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Abstract:
We study location choices and firm performance in the German machine tool industry, focusing on the forced migration of East German firms after World War II. Our analysis of location choices supports earlier findings that industry agglomerations attract further entrants. Relocating firms outperformed entrants that possessed no prior industry experience; apparently were able to build on their prewar capabilities. We find no evidence suggesting that firm performance benefited from agglomeration effects.

Key words: Capabilities; agglomeration economies; location choice; firm survival; machine tool industry
Jel codes: L20; R20; R30

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1. Introduction

From the end of World War II in 1945 to the erection of the Berlin Wall in 1961, more than 2.5 million people left East Germany to settle in West Germany. Among them were thousands of business owners. Many reestablished their firms at new West German locations. To take but one example: Pfauter Co. was a Chemnitz-based maker of machine tools for gear production. In 1945 the company was managed by the founder's four sons. Subsequently, they were expropriated by the socialist government and the firm's facilities dismantled by the Soviet occupation forces. In 1949, three of the Pfauter brothers, joined by loyal employees, moved their company to Stuttgart, a city in southwest Germany. The remaining brother was detained by the Soviets. At its new location, the firm again grew into a successful maker of gear production technology. It was acquired by Gleason Corporation of Rochester, NY, in 1997.

There are numerous other examples of German firms that had to relocate after 1945, including famous ones like Siemens and Carl Zeiss. In this paper, we focus on the forced migration of machine tool firms. Based on trade publications, we were able to assemble a novel dataset encompassing the complete German firm population in the machine tool industry from 1936 to 2002, a total of 2,906 firms. We focus our analysis on the East German firms that involuntarily relocated all their operations in the context of emerging state socialism. Their location choices and subsequent performance provide a rare opportunity to deal with well-known complications in analyzing the geographic dimension of industry evolution.

The impact of agglomeration economies on the location choices of firms has attracted much scholarly attention in recent years (Figuereido et al., 2002; Rosenthal and Strange, 2003; Van Oort and Atzema, 2004). Empirically, the effects of agglomeration economies on the emergence of new entrants are difficult to disentangle from differences in the supply of potential entrants or regional "birth potential" (Carlton, 1979) since both may cause new entry to cluster in already agglomerated regions (Buenstorf and Klepper, 2006). By identifying firms that were forced to give up their East German locations, we are able to analyze location choices that were unaffected by regional birth potential. In the second part of the empirical analysis, the post-World War II performance of machine tool firms is studied, comparing moving firms to post-World War II entrants and West German incumbents with prewar experience at their postwar locations. In addition to the effect of agglomeration on firm performance, we are particularly interested in the effects of pre-World War II industry

experience on postwar performance, and whether these were conditioned by the forced relocations.

The paper contributes to the emerging literature on the spatial dimension of firm capabilities and industry evolution (see, e.g., Klepper, 2006, for a survey). Existing industry centers, particularly agglomerations of firms active within the same product classes, strongly attracted the relocating machine tool firms. However, we find no evidence suggesting that firm performance benefited from agglomeration effects. Our findings moreover suggest that most firm capabilities are "portable" in the sense that they are not destroyed by changing the firm's location.

The remainder of the paper is organized as follows: In the next section, we discuss the theoretical background of the analysis and present related earlier findings. Section 3 introduces the historical context of our analysis. It also contains a detailed description of the data on which the empirical analysis is based. Econometric results regarding the location choices of the moving firms and the survival of machine tool firms are presented in Section 4. A discussion of our findings in Section 5 concludes the paper.

2. Theoretical Background

Organizational capabilities

Business firms need specific capabilities to survive and possibly grow (Dosi et al., 2000). Firm-specific knowledge underlying its capabilities enables a firm to deploy its resources toward desirable ends (Amit and Shoemaker, 1993) and adapt to a changing environment (Teece et al., 1997). To be of strategic value, capabilities need to be long-lived and difficult to substitute or imitate (Dierickx and Cool, 1989).

New firms have been found to possess specific bundles of capabilities from their inception, which are derived from the prior experiences of their founders and first-round employees. The match between capabilities based on pre-entry experience and the challenges confronted post-entry is a major determinant of firms' entry decisions and subsequent performance. In particular, there is substantial evidence that the survival chances and performance of corporate spin-offs are enhanced by the prior industry experience of their founders (Helfat and Lieberman, 2002). A widely recognized stylized fact of industry evolution moreover indicates that incumbents' exit hazards tend to decrease with post-entry experience. This suggests that firms are able to expand their capability base after entry, thus overcoming the "liability of newness" (Freeman et al., 1983).

