REGIONAL DIFFERENCES IN THE EVOLUTION OF THE U.S. FREEZER INDUSTRY

Emma Bojinova, Canisius College

ABSTRACT

The regional dimension of industry dynamics has emerged as an important research topic in the recent years. Regions within a country differ in terms of availability of natural resources, infrastructure, institutions, population, and labor force with a specific set of skills. Consequently, there can be substantial disparities in prosperity and industrial development across regions.

This paper analyzes the patterns of regional development in the U.S. freezer industry for the period 1946-1981. The analysis is based on the U.S. Census Division of the United States into nine distinct regions/divisions. Along with many other U.S. manufacturing industries, the freezer industry experienced a severe shakeout or a substantial drop in the number of producers over a relatively short period of time. The industry was also highly geographically concentrated in a few regions during the entire study period.

The evolution of freezers is divided into three stages – growth, shakeout, and stabilization. Various statistics are computed to determine whether the different regions exhibited dissimilar dynamics. A survival analysis is used to make further comparisons of the selected regions. Overall, the paper presents some evidence for the dissimilar development of the regions and provides a short discussion about the possible reasons for these differences.

INTRODUCTION

Many industries experience substantial changes in the number of producers over time. A number of studies documented a common evolutionary pattern in different manufacturing industries in the United States (Gort & Klepper, 1982; Klepper & Grady, 1990; Agarwal, 1998) and in the United Kingdom (Simons, 2005). The number of producers initially increased after the inception of a product, reached a peak, and then, suddenly declined. This decline can be gradual or very rapid and is referred to as a shakeout. Products that underwent many and/or substantial technological changes were subject to more severe shakeouts–the number of firms dropped by more than 60% over a short period of time (Agarwal, 1998). Such substantial changes in the number of competing manufacturers significantly affected the market structure in those industries and many of them eventually became oligopolistic in nature.

These common patterns sparked a great interest in researchers to determine the causes of shakeouts. A number of theories were developed to explain shakeouts and the role of technological developments was identified as the main factor influencing competition and the number of firms in an industry (see for example, Utterback & Suàrez, 1993; Jovanovic & MacDonald, 1994; Klepper, 1996, 2001). In short, firms (both incumbents and new entrants) that are unable to develop and/or adopt the new technological innovations become less competitive,

lose some of their customers, experience continuous declines in their profits, and are eventually forced to exit the industry. This triggers a shakeout.

Many of the empirical studies regarding industry shakeouts were conducted at a country level and investigated how the number of producers in a given industry changed over time. They rarely considered the impact of geographic location (for a detailed discussion see Boschma & Lambooy, 1999; Boschma & Frenken, 2011). Recently, researchers started to pay more attention to the locational aspect of industrial dynamics. Regions within a country are often endowed with different factors of productions. They differ in terms of their availability of natural resources, population, human and physical capital, infrastructure, and institutions. Consequently, there can be substantial disparities in development, income distribution, and prospects for economic growth across the different regions.

This paper investigates whether there are regional differences in the evolution of the U.S. home and farm freezer industry. The industry experienced a severe shakeout several years after the mass production of freezers began. This industry was also geographically concentrated in a few regions throughout the study period. The freezer industry was chosen because it has been rarely considered in the industrial studies of shakeouts, but most importantly the regional component of its evolution has not been studied so far. The main research questions of this paper are:

1. Do the evolutionary patterns for the different regions fit the country-level pattern?
2. Can the differences between patterns of regional development/evolution be explained by theories of industry shakeouts or the theories in the regional science literature?

To answer these questions, a historical dataset of firm location is created and analyzed. The source of data is the Thomas' Register of American Manufacturers, which tracks manufacturing establishments over time and provides information about their location (incl. specific address) and approximate capital rating designed by the publisher. The analysis is based on the U.S. Census division of the United States into nine distinct regions. Three of the regions attracted the majority of freezer producers and are considered separately, whereas the other six regions had a relatively small number of firms throughout the years and are combined into one larger region. The evolution of the industry is divided into three stages following Klepper and Grady (1990): growth, shakeout, and stabilization. Various statistics are computed and compared across the different regions during each stage of development, such as the change in the number of establishments, entry and exit rates, proportion of large establishments, percentage drop during the shakeout, etc. The paper provides evidence that the different regions seem to exhibit dissimilar dynamics. Two hypotheses are tested to determine which theories of industry shakeouts or spatial concentration fit better with the patterns of development in the selected industry.

The paper is structured as follows. In section 2, a brief literature review is presented focusing on the main theories of industry shakeouts and the regional science theories. Section 3 provides description of the data, as well as the employed methodology. Section 4 analyzes the industrial dynamics in the different regions. Section 5 provides a short discussion, summarizes the findings, and concludes.

