AGGLOMERATION AND CLUSTERING OVER THE INDUSTRY LIFE CYCLE: TOWARD A DYNAMIC MODEL OF GEOGRAPHIC CONCENTRATION

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Research on agglomeration finds that either a higher survival rate of incumbent firms or a higher founding rate of new entrants, or both, can sustain an industry cluster. The conditioning effects of time on the two distinct mechanisms of survival and founding are, however, rarely examined. We argue that the forces driving geographic concentration vary across the industry life cycle. Data from Ontario’s winery industry from 1865 to 1974 demonstrates a dynamic model of geographic concentration: agglomeration attracts more new entry in the growth stage only, whereas it contributes to firm survival in the mature stage only. The results not only establish the importance of understanding the temporal dynamics underlying agglomeration externalities, but also provide a possible explanation for the mixed empirical results found in previous studies.

INTRODUCTION

Social scientists have long noticed that firms engaged in the same business tend to be persistently collocated with one another in a small number of places, a phenomenon labeled as ‘economies of agglomeration’ by Alfred Marshall (1920). More recently, the term ‘industry cluster’ was coined to refer to places where firms and related institutions in an industry are collocated (Porter, 1990). In recent decades, research on industry clusters has accumulated a growing body of literature that attributes the persistence of industry geographic concentration to two separate but intertwined mechanisms: survival and founding. The survival mechanism maintains that firms collocating with one another obtain economic gains by sharing common resources such as natural advantage (Hoover, 1948), skilled labor, specialized suppliers, and knowledge spillovers (Krugman, 1991). These regional advantages enable clustered firms to perform better and thus survive longer than less clustered ones, resulting in the persistence of geographic concentration. In contrast, the founding mechanism posits that geographic concentration can also persist if industry clusters attract more investments than other places (Gordon and McCann, 2000; Rosenthal and Strange, 2003). Given the promise of exclusive economic gains from collocation, investors are more likely to found their businesses within industry clusters. Moreover, entrepreneurs in industry clusters are embedded in local social networks and are therefore more likely to observe and explore investment opportunities (Sorenson and Audia, 2000).

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However, even if industry clusters are sustained by attracting more investments or aiding in the survival of local firms, or even both, an important issue that remains unclear is whether the two mechanisms of founding and survival are both equally effective at the same time or if, at certain stages of an industry’s evolution, one plays a more dominant role than the other. Notably, this crucial aspect of cluster dynamics has been largely overlooked and understudied in the existing literature. Most empirical studies on industry clusters do not explicitly control for temporal dynamics experienced by industry clusters during the evolution of an industry. Some empirical studies, in using survey data (e.g., DeCarolis and Deeds, 1999; Mesquita and Lazzarini, 2008) or single-year observations (e.g., Canina, Enz and Harrison, 2005; Chung and Kalnins, 2001; Rosenthal and Strange, 2003), only provide a snapshot view of cluster dynamics. Some other studies, though utilizing longitudinal data (e.g., Baptista and Swann, 1998; Chang and Park, 2005; Gilbert, McDougall and Audretsch, 2008; Kalnins and Chung, 2004; McCann and Vroom, 2010; Wennberg and Lindqvist, 2010), do not incorporate the temporal dimension into their investigation, implicitly assuming that the types and potencies of agglomeration externalities are fixed across an industry life cycle (ILC). A few recent studies have identified some temporal occurrences, such as the abnormally rapid entry of integrated circuit producers in Silicon Valley from 1965 to 1973 (Klepper, 2010). However, these studies have not specifically examined how the formation of industry clusters, which resulted from agglomeration externalities, is conditioned by temporal particularities.

Thus, the question remains as to whether and when the role of agglomeration shifts from enticing firms to enter the cluster to cushioning the brunt of industry shakeout. Without teasing out and scrutinizing the temporal dynamics of clusters, the results obtained from prior studies are difficult to compare to each other since each of these may have captured different roles of agglomeration at different time points. For example, while many studies show that agglomeration attracts new entrants (e.g., Kalnins and Chung, 2004; Stuart and Sorenson, 2003), Shaver and Flyer (2000) find that firms possessing superior technology tend to locate some distance from where most firms cluster. They attribute this adverse selection to the fact that a more advanced firm wants to avoid knowledge spillover to neighboring firms. Yet, while firm heterogeneity certainly stands as a plausible explanation here, temporal dynamics could be a potential alternative explanation. In fact, whether adverse selection (Shaver and Flyer, 2000) or the overall attractiveness of clusters to investors, as found in many other studies, is more pronounced may well depend on the ILC; i.e., at which stage of an industry’s evolution will the risk of leaking superior technology to competitors outweigh the benefits of agglomeration? However, by limiting their analysis to 1987, Shaver and Flyer (2000) overlook the possible temporal contingency. Similar critiques may apply to other studies. This concern prompts Schmitz and Nadvi (1999) to question whether the passive advantages of clustering alone can sustain clusters. In the same vein, McCann and Folta (2008) urge researchers to investigate the temporal dynamics of agglomeration externalities.

