	(0.134)	(0.134)	(0.145)
Unemployment rate	-0.472 ***	-0.472 ***	-0.440 ***	-0.695 ***	-0.132	-0.132	-0.117	-0.303 *
	(0.093)	(0.161)	(0.162)	(0.250)	(0.132)	(0.123)	(0.126)	(0.180)
Number of patents / 1,000 inhab.	0.079 *	0.079	0.100	0.092	-0.004	-0.004	-0.025	-0.031
	(0.047)	(0.096)	(0.100)	(0.105)	(0.082)	(0.073)	(0.076)	(0.078)
Avg. number of citations / patent	-0.311	-0.311	-0.286	-0.202	0.037	0.037	0.090	0.151
	(0.215)	(0.345)	(0.355)	(0.377)	(0.197)	(0.246)	(0.251)	(0.262)
Constant	-5.205	-5.205	-4.392	-1.503	-9.018 **	-9.018 **	-10.831 **	-8.725 *
	(4.937)	(6.828)	(7.164)	(7.358)	(3.621)	(4.420)	(4.622)	(4.745)
Durbin-Wu-Hausman test: Chi² (1)	-	-	-	2.586	-	-	-	3.529 *
F-test (1, 349)	-	-	-	2.621	-	-	-	3.484 *
Standard errors	Clustered	Robust	Robust	Robust	Clustered	Robust	Robust	Robust
Adjusted r-squared	0.479	0.479	0.481	0.44	0.285	0.285	0.288	0.230
Number of obs. (regions x yrs.)	370	370	360	360	370	370	360	360

Note: All regressors log transformed and measured in 1989; instrument variable: share of destroyed housing 1946 / 1939; statistical significance: * p<0.10, ** p<0.05, *** p<0.01.

Table A7 Robustness tests for regional migrant inflows for non-star and star inventors

Panel A – Alternative star/non-star inventor definition based on DD patent quantity

	Non-star inventors (<p90)			Star inventors (≥p90)		
	POLS	POLS	2SLS	POLS	POLS	2SLS
	(Ia)	(IIa)	(IIIa)	(Ib)	(IIb)	(IIIb)
Social tie intensity	0.128	0.135	0.616 *	-0.025	-0.024	0.418 *
	(0.088)	(0.091)	(0.332)	(0.056)	(0.059)	(0.220)
Instrument: War destruction 1946 / 1939	No	No	Yes	No	No	Yes
Regional characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test: Chi² (1)	-	-	2.394	-	-	5.183 **
F-Test (1, 349)	-	-	2.429	-	-	4.905 **
Adjusted r-squared	0.470	0.473	0.432	0.305	0.298	0.214
Number of obs. (regions x yrs.)	370	360	360	370	360	360

Panel B – Alternative star/non-star inventor definition based on formal education

	Non-star inv. (no academ. degree)			Star inv. (academ. degree)		
	POLS	POLS	2SLS	POLS	POLS	2SLS
	(Ia)	(IIa)	(IIIa)	(Ib)	(IIb)	(IIIb)
Social tie intensity	0.089	0.065	0.625 **	0.094	0.124	0.458
	(0.079)	(0.081)	(0.300)	(0.080)	(0.084)	(0.313)
Instrument: War destruction 1946 / 1939	No	No	Yes	No	No	Yes
Regional characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test: Chi² (1)	-	-	4.275 **	-	-	1.283
F-Test (1, 349)	-	-	4.490 **	-	-	1.257
Adjusted r-squared	0.404	0.41	0.336	0.488	0.484	0.464
Number of obs. (regions x yrs.)	370	360	360	370	360	360

Panel C – Alternative social tie intensity (family relatives and friends)

	Non-star inventors			Star inventors		
	POLS	POLS	2SLS	POLS	POLS	2SLS
	(Ia)	(IIa)	(IIIa)	(Ib)	(IIb)	(IIIb)
Social tie intensity (friends and relatives)	0.150 *	0.163 *	0.927 *	-0.054	-0.076	0.381
	(0.083)	(0.086)	(0.482)	(0.056)	(0.059)	(0.295)
Instrument: War destruction 1946 / 1939	No	No	Yes	No	No	Yes
Regional characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test: Chi² (1)	-	-	3.266 *	-	-	2.937 *
F-Test (1, 349)	-	-	3.345 *	-	-	2.883 *
Adjusted r-squared	0.477	0.479	0.382	0.285	0.288	0.196
Number of obs. (regions x yrs.)	370	360	360	370	360	360

