Regional Analysis of the Evolution of the U.S. DDT Industry

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Geographic location is often a missing component in industry evolution literature whereas the time aspect is rarely considered in agglomeration studies. This paper attempts to fill this gap by evaluating the patterns of industry evolution across different regions. A historical data set for the U.S. DDT industry is created and analyzed. First, the change in the number of firms over the industry life cycle is considered, as well as the variation in the patterns of entry and exit across different regions. This part of the analysis is based on the U.S. Census division of the United States into 4 distinct regions: Northeast, Midwest, South, and West. Next, a comparison of the patterns of industry evolution in the core of the industry, where the majority of firms are located, versus its periphery is made. I find some evidence that the different regions exhibited dissimilar dynamics.

JEL classification: F12, F14, O18, R12

Key words: geographic concentration, industry location, shakeout, regional analysis

INTRODUCTION

Industry dynamics have been of great interest to many researchers in the recent years. Many studies document a common pattern of development across different manufacturing products in the United States during the past century. In particular, the number of firms increased after the inception of a product, it reached a peak, which was followed by a sharp decline, referred to as a shakeout, and then a period of stabilization occurred.
A number of theories have been developed to address this pattern and the link between technology and market structure has been used to explain these regularities. Similar studies are available for the United Kingdom for a number of industries (see for example, Boschma & Wenting, 2007; Simons, 2005). In general, the empirical studies of industry dynamics are conducted at a country level and investigate how the number of producers in a given industry changes over time. However, they rarely consider the impact of geographic location (for a detailed discussion see Boschma & Lambooy, 1999; Boschma & Frenken, 2011).

This paper tries to make a connection between the studies of industry evolution and the studies of geographic agglomeration, which in majority of the cases overlook the time aspect of industry location. For this purpose, a historical dataset of firm location is created and analyzed for the U.S. DDT industry. First, the change in the number of firms over the industry life cycle is considered, as well as at the variation in the patterns of entry and exit across different regions. This part of the analysis is based on the U.S. Census division of the United States into 4 distinct regions: Northeast, Midwest, South, and West. Since the main explanation for different patterns of industry evolution (i.e. the shakeout) is technological change, it is likely that differences in the rates of knowledge transmission across geographic regions will lead to regional variation in industry dynamics.

Next, I compare the patterns of industry evolution in the core of the industry where the majority of firms are located versus its periphery. Of key interest is whether there is regional variation in industry dynamics. In particular, I try to give an answer to the following question—do all regions experience a symmetric shakeout, or is the shakeout concentrated on the periphery, outside of the technological frontier? The source of data for this analysis is the Thomas’ Register of American Manufacturers, which tracks manufacturing firms over time. For both parts of the analysis, I divide the product evolution into 3 stages following Klepper and Grady (1990) and compare the duration of these stages, the average net entry rates in each stage, as well as the severity of the shakeout across the regions. I find evidence that the different regions seem to
exhibit dissimilar dynamics and the shakeout was delayed and smaller in the periphery or in the secondary region.

**LITERATURE REVIEW**

**Stylized Facts**

A lot of research has been done on the evolution of new products from birth to maturity (see for example, Utterback & Suarez, 1993; Abernathy & Utterback, 1978; Nelson & Winter, 1978; Dasgupta & Stiglitz, 1980; Futia, 1980; Jovanovic, 1982; Dunne, Roberts, & Samuelson, 1989; Carree & Thurik, 2000; Geroski & Mazzucato, 2002). However, Gort and Klepper (1982) is the first study to derive stylized facts of industry dynamics with respect to shakeouts. The authors construct an evolutionary theory of diffusion of innovations to explain the development of new products. According to them the time path of events is a crucial determinant of market structure. They divide the life cycle of a product into 5 stages, each characterized by a certain number of producers. The authors analyze the product evolution in forty-six U.S. industries for a 73-year period by decomposing the diffusion of innovations for each product into 5 stages and observing the number of firms, innovations, and output in each stage. The data for the analysis came from the Thomas’ Register of American Manufacturers, supplemented by data obtained from various government and private sources. According to their findings the markets for most of the new products appeared to go through at least five stages of evolution, as well as passed through a stage with a sharp decline in the number of firms or a shakeout. For instance, automobile tire producers reached a peak of 275 firms and then their number dropped to 211 in stage four. The drop is approximately 77% corresponding to a severe shakeout. They come to a conclusion that the number and composition of producers is influenced to a greater extent by “discrete events such as technological change and the flow of information among existing and potential producers” (see p. 653).