BRIEF LITERATURE REVIEW

The three leading and most relevant theories of industry shakeouts are the "dominant design" by Utterback and Suàrez (1993), the "innovative gamble" of Jovanovic and MacDonald (1994), and Klepper (1996)'s theory of increasing returns to R&D. All of them explain shakeouts as a consequence of some type(s) of technological change. It is difficult to test these theories directly because it is hard to determine the impact of technological change (Klepper & Simons, 2005). However, analysis of entry and exit rates, as well as, of survival rates can provide evidence for which one of these three theories fits more with the available data for the home and farm freezer industry. These theories have different predictions for industrial dynamics with regards to entry and exit patterns and survival of incumbents compared to later entrants.

According to Utterback and Suàrez (1993), the occurrence of a dominant design affects competition and the number of firms in an industry. This dominant design can be one or two specific features of a product or a process innovation that become(s) a standard. Being superior to the other existing design structures it provides an incentive for innovation. Firms that are unable to innovate are forced to exit, which triggers a shakeout in the industry. Only the most capable innovators survive. Exit rates decrease and the number of firms stabilizes after the shakeout. The theory predicts higher survival rates for early entrants or incumbents in the beginning. However, as the least capable innovators exit the market, the survival rates for both early entrants and firms that entered during the shakeout (late entrants) become more similar.

In Jovanovic and MacDonald (1994), shakeouts are caused by a single major refinement following a basic innovation, which increases the optimal size 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. As unsuccessful innovators leave the industry, contributing to a shakeout, the number of firms stabilizes. This theory has similar predictions– entry rates drop with the onset of the shakeout, exit rates increase during the shakeout, and eventually the number of firms levels off. Early entrants have a competitive advantage over post-shakeout entrants initially but as late entrants gain experience the difference between survival rates of the pre- and post-shakeout entrants becomes insignificant.

Klepper's (1996) theory predicts that shakeouts are a consequence of a broader evolutionary process arising from increasing returns to scale to R&D. Incumbents benefit more from R&D (especially process innovations) and become more competitive compared to later entrants. Process R&D lowers average cost of production and bigger firms gain advantage due to increasing returns to scale. 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 a shakeout. Only the most capable entrants are able to compete with the incumbents. The advantage of early entrants over post-shakeout entrants can become even stronger over time which may prevent future entry in this industry. The predictions of this theory are different than those of the "dominant design" and "innovative gamble" - exit rates will not diminish eventually and survival rates of incumbents and post-shakeout entrants will not become similar over time.

Earlier entrants will still have advantage over late entrants and the industry will become even more dominated by some of the incumbents.

The three theories of industry shakeouts do not make any predictions regarding patterns of industrial development in the different regions within a country. In contrast, there is a broad literature focusing on geographic agglomeration and changes in location over time. However, these theories do not specifically address the shakeout phenomenon. Some of these theories are relevant to the scope of this paper and will be briefly discussed next.

Industrial activities may cluster in specific geographical areas due to positive externalities associated with labor market pooling (availability of skilled labor), access to suppliers of specialized equipment and inputs (supply-side factors), proximity to customers (demand-side factors), transportation cost savings, and knowledge spillovers within or across industries (Krugman, 1991). In addition, some regions can grow faster than others based on their ability to generate new knowledge (Romer, 1986).

A number of theories have been developed to explain the possible changes in spatial concentration of industries over time. According to the profit-cycle theory, production activities are likely to be more concentrated initially, but as industries mature they will tend to be more dispersed due to changes in profit opportunities (Markusen, 1985). Some geographical areas can act as "nursery" centers in promoting innovation and will attract younger firms (Duranton & Puga, 2001). These firms will have access to different production technologies that will allow them to experiment and innovate until they find their "ideal" production process. Then, they will move away from the "nursery" centers to places with lower costs of production. The decline in the concentration of firms in a particular geographical area over time can also be due to the diminishing importance of external economies of scale after a product is developed and goes through its growth stage. In the mature phase, the product becomes standardized and specialized skills become less important (Hansen, 1988). This destabilizes the process of local concentration.

On the other hand, clusters may form in specific locations simply due to historical accidents (Krugman, 1991). As firms concentrate in these locations they benefit from being close to their competitors and attract more suppliers of their inputs and workers with specific skills. This leads to a cumulative process that promotes industrial growth and development in these locations and economic activities can continue to stay concentrated in this location for the entire product life cycle. Spinoffs (startups found by at least one person who was previously employed by another producer in the same industry) and spinoff dynamics have a significant role in fostering innovation and regional economic development. For instance, in the U.S. automobile, tire, semiconductors, footwear, high technology, and fashion industries clusters emerged by historical precedents and spinoff dynamics lead to a lock-in effect (Sorenson & Audia, 2000; Moore & Davis, 2004; Neck, Meyer, Cohen, & Corbett, 2004; Klepper, 2007, 2010; Wenting, 2008; Buenstorf & Klepper, 2009, 2010).

The theories of clustering and locational change over the product life cycle predict different patterns of industry dynamics. In the first case, regional concentration of production activities will tend to be relatively constant over time. In the second case, the concentration of an industry will decline during the later stages of a product development. One of the goals of this paper is to check which theory fits better with the data for the U.S. freezer industry.