In response to these concerns, our paper incorporates the conditioning aspect of time by analyzing agglomeration over different phases of industry evolution. As we discuss, a more thorough understanding of cluster dynamics requires investigation of both the mechanisms of founding and survival across the ILC. Our study is situated in Ontario’s wine production starting from the industry’s birth in 1865 to 1974. As elaborated later, several features of the industry, and its relatively clear-cut history with two distinct life-cycle stages, make it an ideal context in which to test our theory. We find that both the founding and survival mechanisms drive geographic concentration, yet their salience varies over time. Specifically, geographic concentration is driven by the founding mechanism only in the growth stage and by the survival mechanisms only in the mature stage. These findings and their implications are important because the survival mechanism focuses more on the existing benefits of clusters, rooted in more exogenous factors, whereas the founding mechanism, in contrast, focuses more on the perceived benefits of clusters and provides more room for active agency. The results, taken together, demonstrate the temporal dynamics underlying geographic concentration and contribute to a more fine-grained understanding of cluster dynamics. The study makes two additional contributions. By examining the conditioning effect of geography on ILC, it suggests that local patterns may vary from industry-wide ones. Additionally, by examining the conditioning effect...
of geography on population density dependence, our study complements the population ecology argument, which mainly emphasizes the role of the temporal dimension on an industry’s vitality rates.

**THE SURVIVAL MECHANISM**

The survival mechanism shapes the geographic concentration of an industry when the mortality rate of firms differs across places. This argument, rooted in the economic geography literature, contends that agglomeration enhances the ability of a location to sustain local business (Oakey and Cooper, 1989; Visser, 1999), since clustered firms gain economic benefits from the externalities of agglomeration (Krugman, 1991). First, agglomeration of many firms in a place generates a market for skilled workers, who naturally go to places where their skills are needed (Ciccone and Hall, 1996; Henderson, 2003). As such, an attractive market receives an influx of skilled workers, providing local firms the advantage of a constant supply of labor. Second, the demand of a large number of clustered firms incentivizes local suppliers to undertake the expense of dedicating themselves to supplying intermediate inputs (Folta, Cooper, and Baik, 2006; Hoover, 1948). Clustered firms can thus benefit from avoiding similar investments (Canina et al., 2005). Third, agglomeration facilitates knowledge spillovers in a place (Audretsch, 1998, 2003; Saxenian, 1994). Geographic proximity enables firms to observe better and imitate the innovations of others, and develop their own (Storper, 1993; Tallman and Phene, 2007; Tallman et al., 2004). Furthermore, clustered firms can achieve collective efficiencies (Schmitz, 1995), by consciously collaborating with each other to improve cluster-level competitiveness (Mesquita and Lazzarini, 2008; Pouder and St. John, 1996; Tallman et al., 2004). In particular, geographic proximity and frequent interaction enable firms to develop relational governance structures that help overcome problems such as free riding (Mesquita, 2007). Additionally, clustered firms receive further economic gains if they are located in places endowed with exclusive natural advantages (Ellison and Glaeser, 1999). Any type of input that is available in only a limited number of places (Sorenson and Baum, 2003), such as low production and transportation costs (Hoover, 1948) and regional identity (Romanelli and Khessina, 2005), can offer a competitive advantage to firms located there.

Both the externalities of agglomeration and natural advantages contribute to the geographic concentration of wine production in Canada. First, wine production has a huge demand for seasonal labor input. A large number of cheap workers are needed to pick grapes in the short grape-harvesting season. Second, commercial winemaking needs a reliable supply of special equipment and materials, such as crushers, presses, fermenters, and necessary chemicals. Third, unlike Europe, which has a long history of winemaking, the knowledge and skills of winemaking were scarce resources in Canada during our observation period. Geographic proximity among clustered wineries facilitated the development and circulation of the necessary knowledge and skills within the winemaking cluster. Additionally, since ideal lands for winemaking are limited and high-quality grapes can be grown only with a certain climate and soil, wineries clustered in places suitable for grape growing have further advantages. Thus, due to the positive externalities of agglomeration and natural advantages, clustered wineries obtain exclusive economic gains and outperform less clustered wineries. Assuming that higher performance will lead to a better chance of survival, our discussion so far leads to the prediction that clustered wineries will outlive less clustered ones. However, as we discuss later, this effect is conditioned by the ILC.