The firm's capability base may be further enhanced by effective agglomeration economies in its home region. Prior research distinguishes two kinds of agglomeration economies. First, intra-industry localization economies arise from the proximity of other firms active in the same industry. Such industry clustering favors pooled labor markets for similarly trained workers, the emergence of specialized suppliers as well as local spillovers of industry-specific knowledge and skills (Marshall, 1920). Second, agglomeration benefits may also arise from being located in urbanized regions featuring a diversity of industries. Urbanization increases local demand and the availability of business services, and may promote innovation through the flow of ideas across industries (Jacobs, 1969; Glaeser et al., 1992).

The local availability of specialized suppliers and business services as well as the social networks of the firm's founders and executives (Sorenson and Audia, 2000) can be considered as extending the firm's capability base. The possibility to draw on a local supply of trained workers may likewise be crucial for a firm to maintain and further its capabilities, whereas knowledge spillovers and urbanization effects on innovativeness are directly related to the firm's dynamic capabilities of adapting to environmental change. These considerations suggest that the capabilities of individual firms are embedded in the regional capability base (Lawson and Lorenz, 1999).

Agglomeration and location choice

Theories of economic clustering envision a self-reinforcing process driven by agglomeration economies. Benefits of agglomeration draw entrants to agglomerated areas and subsequently enhance their performance relative to firms located in more isolated regions (Porter, 1990; Krugman, 1991; Brenner, 2004). As a consequence, new entry and differential firm survival both tend to reinforce geographic concentrations that may initially have occurred by chance alone.

The impact of geographic factors on the location choices of new firms has been analyzed by a substantial econometric literature (e.g., Carlton, 1983; Bartik, 1985; Hansen, 1987). These studies confront the problem that the location choices of new firms tend to be affected by the founders' geographic roots. More firms may locate in some regions simply because in these regions there are more potential entrants – the "birth potential" effect discussed by Carlton (1979). Accordingly, actual patterns of entry locations cannot be expected to fully reflect regional differences in the expected profitability of operations.

The importance of entrants' geographic roots in their location choices is not easily accounted for in the empirical work. One strategy is to analyze the small-scale choice among

specific locations within a broader region, assuming that all entrants originated within that region (Rosenthal and Strange, 2003). Alternatively, one can control for the home region of new entrants, which obviously presupposes access to data providing the respective information. A pioneering study in this context is owed to Figuereido et al. (2002) who exploit a matched employee-employer dataset to study the location choices of entrepreneurial startups in Portugal. These authors find that, while entrepreneurs tended to locate in their home regions, the effect of agglomerative forces was greater in attracting firms from outside the region than in inducing firms to locate in their home regions. In a study of the historical U.S. tire industry, Buenstorf and Klepper (2006) similarly find that agglomeration had little impact on whether or not firms located in their home region, but substantially affected the minority of firms, particularly startups with little industry experience, that located elsewhere.

Geographic roots are less likely to affect the location choices for new branch plants of existing firms, which have also been studied before (Smith and Florida, 1994; Head et al., 1995, Guimaraes et al., 2000). However, these choices are much less informative as regards the role of agglomeration. Frequently, branch plants are only production sites for which many of the expected benefits of agglomeration on firm capabilities (such as knowledge spillovers) are of little import. In addition, decisions for locating branch plants may be dominated by highly specific factors. For example, Japanese automotive suppliers tended to locate their U.S. plants close to Japanese automakers' plants rather than in centers of automobile production more generally (Smith and Florida, 1994).

Lacking systematic data on the geographic origins of all entrants in the German machine tool industry, we exploit, in the analysis of location choice, the "natural experiment"[1] of post-World War II relocations and limit our attention to the subset of East German firms moving to West Germany. Similar to branch plants, we expect the location choices of moving firms to be unaffected by the firms' geographic roots. Thus, they should provide us with a clean measure of how important agglomeration was as an attractor of movers. Beyond this, we analyze the technological scope (if any) at which localization economies were effective. To this purpose, the industry data are disaggregated into several levels of submarkets (defined by the different materials processing operations that specific machine tools perform). We also study the effects of urbanization (proxied by regional population density). Finally, it cannot be ruled out that location choices were confounded by

[1] This term is adopted by Kogut and Zander (2000) in an analogous context. They use the example of Carl Zeiss, a prominent optical firm that after 1945 was divided into two separate firms in East and West Germany, to study innovativeness under different political regimes. Also similar in spirit to our analysis, Davis and Weinstein (2002) interpret the Allied bombings of Japanese cities in World War II as a temporary shock in testing theories of economic geography.

nonsystematic factors. Particularly in the first years following World War II, political and economic conditions in Germany were difficult and firms may have been severely constrained in where they could move (for both administrative and rather practical reasons, such as plant availability). Accordingly, we distinguish between the location choices of early and late movers. We expect the latter to yield a cleaner measure of agglomeration effects.

Agglomeration and localized firm capabilities

The forced relocation of machine tool firms provides an opportunity to study the extent to which firms are able to maintain their capability base when confronted with adverse shocks. From the prior literature on capabilities, conflicting predictions can be derived.