DATA DESCRIPTION AND METHODOLOGY

The data source for the following analysis is the Thomas' Register of American Manufacturers. The data were compiled from microfilms for the period 1946-1981. The Register is a relatively reliable source of data and has been typically used in the industry shakeouts literature. It contains information about the name and address (state, city, and often detailed address) of the U.S. manufacturers of home and farm freezers. It also provides a capital rating (a non-numeric coding) that can be used as a crude measure of firm size. Establishments with capital above $1,000,000 have a rating of AAAA, establishments with capital above $500,000 but below $1,000,000 have a rating of AAA, establishments with capital between $200,000 and $499,999 receive a rating of AA, etc. Establishments with unknown capital are given a rating of X. Producers with production facilities in different cities are counted as separate establishments.

The home and farm freezer industry was selected for two reasons - first, it experienced a severe shakeout in 1955, and second, it had enough observations for conducting the geographical analysis. The time span is limited to 1981 because the main focus of this paper is on the shakeout period and this period ended several years prior to 1981. The list of freezer producers was slightly adjusted for minor gaps in the time series data.

The regional analysis is based on the U.S. Census partition of the United States into 9 distinct divisions or regions: New England (Region 1), Middle Atlantic (Region 2), East North Central (Region 3), West North Central (Region 4), South Atlantic (Region 5), East South Central (Region 6), West South Central (Region 7), Mountain (Region 8), and Pacific (Region 9). Regions 2, 3, and 4 had the largest concentration of freezer producers throughout the study period. In contrast, regions 1, 5, 6, 7, 8, and 9 had just a few establishments over the years (at most 3 in a given year) and were combined into a single region named Region 1, 5-9.

The paper utilized the algorithm developed in Klepper and Grady (1990) to determine the different stages of industrial evolution for each region described above and for the industry as a whole. In particular, the life cycle of a product consists of 3 stages. Stage 1 is the growth period – it starts with the product inception and ends at the peak year (i.e., the year with the maximum number of producers). When there is more than one year with the same maximum number of establishments, the peak year is the one that has the highest average number of establishments in the following three years. Stage 2 is the shakeout period. The number of establishments declines during this stage. The shakeout period ends in the year after which the annual change in the number of establishments averaged over the next 5, 10, 15, 20, ... years is greater than -1.0% of the peak number of establishments. Stage 3 is the post-shakeout period.

REGIONAL ANALYSIS

The missing component of the industry evolution studies conducted at the country level is the geographic dimension of industry dynamics. Different regions often differ in terms of their endowments, access to resources and institutions, as well as the level of competition among firms. Because of that, it is likely to expect different patterns of industrial evolution for the different regions. These disparities in regional development and their causes constitute an

important research question because they affect the rates of local economic growth, income distribution, and the well-being of local residents.

In this section, the regional development of the U.S. freezer industry will be analyzed by providing a graphical presentation of the different regions in terms of entry, exit, and number of establishments over time and by comparing a number of statistical measures for each stage of development and also the survival rates of pre- and post-shakeout entrants across regions and in the entire industry. In addition, the implications of the three theories of shakeouts and the theories of regional concentration will be considered in order to determine which theory fits better with the data available for the freezer industry.

Home and farm freezer units were introduced into the U.S. market in 1929 (see for example Gort & Klepper, 1982; Klepper & Grady, 1990). Their production was suspended during the Great Depression and the World War II. After the end of the war freezers became very popular and their production was resumed. Initially, freezers were built as a compartment in a larger refrigerator, but they were expensive to run and required thawing to remove the build-up of ice around the freezing units. The technology of frost-free refrigeration was developed in 1950s, which made freezers more efficient and easier to maintain (Ormrod, 1990). The design and energy efficiency of freezers were improved multiple times over the next three decades. Many other advances such as automatic ice units and self-compartmentalized freezing units were also developed.

The major freezer producers in the 1940s were Amana Society (later acquired by Raytheon), Maytag, General Electric, General Motor's Frigidaire, and Westinghouse Electric. Amana Society and Maytag were established in Iowa, General Electric in Connecticut, and the last two companies operated in Ohio. The majority of freezer manufacturers were located in Region 3 (East North Central) and Region 2 (Middle Atlantic), there were some in Region 4 (West North Central), and just a few in the other regions. Region 3 can be considered as the industry center because it had the highest concentration of establishments throughout the years.