Klepper and Grady (1990) further investigate the evolution of new industries. They construct a model to explain how chance events and
exogenous factors that affect the number of firms (both entrants and incumbents) in an industry and the ease of imitation of the leaders in the industry will influence the market structure at maturity. According to the model the number of firms in new industries first grows, then drops substantially, which is considered an industry shakeout, and finally it levels off or stabilizes. Thus, the authors define three stages in industry/product development. They extend the data series on the number of producers collected by Gort and Klepper (1982) through 1981 for most of the products. Klepper and Grady (1990) find that the evolution pattern for all products is similar in terms of the stages of development but the length of each stage and the mean annual change in the number of producers substantially differs across products.

In Agarwal (1998) thirty-one of the products in Gort and Klepper (1982), as well as two other products, are examined and the data set is expanded through 1991. The author divides the products into two groups—technical and non-technical. Based on a time trend analysis of patents, she finds evidence that the two groups had different patterns of patent activity. Furthermore, for more than half of the technical products the patent activity peaked in the period of severe drop in the number of firms in the industry, which suggests that after the contraction period most of the possibilities for big innovations had already been realized or alternatively this was a consequence of increased competition among firms in the later stages of development. In addition, the aging patterns revealed by the trend analysis of the number of firms, product prices, and quantity are consistent for a wide range of products and confirm the stylized facts reported by Gort and Klepper (1982).

Simons (2005) examines the possibility of having common patterns in industry dynamics across different countries. He has collected data for the manufacturers of 18 products in the United States and the United Kingdom from the annual editions of the Thomas’ Register of American Manufacturers and the Kelly’s Directory of Merchants and Suppliers of the World. The author compares the evolution patterns in the two countries. He finds out surprising similarities—products that had severe shakeouts in one country also experienced severe shakeouts in the other country.
with a similar degree of the shakeout severity. Even the timing of the shakeout was similar across the two countries. This is consistent with the evidence provided in Bain (1966) and Pryor (1972) that industries with high concentration ratios in one country have similar high concentration ratios in all industrialized countries they studied. The same applies to industries characterized by low concentration ratios. Products that did not have shakeouts in the United Kingdom lacked shakeouts in the United States as well. The common patterns suggest that “product-specific characteristics, such as technological change, prevail over common cross-national differences to determine key industry dynamics” (p.15).

**Evolution Theories**

Among all the different models of industry evolution that have been developed since 1980s, it is worth mentioning three important evolution theories looking at the determinants and reasons for industry shakeouts— the dominant design by Utterback and Suarez (1993), the “innovative gamble” of Jovanovic and MacDonald (1994), and Klepper (1996)’s theory of increasing returns. In Utterback and Suarez (1993) the occurrence of a dominant design affects competition and the number of firms in an industry. According to the authors it can be one or two specific features of a product or even a process technology that become(s) the standard and establish(es) dominance over the other existing design structures. The dominant design is a result of the available technology and the existing knowledge about consumers’ preferences. The focus is on a single and lasting dominant design that triggers the industry shakeout. The authors apply their theory to 8 products subject to substantial technological change such as automobiles, picture tubes, and calculators. They conclude that the number of firms or population density “may only be a reflection of underlying driving forces based on technological change that determine the form and level of competition, the attractiveness of entry, and ultimately the structure of an industry” (p. 19).