Effects of pre-entry experience on spin-off performance suggest that individuals and founder teams are able to transfer relevant knowledge to their new ventures. To some extent at least, firm capabilities appear to be transferable between firm organizations through entrepreneurship and individual labor mobility. In the same vein, it would be expected that owners and managers of the firms relocating after World War II were able to rebuild organizational capabilities even though they were leaving behind most of the firm's physical assets. In terms of performance, firms migrating out of East Germany should thus exhibit a similar performance to West German firms that continued their activities at their prewar locations. Both would be expected to outperform postwar entrants into the industry.[2]

A different prediction emerges if firm capabilities are mostly localized, i.e., if experience at the present location has a stronger performance effect than experience accumulated elsewhere. Such a localization of capabilities would be expected, for example, if membership in local social networks or dependence on immobile factors were major determinants of capabilities. In the present context, localization of capabilities would translate into a weaker performance of the moving East German firms relative to their West German competitors that also had pre-World War II industry experience. On the other hand, unless the effects of post-entry experience were perfectly localized, relocating experienced firms would still be expected to outperform firms that were newly entering the industry after World War II.

In addition to the potential localization of capabilities, we also study direct effects of agglomeration on firm performance. In this, we build on recent investigations into industry evolution, especially the relationship between pre-entry performance and agglomeration. Klepper (2007), in studying the historical automotive cluster in Detroit, finds that once

[2] We limit our analysis to firms with post-World War II locations in West Germany, including those that moved from East German locations. The exclusion of firms that remained in East Germany is both due to data availability and the lack of a meaningful competitive process under conditions of socialism.

differences in pre-entry background are controlled for, the performance of Detroit firms was indistinguishable from that of firms located elsewhere. Among the Detroit firms, only spin-offs from incumbent firms were particularly successful. Similar results are obtained by Buenstorf and Klepper (2005) in the context of the historical U.S. tire industry. They find that performance effects of localization were limited to the center of the industry in Akron, Ohio, while producers in other industry agglomerations were not significantly outperforming isolated firms. Similar to Detroit, the effects of being based in Akron were furthermore limited to diversifiers and spin-offs, while other startups entering in Akron performed modestly.

Both the Detroit and Akron cases suggest that the performance of these industry clusters was mostly due to the distinctive capabilities of the firms located there, which can be traced back to their pre-entry experience. In the present paper, the role of agglomeration in explaining firm performance is estimated controlling for differences in firms' prewar experience in the machine tool industry. We also explore the possibility that firms require capabilities to benefit from agglomeration, and investigate whether there are any differences in the effects of localization between experienced firms and new entrants as well as between movers and local incumbents within the group of experienced firms.

3. Empirical Setting: The German Machine Tool Industry

The machine tool industry is characterized by a highly diverse spectrum of products. In spite of this heterogeneity, machine tools can be defined generally as "mechanized and more or less automated production equipment which, by movement between tool and workpiece, produces a given form or change of the workpiece" (DIN, 1981/1982). The roots of the machine tool industry go back to Henry Maudslay and his invention of the support lathe in Britain in 1794. The origin of the German machine tool industry dates back to the mid-19th century; but it was only at the turn of the 20th century that German firms became serious competitors of the then leading U.S. producers in the global machine tool market. While the U.S. firms had established their strong position through the universality of their machine tools,[3] German manufacturers focused on the quality standards of their products. They succeeded by revising and optimizing American machine designs, making use of a strong endowment of technological capabilities (Laske, 1995).

[3] This is in contrast to other international technical improvements, which were rather limited in their scope of applicability.

Both World Wars strengthened the U.S. position in the global market. Germany's producers suffered from the destruction of plants and engineering drawings in World War II (Schwab, 1996) and also from the dismantling of plants as part of the postwar restitution schemes (Mazzoleni, 1997). On the other hand, strong postwar demand favored the comeback of the German industry. The world's machine tool industry grew at a pace of 10 per cent p.a. from 1950 to 1970, in part due to the machinery needs of the European manufacturing industry that had almost entirely been destroyed (Arnold, 2003). Output and exports of German machine tools strongly benefited from these developments and continued to grow well into the early 1990s (Figure 1).

Beginning in the 1950s, the introduction of numerical controls (NC) marked a major technological upheaval in the industry. While NC machines diffused rather quickly in the U.S. and Japan, German machine tool producers were slow to adopt this technology. This laggardness was a major factor underlying the crisis in terms of production, exports, and employment that Germany's machine tool industry experienced at the beginning of the 1990s (Figure 1) and from which it only recovered from the mid-1990s onward.