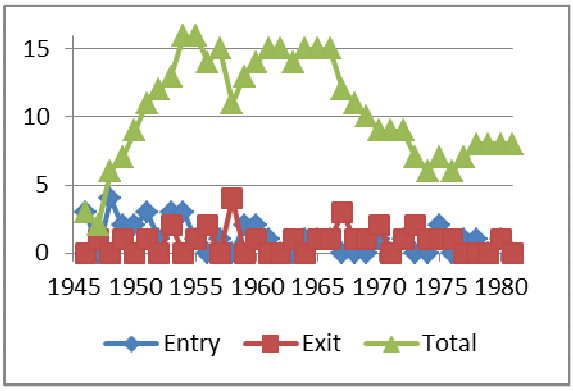
Figure 1 presents the total number of establishments, entry and exit counts by region in the freezer industry for the period 1946-1981. The four regions appear to have experienced different patterns of development. The declines in the number of establishments in Regions 2, 3, and 4 seem to be more substantial compared to the combined region (Regions 1, 5-9). In addition, the decline in the latter region started later than in the other three regions. Moreover, a comparison of the regional patterns with the entire industry shows that these patterns of industry dynamics look dissimilar. Perhaps, just the pattern for Region 3 seems to fit to some extend with the one for the industry as a whole. Entry and exit patterns also appear to be different across the different regions. Additional statistics are necessary to make better comparisons among the regions and the entire industry.

As described in the previous section, the evolution of freezer industry is divided into three stages: growth, shakeout, and stabilization following Klepper and Grady (1990). A number of important descriptive statistics are computed for each of the regions and the entire industry by stage of development. These statistics are summarized in Table 1.

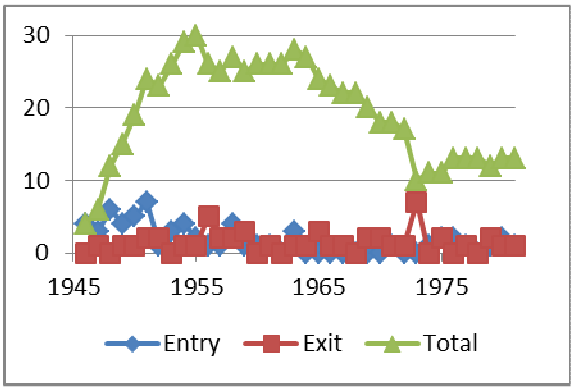
The average net entry rate is computed by averaging the net entry rates in each stage (i.e., the difference between the number of establishments entered in and those that left the region/industry in a given year divided by the total number of establishments in the previous year). This statistic is useful in comparing the entry and exit patterns across regions. Similarly,

average net entry rates for the first quarter of the shakeout period for the entire industry (not for a particular region) is calculated for all regions. For instance, the shakeout in the freezer industry began after 1955, the peak year, and ended in 1973. The duration of the shakeout was 18 years. One quarter of 18 years is 4.5 years. Therefore, years 1956-1960 were considered as the first quarter of the shakeout.

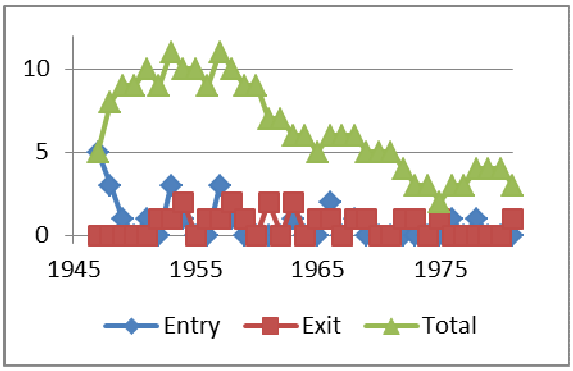
Figure 1: Evolution of Freezer Industry by Region and for the Entire Industry



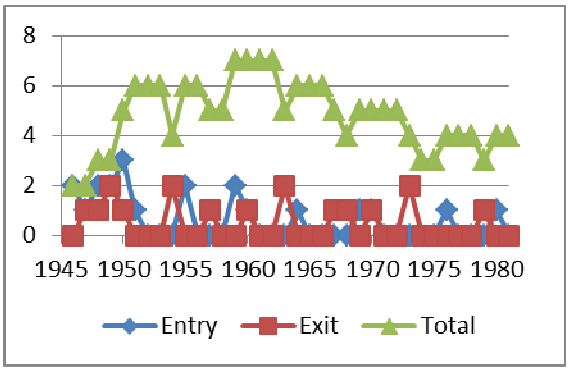
Panel a: Region 2



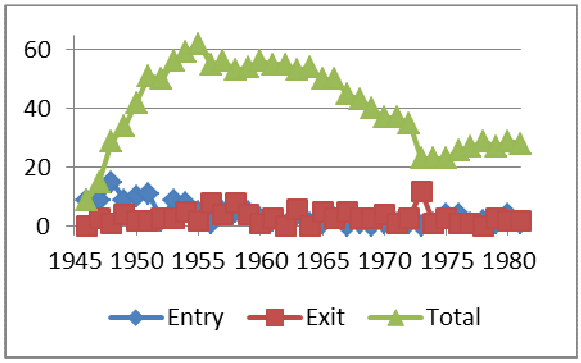
Panel b: Region 3



Panel c: Region 4



Panel d: Regions 1, 5-9



Panel e: All Regions (Entire Industry)

Several studies found a positive relationship between firm size and process innovations (Mansfield, 1981; Scherer, 1991; Cohen & Klepper, 1996), which in turn affect firm survival. The capital rating is utilized to distinguish freezer producers by their size. The percentage of

large establishments is computed as the ratio of the number of distinct manufacturing establishments with a capital rating of AAA or higher to the total number of establishments in each stage and region. All establishments that entered or exited are counted.