Panel D – Alternative social tie intensity (expellee data from West German census 1961)

	Non-star inventors			Star inventors		
	POLS	POLS	2SLS	POLS	POLS	2SLS
	(Ia)	(IIa)	(IIIa)	(Ib)	(IIb)	(IIIb)
Social tie intensity (expellees)	0.157 **	0.160 **	0.416 **	0.042	0.040	0.171
	(0.072)	(0.072)	(0.188)	(0.051)	(0.051)	(0.120)
Instrument: War destruction 1946 / 1939	No	No	Yes	No	No	Yes
Regional characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test: Chi² (1)	-	-	2.062	-	-	1.220
F-Test (1, 349)	-	-	2.062	-	-	1.176
Adjusted r-squared	0.48	0.482	0.462	0.285	0.287	0.273
Number of obs. (regions x yrs.)	370	360	360	370	360	360

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Panel E – Commuting (exclusion of border regions in West Germany)

	Non-star inventors						Star inventors					
	POLS		POLS		2SLS		POLS		POLS		2SLS	
	(Ia)		(IIa)		(IIIa)		(Ib)		(IIb)		(IIIb)	
Social tie intensity	0.194	**	0.210	**	0.675	**	-0.062		-0.087		0.235	
	(0.089)		(0.092)		(0.306)		(0.060)		(0.062)		(0.189)	
Instrument: War destruction 1946 / 1939	No		No		Yes		No		No		Yes	
Regional characteristics	Yes		Yes		Yes		Yes		Yes		Yes	
Durbin-Wu-Hausman test: Chi² (1)	-		-		2.747	*	-		-		3.499	*
F-Test (1, 349)	-		-		2.779	*	-		-		3.449	*
Adjusted r-squared	0.494		0.498		0.457		0.317		0.323		0.270	
Number of obs. (regions x yrs.)	320		310		310		320		310		310	

Note: Controls include the same set of regressors as in main specification; specifications IIa and IIb use sample of 72 regions with valid data on war destruction; robust standard errors in parentheses; statistical significance: * p<0.10, ** p<0.05, *** p<0.01.

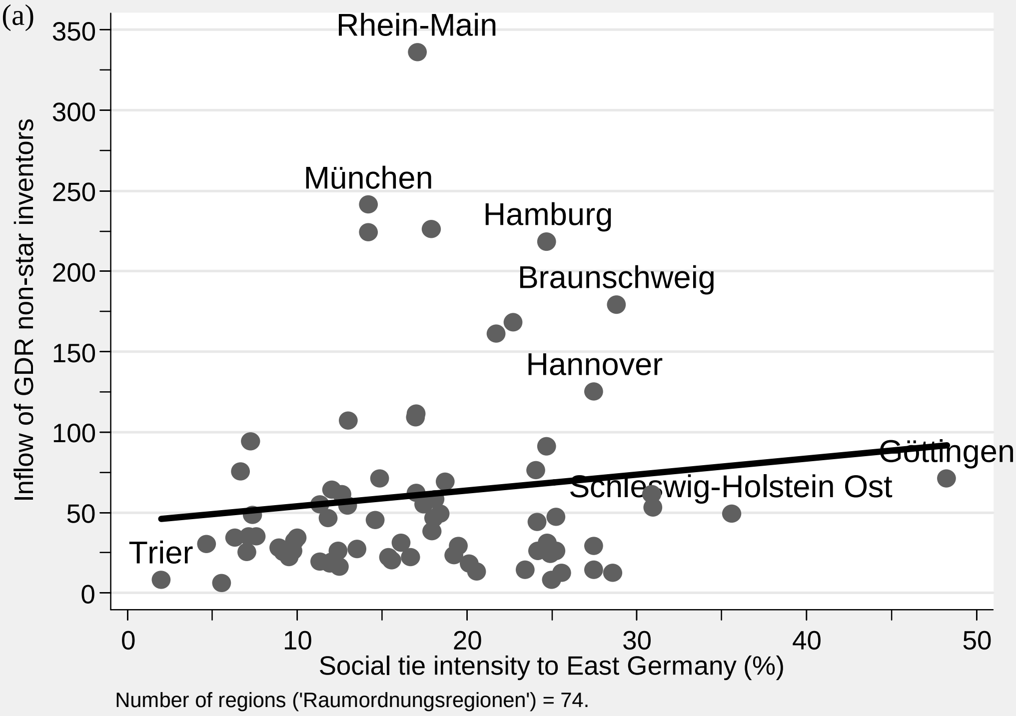
Table A8 Cross border citations as alternative social ties