The German machine tool industry has traditionally been dominated by large numbers of the small and medium-sized, owner-managed businesses that are characteristic of the German *Mittelstand*. Over the past decades, the total number of active producers has been gradually decreasing (Figure 2). The shakeout in the number of producers has not been as drastic as in other industries, with their total number falling from a maximum of 804 in 1955 (and another high of 798 in 1969) to 371 in 2002. In terms of submarkets, metal cutting machines dominated the industry throughout the period under investigation, both as regards firm numbers (approx. 40-50 per cent of all manufacturers produce at least one product of this type) and total share of production volume (ca. 70 per cent; cf. Schwab, 1996). Next are metal forming machines with approximately 25-30 per cent of all producers, followed by special purpose machines and, finally, metal separating techniques.

Geographically, the industry is strongly clustered in the federal states of Baden-Württemberg, North Rhine-Westphalia, and Bavaria, where 45 per cent, 20 per cent, and 13 per cent, respectively, of all companies were located in 2003 (VDW, 2005). Industry output is similarly concentrated across regions. The three big postwar agglomerations accounted for 88 per cent of the total production in 2003 (53 per cent in Baden-Württemberg, 20 per cent in Bavaria, and 15 per cent in North Rhine-Westphalia; (VDW, 2005)).

While being historical centers of the industry, today's top regions have not always been its only agglomerations. Before World War II, one third of all establishments was

located in the eastern part of Germany, particularly in and around the Saxonian cities of Chemnitz, Leipzig, and Dresden. In this region, which was part of the Soviet-occupied zone that later became East Germany, the emerging regime of state socialism with its centrally planned economy made the operation of private manufacturing firms next to impossible. Owners of larger firms were mostly expropriated, and government-controlled managements were installed. In addition, the Soviet Union pursued a much stricter regime of reparation payments and plant demolition in its occupation zone than the Western Allies. This situation induced numerous firm owners to escape to West Germany before this was made impossible by the erection of the Berlin Wall in 1961. Thus, the post-World War II situation in East Germany stands in striking contrast the voluntary choice to relocate a private firm, motivated by the ambition to improve the firm's current situation and increase profits.[4]

State-owned machine tool firms remained active in East Germany during the era of state socialism, but they were not competitive on the global market and are not listed in the sources underlying our data. After German reunification in 1990, these firms were frequently shut down or had to downsize drastically. Many were acquired by West German competitors, and a large number of new West German branch plants were also established in East Germany. Nonetheless, the former East German centers of the industry are of little importance today, with Saxony and Thuringia only contributing 3.2 per cent and 4.1 per cent, respectively, to industry output in 2003 (VDW, 2005)

4. Econometric Analysis

Data sources

The historical development outlined above builds the background for the construction of our database. From the buyer's guide "Wer baut Maschinen" ("Who makes machinery"), issued annually by the Verein Deutscher Maschinen- und Anlagenbau (VDMA) since 1932[5], we collected detailed data about the full population of machine tool producers that were active in the period 1949 to 2002 in at least one of the following technology classes: metal cutting, separating, forming, and special purpose machine tools. Within the technology classes, we

[4] In addition to leaving what later became East Germany, firms also relocated from the easternmost regions of prewar Germany. After World War II the German population was forced to leave these regions. This gave rise to a large wave of refugees relocating to the West right after the end of the war, including owners of machine tool firms, some of whom tried to reestablish their firms at new, West German locations. Our sample includes five firms coming from these easternmost regions.

[5] The catalogues for the time periods 1932-1935, 1944-1948 as well as for 1952 cannot be consulted for the investigation as they were either destroyed during the war, not issued in the immediate aftermath of World War II, or not archived. Missing values for 1952 are approximated by the values reported for 1951.

further differentiated producers according to 36 product types. The data mostly refer to West Germany in the years 1949 through 1990; after reunification in 1990, East German firms were also added to the listings.

We used volumes of the same catalogue issued between 1936 and 1943, including the last volume issued just before the end of World War II, to identify firms that moved from East Germany to the western part of Germany. The total number of these firms is 43, which corresponds to 23 per cent of all firms listed at East German locations (and almost eight per cent of the overall firm population) in 1938. Only three of them stayed in the vicinity of their original location (i.e., they entered in a contiguous *Raumordnungsregion*). The biggest attractors of relocating firms are found in Baden-Württemberg and North Rhine-Westphalia, two federal states that share no boundary with East Germany; 21 of all movers relocated there.

Prewar volumes of the buyer's guide are also used to differentiate between experienced firms, i.e., those already active in the industry before 1949, and new entrants established after 1949. Finally, census data were used to calculate regional population density at the level of *Raumordnungsregionen*, which we use as a proxy for urbanization economies.[6]

Location choices of relocating firms

First, we study the location choices of the 43 firms who had to give up their East German locations and are first listed in West Germany between 1949 and 1962. We adopt the conditional logit framework dating back to Carlton (1983), which is commonly used in this kind of analysis. This setup estimates parameters to maximize the likelihood for each entrant to have chosen their actual location. We assume that firms chose their new locations from among the 75 West German *Raumordnungsregionen* (including Berlin) according to regional characteristics.[7] In particular, we are interested in whether regions that already had a larger population of machine tool firms also attracted more of the moving firms.