The age of establishments can be used as a proxy for their production experience (productivity can increase over time due to the "learning by doing" effect) or innovative capabilities. Incumbents were found to have substantially lower hazard rates compared to later entrants and this outcome was related to the higher probability of survival of innovators and the higher likelihood of early entrants to innovate (Klepper & Simons, 2005).

The percentage drop in stage 2 and percentage drop during the first quarter of the shakeout for the entire industry are two other measures listed in Table 1. They are useful in determining the severity of the shakeout in each region and the entire industry. The first measure is computed as the difference between the peak number of establishments and the number of establishments at the end of the shakeout divided by the peak number. The percentage drop during the first quarter of the shakeout is calculated in a similar way but in this case we subtract the number of establishments at the end of the first quarter.

Table 1
Descriptive Statistics by Stage and Region

	Region 2	Region 3	Region 4	Regions 1, 5-9	All Regions
Stage 1 (Growth)	(1946-1954)	(1946-1955)	(1946-1953)	(1946-1959)	(1946-1955)
Average net entry rate	0.34	0.28	0.16	0.14	0.27
% large establishments	36.36	52.63	53.85	50.00	49.44
Average age	2.76	3.35	3.69	3.38	3.68
Peak number of establishments	16	30	11	7	62
Stage 2 (Shakeout)	(1955-1973)	(1956-1973)	(1954-1974)	(1960-1973)	(1956-1973)
Average net entry rate	-0.036	-0.052	-0.053	-0.043	-0.049
Average net entry rate in 1st Q	-0.012	-0.025	-0.014	0.058	-0.018
Percentage drop in stage 2	56.25	66.67	72.73	42.86	62.90
Percentage drop in 1st Q	12.50	13.33	18.18	-16.67	9.68
% large establishments	40.00	68.09	61.11	40.00	58.51
Average age	9.93	12.40	9.06	14.8	11.90
Stage 3 (Stabilization)	(1974-1981)	(1974-1981)	(1975-1981)	(1974-1981)	(1974-1981)
Average net entry rate	0.024	0.036	0.036	0.052	0.027
% large establishments	81.82	85.71	75.00	80.00	80.49
Average age	12.09	14.35	12.50	19.6	14.50
Number of establishments in 1981	8	13	3	4	28

A comparison of the different regions reveals the following patterns. The duration of stage 1, or the period of growth, was slightly shorter in regions 2 and 4, but it was four years longer in the combined region as compared to region 3 and the entire industry. In other words, the shakeout started earlier in regions 2 and 4 and later in regions 1, 5-9. A possible explanation for this outcome is that technological changes peaked faster in regions 2, 3, and 4 than in regions

1, 5-9. The average age of establishments located in region 4 was the highest among all regions, which suggests that freezer producers in this region had on average more experience compared to their competitors in the rest of the country. In addition, this region had the highest proportion of large establishments and one of the lowest average net entry rates indicating that the growth period was relatively rapid and involved more large rather than small establishments. Regions 2, on the other hand, had both lower average age and lower percentage of large establishments. This suggests that stage 1 in region 2 was characterized by a larger number of small and younger establishments, which is also evident by the highest average net entry rate in this region compared to the other regions. Region 3, the industry center, developed in a similar way as the entire industry.

The shakeout lasted longer in region 4 compared to regions 3 and 2 (three and two years longer, respectively). The shortest span of the shakeout period was observed for regions 1, 5-9. The average net entry rates were negative indicating that exit rates exceeded entry rates in all regions during stage 2. The percentage drop in the number of establishments exceeded 55% in regions 2, 3, and 4. Only the combined region (1, 5-9) had a decline that was lower than 50%, which indicates that the shakeout was not so severe in this location. The statistics for the first quarter of the shakeout confirm this finding–the average net entry rate was positive and the number of establishments did not drop, it actually went up by 16.67%. This also is consistent with the graphical depiction in figure 1. An interesting observation is that the combined region had the highest average age in stage 2. This is due to the fact that some of the youngest establishments did not survive during the shakeout.

Region 4 was affected most in comparison to the other regions. It had the lowest average net entry rate and the highest percentage drop in stage 2 and during the first quarter of the shakeout for the entire industry. The average age of all establishments in this region was the lowest of all regions signifying that some of the earlier entrants also ended up leaving the industry.

Region 3, which had the highest concentration of freezer producers, also experienced one of the biggest drops in the number of establishments, both during the first quarter and for the whole shakeout period. However, it had the biggest percentage of large establishments and one of the highest average ages in stage 2. This suggests that, even though the shakeout was more severe in this region, it affected mainly the late entrants and the smaller establishments. It is consistent with the findings in Boschma and Wenting (2007) that the concentration of many automobile producers in a given region in Great Britain negatively affected the survival rates of new entrants and this impact was stronger during the later stages of industry evolution.