Jovanovic and MacDonald (1994) construct an infinite horizon model for a homogeneous good in a competitive market using the intuition derived in Gort and Klepper (1982). The argument is that shakeouts are
caused by a single major refinement following a basic innovation, which increases the optimal size of a firm. In short, when low-tech firms innovate they become high-tech with lower marginal cost of production. As their number increases, the output in the industry grows and the price of the product falls. Since profitability in the industry is affected, the incumbents that have not successfully innovated are forced to exit the industry. A shakeout follows, which is caused not only by the innovation but also by the increase in firms’ optimal scale of production that necessitates the drop in the number of firms. In each stage firms decide whether to innovate or not and because of that this model is referred to as the “innovative gamble” in the literature. It predicts that the number of firms in an industry first rises due to invention, stabilizes until the refinement, then increases further. Finally, the number of producers either levels off or drops since many firms exit the industry.

The authors compare their theory with the evolution of the U.S. automobile tire industry using the dataset in Gort and Klepper (1982). They determine that the Banbury mixer, which “eliminated the slow, space-intensive, and hazardous process of mixing rubber with other compounds and facilitated large-scale production” (p. 345), is the refinement that triggered the shakeout in the industry and the year of the refinement was determined to be 1913. This is in accordance with the profit opportunities found in the data on the stock prices of tires. They also do not find evidence that the shakeout was related to the fortunes of automobile producers because of the timing of the shakeout. In particular, they look at the time path of automobile sales in the United States and argue that if the shakeout was demand-determined, the tire industry dynamics would have closely followed the automobile industry dynamics, which is not what the data reveals. The shakeout in automobile industry started around 1910, about 12 years earlier than the shakeout in the tire industry.

Klepper (1996) constructs an alternative model of industry shakeouts that emphasized both product and process innovations. Product R&D develops new features of a product and thus expands the firm’s market share by attracting new buyers. Producers are endowed with different
innovation expertise, which affects the success of a product R&D. Firms with successful product innovations gain monopoly power for one period. This induces initial entry and increases the number of firms in the industry. In contrast, process R&D lowers the average cost of production. The value of this cost reduction is proportional to the level of output produced. Hence, bigger firms receive higher returns from process innovations which give rise to increasing returns to scale. This idea can be traced back to Schumpeter (1950) who talks about the advantages of bigger firms for R&D. The model explains how process innovation helps incumbent firms grow and gives them advantage over the new entrants. The relationship between firm size and the nature of innovation are investigated also by Cohen and Klepper (1996), Mansfield (1981), and Scherer (1991). These studies find that the share of process innovation increases with firm size or market concentration which is consistent with the characteristics of the model developed in Klepper (1996). Klepper argues that the decrease in the number of new entrants, along with the increase in the number of firms that exit the industry due to unsuccessful innovations, contribute to the shakeout. The type of entrants (e.g. new versus diversifying firms, or single-plant versus multi-plant enterprises, small versus large firms) and their prior production experience (varying from none to extensive) in related product or geographic markets can significantly affect the growth rates in a particular industry, as well as firm survival rates (see for example, Gorecki, 1975; Schwalbach, 1987; Evans, 1987; Dunne, Roberts, & Samuelson, 1989; Dunne, Klimek, & Roberts, 2005).

Some of the implications of the Klepper’s theory differ from those derived by Jovanovic and MacDonald (1994) and Utterback and Suarez (1993). For instance, this model does not predict stabilization in the number of firms after the shakeout, instead their number continues to decline. Moreover, it implies that “firm differences get magnified as size begets size, which imparts an advantage to early entry and leads to an eventual decline in the number of firms and the rate of product innovation” (p. 581). Thus, bigger firms can take advantage of increasing returns to scale and will account for most of the process innovations. This issue
is not addressed in the other two theories. Even though that all models emphasize that technological change is the main reason for industry shakeouts, the specific reason for the industry shakeout differ among the three models. The model developed in Klepper (1996) and further extended in Klepper (2002) is considered as the central model in industry evolution literature.