Three alternative levels of aggregation are utilized to measure the effects of localization at the level of *Raumordnungsregionen*. Our broadest measure of localization includes all firms listed as machine tool producers. Alternatively, we only include firms active in the same technology class, or only firms active in the same product market as the relocating

[6] *Raumordnungsregionen* (regional planning districts) reflect regional commuter flows and consist of one or several *Landkreise* (counties). There are 97 *Raumordnungsregionen* in Germany. Calculation of historical population densities was complicated by administrative reforms changing the boundaries of individual *Landkreise*. Some interpolation was required in early years. For the year 1948, we use 1949 data.

[7] All but two regions were home to at least one machine tool producer. Presumably, these two regions offered poor conditions for entrants. They were excluded from the analysis.

firm. This enables us to investigate whether the moving firms were primarily attracted by highly similar firms, or whether broader agglomerations of machine tool firms active in other product markets and technologies proved to be stronger attractors.[8] Specifically, for each region, we calculated the share of machine tool firms located there (at the respective level of aggregation), expressed as a percentage of all active firms in the respective year.

The initial model includes, as explanatory variables, our most restrictive measure of localization – the regional share of producers active in the same product category as the target firm – as well as the regional population density as a proxy for urbanization. In this and all following models of location choice, values of explanatory variables pertain to the year preceding the entry of the respective firm.[9] Results of this estimation are reported as Model 1 in Table 1. Coefficient estimates for both variables are positive and significant at the .01 level. They indicate that both localization and urbanization effects increased the probability that moving firms located in a given region.

In Model 2, the regional share of machine tool firms, aggregated over the entire industry, is added to the specification. This reduces the effect of the more narrow localization measure by more than 30 per cent (it remains marginally significant at the .10 level). The coefficient estimate of the new, broad localization measure is also positive, though smaller and not significantly different from zero, suggesting that firms were primarily attracted by the presence of producers active in their own product markets.[10] Model 3 is a variant of this model, where the intermediate technology level of aggregation is substituted for the broad, industry-wide localization measure. Similar to Model 2, this addition reduces the effect of the narrow, product-based localization measure, which loses its significance but nonetheless remains more sizable than the broader effect. The effect of the urbanization proxy is little affected by the modifications.

Models 1-3 indicate that localization and urbanization economies were effective attractors of relocating firms. As a final issue related to location choice, we return to the specification of Model 1 but interact the explanatory variables with dummy variables, distinguishing early (pre-1951) from late (1951-1962)[11] movers to see how relevant constraints in the location choices were for the earliest movers. Results of this specification (Model 4) indicate that our concerns regarding the potentially more haphazard early location

[8] Firms re-entering the industry after relocation are assigned to a single product class if at least 50 per cent of all their machine types belong to one and the same product class. In eight cases the products are evenly spread over two or three classes. These firms are treated as simultaneous entrants in all their classes.
[9] Regional firm population data for the year 1948 were approximated by the respective values of 1949.
[10] This interpretation is corroborated by results of another (unreported) model that only includes the urbanization proxy and the broad measure of localization, which yielded a slightly inferior fit compared to Model 1.
[11] These years were chosen to balance the number of firms between both categories.

choices are largely unfounded. Both early and late movers are attracted to the existing centers of the industry. In contrast, the effect of urbanization is stronger for the later movers, while it is not significantly different from zero for the earlier ones. Possibly, this reflects difficulties in obtaining suitable real estate in more densely populated regions, which were particularly hard hit, right at the end of World War II.

Firm survival

We adopt survival in the machine tool industry (aggregated over all submarkets) as an indicator of firm performance. This choice of performance criterion is mandated by the data since neither financial information nor sales or employment statistics are available for the complete firm population and the entire period under investigation. It is justified by opportunity cost considerations: even if firms voluntarily left the industry (rather than exiting through bankruptcy), we expect this decision to reflect relatively poor performance or at least its anticipation. In the case of exit by acquisition, interpreting exit as an indicator of poor performance is less easy to justify. However, most firms in the German machine tool industry are family-owned SMEs. There is no evidence suggesting that trade sales play a similar role as, for example, in the biotech industry, where venture capitalists have more influence and selling the firm is a prominent exit option. Thus, in our sample, even acquisitions are more likely to be caused by problems in the acquired firm rather than by the acquiring firm's attempt to buy into promising new technologies.