In stage 3, all regions were characterized by a larger number of bigger and older or more experienced establishments. The average age was typically above 12 years and the percentage of large establishments was at least 75 in each region. This confirms the results found in Cefis and Marsili (2006) that small and young firms are at a higher risk of exit. It is also supported by Klepper and Simons (2000) finding that larger firms had in general higher survival rates in the U.S. tire industry. The average net entry rate was relatively low, with just a few entries and exits per year. Region 3 had the highest proportion of large establishments, one of the highest average ages, and the biggest number of operating manufacturing establishments in 1981.

To determine which of the theories of industry shakeouts and of clustering, discussed in the literature review section, fit more with the regional patterns of development in the freezer industry the following two hypotheses will be tested:

H1 *If the shakeout in the freezer industry was a consequence of some kind of technological change(s) as explained by the "dominant design" or "innovative gamble" theories, the survival rates of post-shakeout entrants should be lower initially, but over time, as those firms gain experience, the differences in survival rates of early and late entrants should become more and more similar. In contrast, if the shakeout was caused by a broader evolutionary process arising from increasing returns to scale to R&D (Klepper, 1996) rather than a particular technological development, the difference in survival rates of early and post-shakeout entrants will not become smaller and smaller over time.*

H2 *If spatial concentration changes over time, manufacturing activities should initially be concentrated in a few core regions or industry centers, but as profit opportunities change (Markusen, 1985), when the "ideal" production process is found (Duranton & Puga, 2001), or when the product becomes standardized and firms begin to search for cost savings (Hansen, 1988), more establishments will move their production facilities to lower-cost locations. This will lead to a decline in the concentration of firms in the core region(s). However, if regional concentration is due to historical accidents and spinoff dynamics led to a lock-in effect, the concentration of producers should not change significantly when an industry goes through the different stages of development.*

Table 2 lists the survival rates of establishments in each region by their time of entry (i.e., before or after the beginning of the shakeout). These survival rates represent the percentage of establishments located in a given region that survived at least five, ten, fifteen, twenty, or twenty-five years. The survival rates of pre-shakeout entrants were typically higher than the rates of post-shakeout entrants in all regions (with one exception) and also for the entire industry as measured by the percentage of establishments that survived 5 or more years, or at least ten years. This is consistent with the predictions of the three theories of industry shakeouts.

Table 2
Survival Rates of Pre- and Post-Shakeout Entrants by Region

	Survived at least 5 years (%)	Survived at least 10 years (%)	Survived at least 15 years (%)	Survived at least 20 years (%)	Survived at least 25 years (%)
Region 2 pre-shakeout entrants	59.09	45.45	40.91	13.64	13.64
Region 2 post-shakeout entrants	56.25	25.00	6.25	6.25	0.00
Region 3 pre-shakeout	67.50	47.50	42.50	25.00	15.00
Region 3 post-shakeout entrants	59.09	31.82	13.64	9.09	4.55
Region 4 pre-shakeout	71.43	42.86	14.29	7.14	7.14
Region 4 post-shakeout entrants	70.00	20.00	10.00	0.00	0.00
Regions 1, 5-9 pre-shakeout entrants	46.46	40.00	26.67	20.00	20.00
Regions 1, 5-9 post-shakeout entrants	50.00	33.33	0.00	0.00	0.00
All pre-shakeout entrants	63.22	44.83	34.48	18.39	14.94
All post-shakeout entrants	61.54	28.85	9.62	5.77	1.92

However, the long-term survival rates (at least 15, 20, or 25 years) of pre- and post-shakeout entrants did not become similar over time in any of the regions. To determine whether these survival rates were really different the following procedure was used. The standard deviation of the proportion in a Binomial experiment with success probability p is $\sqrt{\frac{p(1-p)}{n}}$. Plugging in the values of p in this formula, one can compute the standard errors in each case. If a difference in proportions is at least two standard deviations greater than any of the standard deviations, this difference will be considered large enough to conclude that survival rates were different. A formal testing for differences in two proportions was inappropriate in most of the cases because *np* or *n(1-p)* was not greater than 5, which violated the assumptions of this test.

Table 3 lists the differences in proportions of pre-and post-shakeout establishments that survived a given number of years (at least 15, 20, or 25) and the associated standard deviations for each region and the entire industry. For instance, considering the proportion of establishments that survived at least 15 years in region 3, the standard deviations for pre- and post-shakeout entrants are 0.078162 (or 7.82%) and 0.073173 (or 7.32%), respectively. Because the difference 42.5% - 13.64% = 28.86% equals more than three times any of the standard errors, the result is obvious that pre-shakeout entrants had higher survival rates than post-shakeout entrants and no formal testing is needed.