**Empirical Studies**

There are a few empirical studies that look at the geographic/locational aspect of shakeouts within a country. One such study is Klepper and Simons (2000). Based on the model developed in Klepper (1996), the authors explore the role of technological change in shaping an industry’s market structure. They consider the role of location as another determinant of firm survival. The argument is that if a firm is located in or close to the industry center (e.g. Akron, Ohio for the tire industry) it can take advantage of knowledge spillovers, become more technologically progressive, and thus would increase its likelihood of survival. The authors use logit models to estimate the impact of firm age, size, and location on probability of producing cord tires. The cord tire is assumed to be one of the most important design innovations. The Banbury mixer has been identified as the innovation responsible for the shakeout in the tire industry in Jovanovic and MacDonald (1994). Klepper and Simons argue that the Banbury mixer was developed by a supplier, it was available to all producers, and it did not have a substantial effect on the production process. Thus, cord tires can be considered as a better innovation contributing to the shakeout. The location coefficient in the different specifications is positive and statistically significant at 5 percent level of significance suggesting that firm location is important predictor for the likelihood of innovations. The authors also estimate a hazard function of exit with the inclusion of different control variables (including a dummy variable for location). They find that the age and size of tire producers considerably affected their survival rates. Larger firms had lower hazard rates in general and were more likely to be located close to the industry center. These firms entered the market
earlier (had the first mover advantage) and were able to accumulate more post-entry knowledge. In addition, tire manufacturers located in Akron that were greater in size had lower hazard as well. For other firms that were outside of the technological frontier, size had modest effects, which suggests that technology is the main factor influencing the survival rate of firms.

Boschma and Wenting (2007) investigate the role of spinoffs and agglomeration externalities to explain the geographic concentration of British automobile industry in the Coventry-Birmingham area during the period 1895–1968. In particular, they estimate several Cox regression models to assess the effects of location, time of entry, and pre-entry techno-economic experience on the survival rate of auto firms. The authors are able to separate the effects of agglomeration economies (in particular, firms locating in regions with high levels of employment in closely related or similar industries) from spinoff dynamics (transfer of knowledge between a spinoff and a parent firm) in the hazard models. According to them, some regions in Great Britain had a comparative advantage from the beginning (the first phase of automobile industry development)—a large pool of skillful labor, supply of local entrepreneurs, knowledge externalities, and experience in closely related activities such as bicycle and coach production. Agglomeration economies were found to have significant negative impact on the hazard rates of firms, i.e. firms locating in regions with high levels of employment in closely related or similar industries had higher survival rates.

On the other hand, the concentration of many automobile firms in a given region had a negative impact on the survival rates of new entrants and this impact is stronger during the later stages of the industry evolution. Boschma and Wenting (2007) conclude that “location influenced the spatial formation of the British automobile industry to a considerable degree” (p. 234–235). The pre-entry techno-economic experience of the entrants is also found to be an important determinant of firm survival. Spinoffs, as well as experienced entrants, had higher survival rates than new entrants without any experience in related backgrounds especially during the initial stage of industry development.
Buenstorf and Klepper (2010) following Buenstorf and Klepper (2009) study the cluster of automobile tire producers in the Akron area, Summit County, Ohio. Tire industry has been highly concentrated in this area since inception and after the shakeout in 1922 the industry evolved to an oligopoly. The authors use a county level data to identify the entrants and test the impact of different region-specific characteristics of agglomeration economies on the choice of geographic location for three types of firms: diversifiers (firms that extended their production line to include tires), spinoffs (startups found by at least one person who was previously employed by another tire producer), and other startups. According to their findings diversifiers were mainly rubber firms and spinoffs were created by former employees of successful tire incumbents. The fact that most of the latter firms originated in Akron and did not move away from the city or far from the city created a self-enforcing concentration. Hence, the tendency of firms to locate in the place where they originate fueled the agglomeration in the tire industry. Similar conclusions regarding the role of the spinoffs for industry agglomeration are drawn for the U.S. automobile industry in Klepper (2007), for the U.S. semiconductor industry in Moore and Davis (2004) and Klepper (2010).