We include data on the entire post-World War II population of 2,267 West German firms (including West Berlin) in the survival analysis. In 2002, the final year of observation, 371 firms were still active in the industry. They are treated as censored exits. The parametric Gompertz specification is adopted, which has been employed in similar contexts before (Klepper, 2002; Buenstorf and Klepper, 2005) and has several advantages for our purposes. Most importantly, as opposed to the more frequently used Cox regression, it allows for relaxing the assumption that hazards are proportional across groups of subjects, i.e., that the impact of age[12] on the hazard is the same for all subjects. This assumption would be hard to justify in the present context since our analysis includes both experienced firms and ones that are new to the industry. Prior work has shown that the age-dependent profile of the exit hazard may strongly differ between diversifiers experienced in related industries and *de novo* entrants (Klepper, 2002). It is even more likely to differ between firms with or without experience in the same industry. Ideally, we would control for the effects of pre-World War II

[12] In our context, "age" is not strictly the age of a firm, but rather the time elapsed after (re)entry into the industry after World War II.

experience by using a hazard model for left-truncated data. However, since we do not know the founding years of all pre-World War II entrants, this possibility is ruled out (Guo, 1993).

Another advantage of the Gompertz specification is that the effect of age on the exit hazard is explicitly estimated. The model thus shows whether increasing age differently affects the hazards of different types of firms. For example, it is plausible to expect that firms remaining at their pre-World War II locations initially benefited more from localization effects than relocating firms, which first had to establish local contacts. This possibility is explored below.

As a baseline model, we first estimate a simplified Gompertz model assuming proportional hazards across types of firms, using only prewar industry experience as an explanatory variable. For this purpose, three dummy variables are included in the model, which respectively denote West German firms with pre-World War II industry experience (dubbed "local incumbents" below), experienced firms relocating from East to West Germany ("moving incumbents"), as well as firms that first entered the machine tool industry after 1962 ("late entrants"). The control group is made up by firms without pre-World War II industry experience that entered through 1962 ("early entrants"). We distinguish between early and late entrants because relocations from East Germany were possible only through 1961, and we want to compare the performance of the relocating firms to that of firms newly entering the industry in the same period of time.

Based on prior findings for other industries, we expect prewar experience to lower the postwar hazard of exiting the machine tool industry. Accordingly, both types of incumbents are expected to be more long-lived than either type of new entrant. To the extent that performance-enhancing effects of experience are due to localized capabilities, they should be weaker for the moving incumbents than for the local incumbents. Finally, in line with the stylized facts of industry evolution (Klepper, 1996), we expect the late post-World War II entrants to perform less well than the early entrants.

Selection bias may be a problem in comparing moving firms to those continuing operations at their prewar locations. It cannot be ruled out that the weakest potential movers refrained from starting anew in West Germany. In this case, the exit hazards for moving firms might be biased downward. To assess the relevance of this potential bias, we investigated whether those East German firms that started anew in West Germany differed, first, from other East German firms that did not move and, second, from firms staying at their original West German locations (the future competitors). Specifically, we compared the different kinds of firms in terms of their average number of products in 1938, the last year before the

war started and an increasingly dirigistic war economy became established. We found that, on average, movers had a slightly bigger scope of production than firms staying in East Germany (3.418 versus 2.622 products), but this difference is not statistically significant. More importantly, there was virtually no difference between the movers and their future competitors in West Germany (3.422 products).[13]

Results of the initial hazard model are reported as Model 5 in Table 2. In line with the expectations, the coefficient estimates of the dummy variables denoting local and moving incumbents are negative, sizable, and highly significant, indicating that experienced firms were less likely to exit the industry than post-World War II entrants. In contrast, the coefficient estimate for the late entrants is significantly positive. Within the group of experienced firms, moving incumbents have a higher exit hazard than local incumbents. However, this difference is rather small and statistically insignificant, suggesting that the relocating firms were able to maintain most if not all of their capabilities.

Model 6 uses the same set of explanatory variables but relaxes the constraint that the age-dependent part of the hazard be identical across types of firms. Accordingly, in this specification, two coefficients are obtained for each independent variable: an age-independent one that measures the effect of the variable at the time of the first postwar observation for the firm, and an age-dependent one that indicates the subsequent development of the effect. The estimation results provide further information on the differences between the various types of firms (this is corroborated by the substantial increase in the log-likelihood of the model). We find that the differences between the types of firms were strongest right after (re)entry and converged afterward. Both groups of new entrants without pre-World War II industry experience see their hazard decline as they gain post-entry experience. In contrast, for both kinds of incumbents the hazard is slightly increasing with age. These findings provide further evidence that moving firms were mostly able to transfer their capabilities to their new locations. Their performance right after reentry is indistinguishable from that of the local incumbents (the difference in the coefficient estimates is insignificant), while they are significantly superior to the new entrants.