Table 3
Differences in Proportions of Survival Rates between Pre- and Post-Shakeout Entrants by Region

	Survived at least 15 years		Survived at least 20 years		Survived at least 25 years	
Region 2: Difference in proportions	0.35	diff.	0.07		0.14	diff.
Standard deviations	0.10	0.06	0.07	0.06	0.07	0.00
Region 3: Difference in proportions	0.29	diff.	0.16	diff.	0.10	
Standard deviations	0.08	0.07	0.07	0.06	0.06	0.04
Region 4: Difference in proportions	0.04		0.07		0.07	
Standard deviations	0.09	0.09	0.07	0.00	0.07	0.00
Regions 1,5-9: Difference in proportions	0.27	diff.	0.20	diff.	0.20	diff.
Standard deviations	0.11	0.00	0.10	0.00	0.10	0.00
All: Difference in proportions	0.25	diff.	0.13	diff.	0.13	diff.
Standard deviations	0.05	0.04	0.04	0.03	0.04	0.02

The differences in proportions of early and late entrants that survived at least 15, 20, or 25 years are typically at least two times greater than the larger of the standard errors in all regions besides region 4. The results for region 4 are inconclusive, but considering the fact that none of the post-shakeout entrants survived more than 20 years in this region, there is some evidence that late entrants were at disadvantage. The small sample sizes make the standard deviations larger and it is really difficult to get significant results.

Overall, the differences in survival rates of pre-and post-shakeout entrants became even larger as the industry matured, which does not support the "dominant design" and "innovative

gamble" theories. Instead, this pattern fits more with the theory of increasing returns to scale in R&D that shakeouts are a consequence of a broader evolutionary process in which technological change leads to increasing returns and gives an advantage to early entrants. This thesis is also supported by the statistics provided in Table 2, which show that the proportion of large and older establishments in all regions is much higher in stage 3 compared to stages 1 and 2.

Table 4 lists the proportions of establishments located in each region by stage of development. It can be used to determine whether concentration of freezer producers in a given location changed over time (hypothesis 2). The fluctuations in the concentration of establishments from stage 1 to stage 2 or from stage 2 to stage 3 in the different regions seem to be relatively small.

Table 4
Proportion of Establishments in Each Region by Stage

	Region 2	Region 3	Region 4	Regions 1, 5-9
Stage 1: Growth	24.719	42.697	14.607	17.978
Stage 2: Shakeout	28.571	44.762	17.143	9.524
Stage 3: Stabilization	26.829	51.220	9.756	12.195

Two different tests were conducted to check whether these changes in concentration were statistically significant. The first one was a test for differences between two proportions. All, but in one case, the test assumptions were satisfied. Those hypothesis tests did not provide evidence that population proportions were different at the 5% level of significance. The second test was a chi-square test for independence. Four contingency tables were created. The test results showed that the number of establishments located in each region was not dependent on the stage of development at the 5% level of significance. In summary, the concentration of establishments in each region in the freezer industry did not change significantly over the product life cycle, which fits more with the theory of concentration due to historical accidents (Krugman, 1991) and the role of spinoffs in creating a lock-in effect.

CONCLUSION

This paper analyzed the patterns of regional evolution in the American freezer industry for the period 1946-1981. All regions went through three stages of industry development - growth, shakeout, and stabilization. This supports the country-level patterns acknowledged by several researchers for the U.S and the United Kingdom.

The graphical depiction showed that the evolutionary patterns for the different regions looked dissimilar, which was also confirmed by the various statistics provided in Table 1. The duration of the growth period was slightly shorter in regions 2 and 4 and longer in the combined region compared to region 3 and the entire industry. The shakeout started earlier in regions 2, 3 and 4. This outcome suggests that technology peaked faster in these regions, and as competition among producers became more intense some of the unsuccessful innovators ended up leaving the industry causing the earlier beginning of the shakeout.

The shakeout was more severe in regions 2, 3, and 4 than in the combined region, where it was much shorter. Regions 3 and 4 had the lowest average net entry rates and the highest percentage drops in stage 2 and also during the first quarter of the shakeout. Region 3, which can be designated as the industry center, had the biggest percentage of large establishments and one of the highest average ages in stage 2 suggesting that the shakeout mainly affected late entrants and smaller establishments. This supports Boschma and Wenting (2007) and Cefis and Marsili (2006) that small and young firms are more likely to exit. It also conforms to the idea that large establishments benefit more from knowledge spillovers, grow even larger, become more competitive, and survive longer.

The survival patterns in all regions were analyzed to determine which theory of industry shakeouts was more consistent with the evolution of the freezer industry. The survival rates of pre-shakeout entrants were generally higher than those of post-shakeout entrants in all regions and in the entire industry throughout the study period. The differences in survival rates did not become smaller and smaller over time, instead, they became larger. This finding does not support the "dominant design" and "innovative gamble" theories, but fits more the predictions of the "increasing returns" theory to R&D that eventually some of the early entrants or incumbents will be dominating the industry.