In summary, spatial concentration of industries can be a consequence of evolutionary process of spinoffs formation or can be a result of agglomeration economies. In some industries such as the U.S. automobiles, tires, semiconductors, footwear, and fashion (Moore & Davis, 2004; Buenstorf & Klepper, 2010; Klepper, 2007 and 2010; Sorenson & Audia, 2000; Wenting, 2008) clusters emerged due to a historical precedent and spinoff dynamics lead to a lock-in effect (the tendency of new start-ups to locate close to their parent company). Boschma and Wenting (2007) argue that spinoff dynamics and agglomeration economies are interrelated- “A high rate of spinoff activity increases the number of local firms, strengthening agglomeration forces, which, in turn, not only enhance spinoff creation, but also increase the survival rate of spinoffs.”

According to Klepper and Simons (2000) the survival of firms in an industry is linked to their location. Boschma and Wenting (2007) find evidence that location was an important determinant for the emergence
of the British automobile cluster along with spinoff dynamics. Therefore, the different regions within a country should have different dynamics if location really matters. In this study, I compare the patterns of industry evolution of the DDT industry in the United States over the past century to evaluate whether different regions (primary versus secondary and more narrowly defined core versus periphery) exhibited dissimilar dynamics. Industries with different patterns of spatial evolution are likely to have location as one of the important determinants of market structure.

**DATA DESCRIPTION**

For the following analysis, I use data from the Thomas’ Register of American Manufacturers for the period 1947–1981. This is a relatively reliable and comprehensive source of data that tracks the U.S. industries over time. It contains information about the name and the address (state, city, and often detailed address) of the U.S. manufacturers. It also provides a capital ratio that can be used as a crude measure of firm size. For instance, firms with capital above $1,000,000 have a rating of AAAA, firms with capital above $500,000 but below $1,000,000 have a rating of AAA, firms with capital between $200,000 and $499,999 receive a rating of AA, etc. Some of the firms have unknown capital for the whole study period and they were given a rating of X. The information in the Register might be incomplete at times due to missing or misreported firms. For instance, some of the branch plants of multi-product firms might not be listed. Note that, I count the producers with production facilities in different cities as separate firms, and thus the manufacturing establishments are referred to as firms.

The focus of this paper is the DDT industry. It has been selected for a number of reasons. Firstly, it experienced a severe shakeout in the past century. Secondly, it has enough observations for the geographical analysis and lastly the locational aspect of the evolution of this industry has not been considered in previous research. The time span is limited to 1981 because the industry had its shakeout many years prior to 1981. The first
year of commercial mass production of DDT was 1943. However, information about DDT producers in the Register appears for the first time in 1947. The publication year of the Thomas’ Register is considered the year of inclusion of the firms in the data set.

**Regional Analysis (Primary vs. Secondary Region)**

This part of the empirical analysis is based on the U.S. Census division of the United States into 4 distinct regions, namely: Northeast (Region 1), Midwest (Region 2), South (Region 3), and West (Region 4). I identify the primary region where the majority of firms are located and a secondary region, which consists of the rest of the country. I follow the algorithm in Kepper and Grady (1990) to determine the different stages of evolution of the DDT industry. In particular, I divide the life cycle of the product into 3 stages. Stage 1 starts with the inception of the product and ends at the peak year. A peak year is defined as the year in which the number of producers reaches a maximum. When there is more than one year with the same maximum number of firms, the peak year is the one that has the highest average number of firms in the next three years. During this stage the number of firms grows. Stage 2 (i.e., the shakeout period) is characterized by a decline in the number of producers and ends in the year after which their number stabilizes. In particular, this is the year after which the annual change in the number of firms averaged over the next 5, 10, 15, 20,..., .. years is greater than −1.0% of the peak number of firms. Stage 3 is the post-shakeout period. I compare the net entry rates, the duration of the different stages, and the severity of the shakeout between the regions to find out whether they exhibit dissimilar dynamics.