The remaining models address how regional industry agglomeration affected the performance of the different types of firms. In Model 7, the percentage of other firms located in the same region and the regional population density are added as measures of localization

[13] Interval censoring due to the lack of information for the immediate postwar years before 1949 might also be a problem. We cannot identify East German firms that started anew in the West but were unsuccessful and thus had to close down again before 1949. However, the same issue is also relevant for Western firms with prewar experience; thus there is no obvious reason why it should bias our results. In addition, it is questionable whether a functioning competitive market process was operative in postwar Germany before the currency reform of 1948.

and urbanization, respectively. Based on the results of the above analysis of location choice, the narrow, product-based measure of localization is used. We find no evidence that firms located in industry centers systematically outperformed firms located elsewhere.[14] Contrary to the theoretical considerations on urbanization economies, being located in a more densely populated region even increased firms' hazard of exit. The other variables in the analysis are unaffected by the changed specification, except that late entrants are now indistinguishable from early ones in their longevity.

Finally, in Model 8, we interact the localization measure with the dummy variables denoting types of firms, thus allowing its effects to vary both across types of firms and over time. Consistent with the prior model, no significant effects of localization are identified for any kind of firm. The relative sizes of coefficient estimates are suggestive, however. Moving incumbents initially seem to have been least likely to benefit from the presence of other producers; and the age-dependent effect of localization on the hazard is most strongly negative in their case. This could be interpreted as suggesting that localization economies operated through localized knowledge and/or integration into local networks. In any case, no firm seems to have benefited substantially from being located in an industry agglomeration.

5. Conclusions

In recent years, empirical studies of industry evolution have begun to analyze how the same industry developed in different countries (Simons, 2001; Cantner et al., 2006; Buenstorf, 2007). This line of work suggests that developmental patterns in the same industries of different countries are highly similar. It provides evidence that the evolution of industries is largely shaped by technological characteristics rather than country-specific institutional determinants. The present paper adopted a slightly different approach. We focused on a striking particularity of a specific national industry, the forced migration of East German machine tool producers after World War II. Rather than studying how this particularity affected the overall pattern of industry evolution relative to other countries, we treated it as a natural experiment providing us with an exceptional opportunity to study the determinants of location choice, and also to assess the role of localized capabilities and agglomeration economies on firm performance.

[14] Alternative model specifications using the broader measures did not yield evidence suggestive of localization economies, either. Twenty-five firms are removed from the sample because they were not continuously listed in a product category and reentered in a different category from the one they had been in before.

The results on firms' location choices suggest that agglomeration is a significant determinant of where firms locate. This result is in line with earlier work; it adds to the small number of findings based on studies that were able to control for the influence of firms' geographic roots. Finding the strongest impact of "narrow" localization effects among firms active in the same product markets resonates with results obtained by Agrawal and Cockburn (2003) for R&D in electrical engineering in North America. They find that patenting and publishing activities are more concentrated in the subfield of signal processing than in electrical engineering more broadly.

As regards performance, our study indicates that firm capabilities are mostly "portable" across locations. In light of the forced relocation and the need to set up new facilities from scratch, the moving firms were surprisingly similar in their performance to the experienced West German firms that did not have to move. In contrast, they strongly differed in performance from new entrants without prewar industry experience, which presumably possessed much less in terms of relevant capabilities.

Perhaps surprisingly, given their tendency to locate in agglomerated regions, we find that movers, as well as other firms in the industry, had little if anything to gain from agglomeration. This result holds for localization measured at various levels of technological aggregation, while the results obtained for population density even suggest that urbanization may have adverse effects on firm survival. While difficult to reconcile with cluster theories, these results are in line with earlier work on geographic aspects of industry evolution showing that, when controlling for differences in firm background and time of entry, there is little evidence for performance-enhancing effects of agglomeration (Klepper, 2007; Buenstorf and Klepper, 2005). Following this line of earlier research, a straightforward issue to deal with next in the context of the German machine tool industry is to look at the most pronounced centers of the industry and how they evolved over time.

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Table 1: Location choices of moving firms

	Model 1	Model 2	Model 3	Model 4
RegFirmshare_product	.1273*** (.0182)	.0854* (.0497)	.0969 (.0602)	
RegFirmshare_industry		.0487 (.0526)		
RegFirmshare_technology			.0333 (.0622)	
RegFirmshare_prod * early				.1498*** (.0276)
RegFirmshare_prod * late				.0997*** (.0363)
RegPopulationDensity	.0004*** (.0001)	.0004*** (.0001)	.0004*** (.0001)	
RegPopDensity * early				.0003 (.0003)
RegPopDensity * late				.0006*** (.0002)
No. of observations (firms)	3139 (43)	3139 (43)	3139 (43)	3139 (43)
Log-likelihood	-162.586	-162.168	-162.446	-164.760
P > chi^2	.0000	.0000	.0000	.0000
Pseudo-R^2	.119	.121	.120	.107

Note: Standard errors in parentheses; *** p≤.01; **p≤.05; *p≤.10

Table 2: Post-World War II firm survival (Gompertz specification)