	All inventors	Star inventors		Non-star inventors
	(I)	(II)		(III)
Citations to DD patents (filing years 1987-1989)	-0.047	0.008		-0.073
	(0.061)	(0.043)		(0.064)
Constant	-5.711	-8.849	**	-3.776
	(4.786)	(3.680)		(4.939)
Regional characteristics	Yes	Yes		Yes
Year dummies	Yes	Yes		Yes
Adjusted r-squared	0.785	0.444		0.766
Number of obs. (regions x yrs.)	370	370		370

Note: Citations to DD patents: total number of patents that had been filed by inventors residing in a particular West German region between 1987 and 1989 and who had cited GDR patents as relevant prior art for their invention; robust standard errors in parentheses; statistical significance: * p<0.10, ** p<0.05, *** p<0.01.

Figure A1 Scatterplots of social tie intensity with total inflows of non-star and star inventors

(a)



(b)

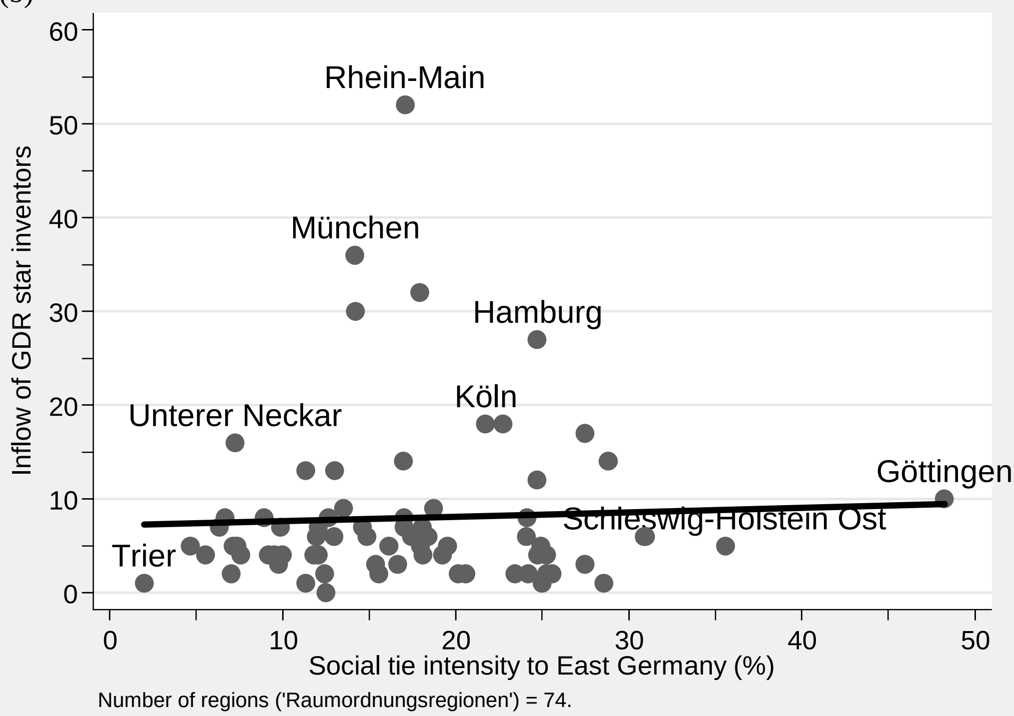


Figure A2 Population weighted share of destroyed dwellings during World War II (War destruction 1946 / 1939)