Dichlorodiphenyltrichloroethane (DDT) was first synthesized in 1874 but its properties as an insecticide were discovered as late as 1939. The mass production of the product in the United States started in 1943. DDT became very popular during the World War II as a control against malaria and other insect-borne diseases. Later, it was also used in agriculture as a pesticide. The success of the product was
due to its high efficiency, low cost, and broad spectrum (see Raloff, 2000; Turusov, Rakitsky, & Tomatis, 2002). The production of DDT significantly increased after the war, reached a peak in 1962, and then it started to decline (see Agency for Toxic Substances and Disease Registry, 2002).

The increased publicity about the adverse side effects of the insecticide and the growing government restrictions on its usage contributed to the fall in production of the product. The American biologist, Rachel Carson, published a book named Silent Spring in 1962 which documented the numerous cases of the detrimental impact on the environment of DDT spraying in the United States. According to the author, the use of pesticides including DDT can cause cancer and their application in agriculture poses a significant threat to wildlife and especially birds. This book made the general public aware of the negative impact of pesticides and was a contributing factor to the started environmental movements afterwards (Lear, 1997). In 1972, all uses of DDT in the United States were banned. The ban went into effect on December 31, 1972. After that, a small number of firms continued to produce the insecticide but all of the output was exported from the country.

The Thomas’ Register of American Manufacturers lists 26 DDT producers in 1947. The majority of these producers were located on the East Coast—18 were in the state of New York and 13 in New York City alone. The high concentration of firms in New York City suggests that geographic location might have been an important determinant of industry development.

For the regional analysis of DDT industry, I combine regions 2 (Midwest), 3 (South), and 4 (West) into one region since the number of producers located there was small throughout the years. The primary region where the majority of firms were located is region 1, Northeast. Figure 1 depicts the number of firms in these regions as well as the total number of firms in the entire industry over the period 1947–1981. The pattern of industry evolution in the Northeastern region closely resembles the pattern in the industry as a whole, which is not surprising given the high concentration of firms there.
From 1947 to 1953, the number of firms in the Northeast region was rising and reached a peak of 35 producers. The average net entry rate in the region was 11.0% in stage 1. Then, a period of decline followed which ended around 1975. After that, the number of firms fluctuated slightly. The average net entry rate in stage 2, the shakeout period, was −8.9%. On average, 12% of the firms were leaving the region each year in the period 1954–1981. According to the algorithm in Klepper and Grady (1990) the shakeout in the Northeast region came to an end in 1977 but since the number of years in the post-shakeout period are less than five, these years are considered as part of stage 2. Consequently, the Northeastern region did not attain stage 3 of industry development by 1981.

From 1947 to 1955, the average net entry in the combined region was 12.3%, a little bit higher than in the main region. The maximum number of firms was attained in 1955 which is two years later than in region 1 or in the entire industry. After the peak year the number of producers started to fall. The decline was gradual and ended in 1975. The average net entry rate during the shakeout period (1955–1976) was −9.8%. 

**Figure 1.** Evolution of DDT Industry by Region.
Analysis of the Evolution of the U.S. DDT Industry

Afterwards, the count of DDT manufacturers in the secondary region stabilized and even increased slightly in 1980 and 1981.

Table 1 summarizes some key statistics of the DDT industry evolution in the Northeast region and the rest of the United States. The percentage drop in the number of firms in the primary region was 40.0% during the first quarter of the industry shakeout (1953–1959). In contrast, the number of firms increased in the periphery by 44.4% for the same period. This suggests that the shakeout was delayed and was smaller in the secondary region. As also shown by figure 1, the pattern of DDT industry evolution in the combined region is different than the pattern in the primary region.

**CORE-PERIPHERY ANALYSIS**

Fifty percent of the DDT firms were located in New York City in 1947. Until the peak year 1953, entry rates averaged at 15.2% per year. Exit rates were low during this time period (4.8%). After 1953, the number of firms located in the core started to gradually decline as exit rates rose.