**THE FOUNDING MECHANISM**

The founding mechanism drives geographic concentration of an industry when the founding rate of firms differs across places. It posits that agglomeration enhances the ability of a place to attract new investments. As discussed earlier, clustered firms benefit from collocating with each other through agglomeration externalities. When deciding where to locate the new business establishment, the potential economic gains derived from agglomeration externalities will make a place with many existing firms a more attractive choice to entrepreneurs (Kalnins and Chung, 2004). Moreover, when many firms involved in similar businesses cluster in one place, the sheer number of them makes these firms an identifiable organizational community and generates a related identity for the place.
where such firms cluster (Piore and Sabel, 1984; Storper, 1995). A strong location identity induces a common perception among outsiders, enhancing the legitimacy and reputation of the local industry in the eyes of investors (McKendrick et al., 2003). Additionally, as geographic proximity facilitates social interaction, social networks are likely to be built up in places where many firms, and thus people, are collocated. As recent studies suggest, potential entrepreneurs are aided by interpersonal social networks that allow them to observe and explore entrepreneurial opportunities within clusters (Sorenson and Audia, 2000; Stuart and Sorenson, 2003). In sum, an industry cluster can be sustainable if agglomeration of existing firms consistently lures new entrants (Gordon and McCann, 2000; Rosenthal and Strange, 2003). In the winemaking industry, an agglomeration of existing wineries provides new entrants access to seasonal workers and a reliable supply of intermediate goods. The clustering of wineries not only signals to entrepreneurs that this place has a reasonable climate and soil for grape growing but also gives the place an identity as a legitimate winemaking cluster. This becomes more important in Canada, a country without a winemaking tradition, since entrepreneurs will prefer to locate new wineries closer to existing ones to acquire winemaking techniques. The above reasons lead to the prediction that an agglomeration of wineries attracts more new entrants. However, as discussed in the following section, this prediction is also conditioned by the ILC.

THE INDUSTRY LIFE CYCLE

The ILC framework states that an industry has its own cycle of life (Vernon, 1966). Three approaches to theorize the ILC have been proposed: evolutionary economics (Klepper and Graddy, 1990), technology management (Utterback and Abernathy, 1975), and organizational ecology (Hannan and Freeman, 1977). In a significant reconciliation effort, Agarwal, Sarkar and Echambadi (2002) aptly observe a common theme across these seemingly disparate streams of research: the discontinuous transformation of competitive dynamics in an industry’s evolution at a particular time that distinguishes the growth stage from the mature stage. Evolutionary economics maintains that entrepreneurial activities dominate the growth stage while routinized activities dominate the mature stage (Nelson and Winter, 1982). The technology management literature concurs that the emergence of a ‘dominant design’ (Christensen, Suarez and Utterback, 1998: 208) triggers a shakeout of firms that are unable to embrace the design fully (Anderson and Tushman, 1990; Suarez and Utterback, 1995; Tushman and Anderson, 1986). Organizational ecology suggests that the rise in organization density increases legitimacy in the early stage of industry evolution but increases selection pressures after the population approaches its carrying capacity at a later stage (Baum and Amburgey, 2002; Carroll and Hannan, 1989). Importantly, all three bodies of literature are unequivocal on a tipping point characterized by the onset of an industry-level shakeout that signifies the beginning of increasingly intensified competition as an industry enters into the mature stage of its life cycle, characterized by routinization of operation, technology standardization, and/or population overcrowdedness (Agarwal et al., 2002).

The growth stage

The growth stage witnesses the birth and subsequent ascendance of a new industry as entrepreneurs commercialize business opportunities. During this period, firms experiment extensively with different strategic approaches in the hope of arriving at a dominant business model that will emerge as the best way of serving the growing market (McGahan, Argyres and Baum, 2004). We argue that firms experiment, not only with technologies, but also with different locations in the hope of locating their business in the ‘right’ places. A ‘right’ place, ideally, should offer a firm a bundle of superior input factors, such as low transportation costs, favorable labor costs and a reliable supply of raw materials. Such a place will supposedly attract more investments, since these input factors are crucial for commercial success. However, when investors have neither a well-established criterion for the ‘right’ place nor enough information to check the qualifications for each potential site, investors are likely to follow the pioneering firms (Gimeno et al., 2005) and favor locations already invested in by others.