	Model 5	Model 6	Model 7	Model 8
Constant	-2.497*** (.054)	-2.281*** (.050)	-.2.378*** (.067)	-2.354*** (.078)
Local incumbent	-.767*** (.059)	-1.625*** (.110)	-1.599*** (.125)	-1.721*** (.171)
Moving incumbent	-.688*** (.154)	-1.344*** (.303)	-1.397*** (.349)	-1.698*** (.499)
Late entrant	.214*** (.060)	.135* (.075)	.128 (.085)	.074 (.105)
RegFirmshare_prod			-.001 (.004)	
RegFirmshare_prod * Local incumbent				.015 (.015)
RegFirmshare_prod * Moving incumb.				.067 (.066)
RegFirmshare_prod * Early entrant				-.006 (.009)
RegFirmshare_prod * Late entrant				-.007 (.012)
RegPopDensity			.0001*** (.0000)	.0001*** (.0000)
Years	-.018*** (.002)	-.035*** (.003)	-.035*** (.003)	-.036*** (.004)
Local incumbent * Years		.049*** (.005)	.048*** (.005)	.054*** (.007)
Moving incumbent * Years		.040*** (.012)	.042*** (.013)	.049*** (.018)
Lateentrant * Years		-.001 (.006)	.002 (006)	.003 (.008)
RegFirmshare_prod * LocalInc * Years				-.0010 (.0006)
RegFirmshare_prod * MovingInc * Yrs				-.0012 (.0037)
RegFirmshare_prod * EarlyEntr * Yrs				.0002 (.0005)
RegFirmshare_prod * LateEntrant * Yrs				-.0001 (.0010)
No. of subjects (failures)	2267 (1896)	2267 (1896)	2242 (1856)	2242 (1856)
Log-likelihood	-3721.940	-3659.518	-3560.597	-3557.482
$P > chi^2$	.000	.000	.000	.000

Note: Robust standard errors in parentheses; *** p≤.01; **p≤.05; *p≤.10

Figure 1: The German machine tool industry: production, exports, and employment; 1949-2003 (Source: VDW, 2005)

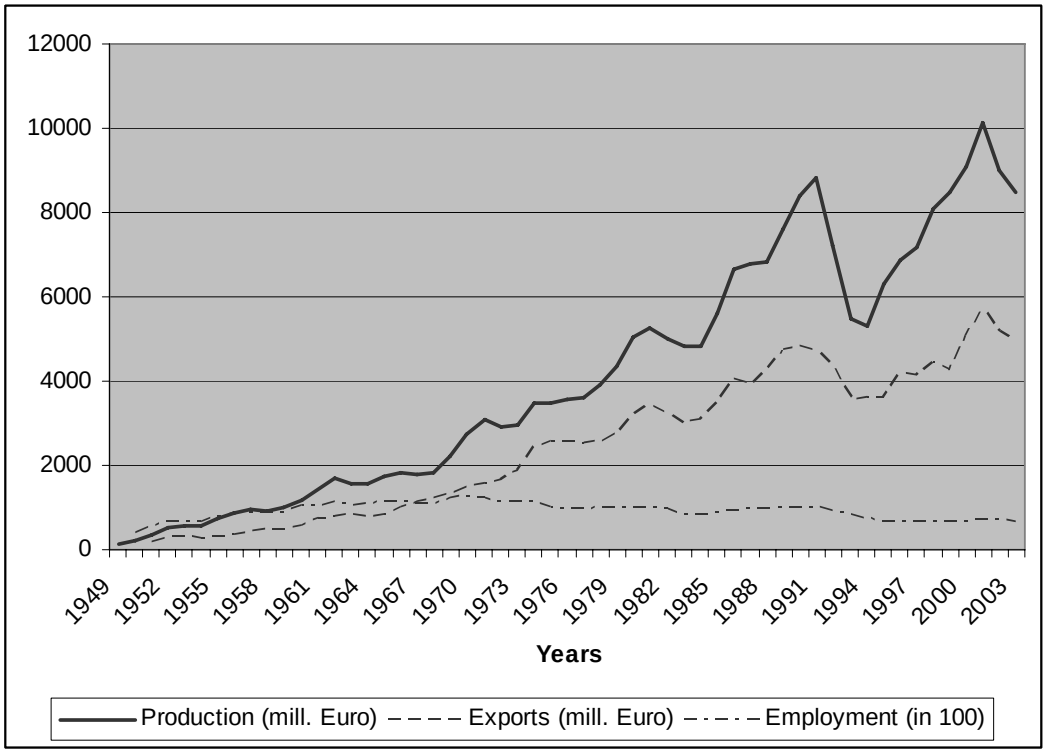

Figure 2: The German machine tool industry: number of active firms; 1949-2002 (own calculation)