<table>
<thead>
<tr>
<th>DDT Region</th>
<th>Region 1 (Northeast)</th>
<th>Regions 2, 3, and 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av. net entry rate</td>
<td>0.110</td>
<td>0.123</td>
</tr>
<tr>
<td>Peak number of firms</td>
<td>35</td>
<td>14</td>
</tr>
<tr>
<td>Av. net entry rate</td>
<td>–0.089</td>
<td>–0.098</td>
</tr>
<tr>
<td>Annual Net Entry Rate</td>
<td>–0.101</td>
<td>–0.124</td>
</tr>
<tr>
<td>Percentage drop in stage 2</td>
<td>0.943</td>
<td>0.929</td>
</tr>
<tr>
<td>Av. Net Entry Rate in 1st quarter</td>
<td>–0.076</td>
<td>–0.030</td>
</tr>
<tr>
<td>Percentage drop in 1st quarter</td>
<td>0.400</td>
<td>–0.444</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Not Attained</td>
<td>1977–1981</td>
</tr>
<tr>
<td>Av. net entry rate</td>
<td>n.a.</td>
<td>0.200</td>
</tr>
<tr>
<td>Number of firms in 1981</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
and entry ceased (excluding years 1960 and 1964). The average net entry rate was –9.3% during the shakeout. The number of firms dropped from 23 to 2 in stage 2, which corresponds to a 91.3% decline or in other words the shakeout was very severe. It ended in 1976 and a period of stabilization followed.

The pattern of industry development in the periphery is different than the one in the core (see figure 2). Entry in the non-New York City region continued until 1955 when the number of firms reached a maximum of 25 firms. The average net entry rate was relatively low, 7.7%. After that, entry into the periphery became sporadic. During the shakeout period, 1956–1970, the number of firms dropped by 92.0%. From 1977 to 1981, the net entry rate became positive and the count of DDT producers located outside of New York City or in the rest of the country slightly went up.

As shown by table 2, as well as figure 2, the decline in the number of DDT producers in the core was more rapid during the first 5 years following the peak and after that was gradual whereas in the periphery the drop was more pronounced after 1970.

**Figure 2.** Evolution of DDT Industry in the Core and Periphery.
In particular, the number of DDT manufacturers in New York City fell by 60.9% during the first quarter of the shakeout (1953–1959) whereas the count of producers located in the rest of the country increased by 19.0% in the same period. This suggests that the shakeout was delayed and it was smaller in the periphery during the first quarter of the shakeout period. Overall, the patterns of industry development in the two regions look dissimilar.

**DISCUSSION AND CONCLUSION**

Geographic location is often a missing component in the industry evolution literature whereas the time aspect is rarely taken into consideration in the studies of agglomeration externalities. With this paper I try to fill that gap in the literature and answer the question of whether different geographic regions exhibit dissimilar dynamics given the heterogeneity of these regions. For this purpose, I create a historical data set for the U.S. DDT industry using data from the Thomas’ Register of American Manufacturers. The industry
underwent a severe shakeout and has been highly geographically concentrated over the years. I use the following procedure to analyze the role of geographic location. First, I divide the United States into 4 regions according to the U. S. Census classification, namely Northeast, Midwest, South, and West. Then, I determine a primary region, where the majority of the producers are located, and a secondary region, which consists of the rest of the country. Next, I determine the core and periphery for the DDT industry—a well-defined industry center where many of the firms operate. I divide the evolution of each region into three distinct stages (a period of rise in the number of firms after inception, a shakeout, and a post-shakeout period) following the algorithm in Klepper and Grady (1990). I compare the average net entry rates in each stage, the duration of the stages, and the severity of the shakeout across regions to determine whether the different regions exhibited dissimilar dynamics. I find evidence that the shakeout was delayed in the secondary region or in the periphery and was smaller in the latter region during the first quarter of the shakeout.

The results of this study suggest that for some industries geographic location might be an important determinant of market structure. A more detailed investigation of the patterns of entry and exit, as well as an assessment of the factors that affect firm survival in various industries, including the DDT industry, is necessary. Additional data needs to be collected to isolate the effects of spinoff dynamics from agglomeration economies on the emergence of clusters, which is my goal for a further research.
References