The freezer industry did not experience significant changes in regional concentration over the product life cycle. Region 3 continued to be the region with the highest proportion of establishments during all stages of industry development, followed by region 2. The absence of changes in spatial concentration is in accordance with the theories of clustering due to spinoff dynamics and the agglomeration forces discussed in Krugman (1991). Manufacturing establishments located in the industry center or in the core regions tend to benefit from knowledge spillovers, labor-market pooling, and proximity to suppliers of inputs.

The unequal development of regions has important consequences for regional growth and prosperity of local residents. Regional industrial policies focusing on innovation and improving local conditions for businesses are likely to attract more manufacturing establishments and the self-reinforcing effects of agglomeration can expand the prospects of economic growth in these regions both in the short and long term.

REFERENCES

Agarwal, R. (1998). Evolutionary trends of industry variables. *International Journal of Industrial Organization,* 16, 511-525.

Boschma, R.A. & K. Frenken (2011). The emerging empirics of evolutionary economic geography. *Journal of Economic Geography*, 11, 295-307.

Boschma, R.A. & J.G. Lambooy (1999). Evolutionary economics and economic geography. *Journal of Evolutionary Economics*, 9, 411-429.

Boschma, R.A. & R. Wenting (2007). The spatial evolution of the British automobile industry: Does location matter? *Industrial and Corporate Change*, 16, 213-238.

Buenstorf, G. & S. Klepper (2009). Heritage and agglomeration: The Akron tyre cluster revisited. *The Economic Journal*, 119, 705-733.

Buenstorf, G. & S. Klepper (2010). Why does entry cluster geographically? Evidence from the U.S. tire industry. *Journal of Urban Economics*, 68, 103-114.

Cefis, E. & O. Marsili (2006). Survivor: The role of innovation in firms' survival. *Research Policy*, 35, 626–641.

Cohen, W.M. & S. Klepper (1996). Firm size and the nature of innovation within industries: The case of process and product R&D. *The Review of Economics and Statistics*, 78, 232-243.

Duranton, G., & D. Puga (2001). Nursery cities: Urban diversity, process innovation, and the life cycle of products. *The American Economic Review,* 91, 1454-1477.

Gort, M. & S. Klepper (1982). Time paths in the diffusion of product innovation. *The Economic Journal*, 92, 630-653.

Hansen, N. (1988). Regional consequences of structural changes in the national and international division of labor. *International Regional Science Review*, 22(2): 121-136.

Jovanovic, B. & G.M. MacDonald (1994). The life cycle of a competitive industry. *The Journal of Political Economy*, 102, 322-347.

Klepper, S. (1996). Entry, exit, growth, and innovation over the product life cycle. *The American Economic Review*, 86, 562-583.

Klepper, S. (2007). Disagreements, spinoffs, and the evolution of Detroit as the capital of the US automobile industry. *Management Science*, 57, 616-631.

Klepper, S. (2010). The origin and growth of industry clusters: The making of Silicon Valley and Detroit. *Journal of Urban Economics*, 67, 15-32.

Klepper, S. & E. Grady (1990). The evolution of new industries and the determinants of market structure. *RAND Journal of Economics*, 21, 27-44.

Klepper, S. & K.L. Simons (1996). Innovation and industry shakeouts. *Business and Economic History*, 25 (1), 81-89.

Klepper, S. & K.L. Simons (2000). The making of an oligopoly: Firm survival and technological change in the evolution of the U.S. tire industry. *The Journal of Political Economy*, 108, 728-760.

Klepper, S. & K.L. Simons (2005). Industry shakeouts and technological change. *International Journal of Industrial Organization*, 23 (1-2), 23-43.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy,* 99 (3), 483– 499.

Markusen, A. (1985). *Profit cycles, oligopoly, and regional development*. Cambridge, MA: MIT Press.

Moore, G. & K. Davis (2004). Learning the Silicon Valley way in T. Bresnahan and A. Gambardella (eds.), *Building High-tech Clusters: Silicon Valley and Beyond*, Cambridge University Press: Cambridge, England.

Neck, H.M., Meyer, G.D., Cohen, B. & A.C. Corbett (2004). An entrepreneurial system view of new venture creation. *Journal of Small Business Management*, 42, 190-208.

Romer, P.M. (1986). Increasing returns and long-run growth. *Journal of Political Economy,* 94, 1002– 1037.

Simons, K.L. (2005). Product market characteristics and the industry life cycle. *Cornell University*, Rensselaer.

Sorenson, O. & P.G. Audia (2000). The social structure of entrepreneurial activity: Geographic concentration of footwear production in the United States, 1940-1989. *American Journal of Sociology*, 106, 424-464.

Utterback, J.M. & F.F. Suàrez (1993). Innovation, competition, and industry structure. *Research Policy*, 22, 1-21.

Wenting, R. (2008). Spinoff dynamics and the spatial formation of the fashion design industry. *Journal of Economic Geography*, 8, 593-614.