For wine production, both the quantity and quality of wine depend on a reliable supply of high-quality grape juice. A winery should either have its own vineyards to grow grapes or be able
to purchase grapes from markets. Since there are only a limited number of ‘right’ places where the climate and soil allow grape growing for wine production, it may seem to be a relatively easy task for entrepreneurs to identify these ‘right’ places and build wineries there. However, this proved to be a challenging task during the early days of Ontario’s winemaking industry. Compared to Europe, Canada has a brief history of winemaking, with the first winery established in 1865. Without localized traditional knowledge of making wines in Ontario, pioneering entrepreneurs experimented with different places for grape growing and winemaking across Ontario. For example, while today we know definitively that northern Ontario is too cold for commercial grape growing and winemaking, early pioneers established wineries as far north as Sudbury, a place not too far away from the tundra!

The reason why pioneering winemakers chose some places over others varies. For example, whereas someone chose to locate closer to wine consumers, others chose to locate closer to grape growers. Regardless of the idiosyncratic reasons behind each location decision however, once a place attracted enough pioneering investments, collocation of the ‘early birds’ formed a critical mass germane to the emergence of a winemaking industry cluster. The clustering of many existing wineries signaled to entrepreneurs that such a place has a natural advantage for making wine. Entrepreneurs were also lured by the perceived positive externalities resulting from the agglomeration of existing wineries (e.g., specialized supplies such as presses and bottles). Furthermore, the clustering of wineries enhanced a place’s public image as a center for the industry, making the place a better recognized location for industry stakeholders. Additionally, social networks among incumbent wine investors and employees also helped new entrants to acquire information and knowledge for starting up their own wineries. Since winemaking techniques were a rare resource in the early days of Ontario’s wine production, access to such information and knowledge was an important factor to consider when new winemakers made location decisions. In particular, since there were so few experienced enologists—most of them were new immigrants from Europe—geographic proximity to and personal connections with these experts was an advantage to a winery. Given these reasons, we predict that the founding mechanism drives geographic concentration in the growth stage.

On the other hand, in the growth stage, the survival mechanism is not a potent force shaping geographic concentration. As discussed earlier, clustered firms in the ‘right’ places are able to achieve better performance, due to positive externalities of agglomeration and natural advantages. However, the performance differences between clustered and less clustered firms does not necessarily make firms located in the wrong places perish, unless market competition is intense enough to select out poor performers. In the growth stage, supply generally falls short of demand as the industry boom creates more customers. Although firms isolated in the wrong places cannot perform as well as firms clustered in the right places, they can still survive as long as they earn a minimum financial return. In our empirical setting, as the market for Ontario wines grew at a rapid rate in the growth stage, wineries across Ontario managed to sell their wines at a profit. Although clustered wineries obtained higher financial returns, less clustered wineries could also earn enough returns to survive. In general, the survival mechanism does not drive an industry’s geographic concentration in its growth stage because market competition is not intense enough to eliminate firms located in less ideal places.

Hypothesis 1: In the growth stage, the founding mechanism rather than the survival mechanism drives geographic concentration: the higher the degree of collocation of a place, the more new firms will be founded in the place.

The mature stage

The onset of the mature stage signifies a structural change in interfirm rivalry. It is comprised of the period in which the market becomes saturated by ever-increasing supply. Such an oversupplied market often forces firms to compete on price. As price competition intensifies, firms with high costs will suffer from shrinking profit margins and may fail to break even. Continuous inferior financial returns will eventually force these less competitive firms to leave the industry, triggering a consolidation process in which only the best performers can survive.

As discussed earlier, firms clustered in the ‘right’ places outperform other firms because of the exclusive economic gains from geographic
In the growth stage, the performance gap between clustered and less clustered firms is tolerable because of high profit margins in the industry. In the mature stage, however, firms suffering from locating in the ‘wrong’ places now face such a disadvantageous position that they may no longer be able to continue business without financial bleeding. Although clustered firms encounter competition among themselves, in general they maintain a competitive advantage over less clustered firms. ‘Competition, in so far as it prevails, will reward and encourage well-located enterprises and shorten the lives of poorly located ones’ (Hoover, 1948: 9–10). As less clustered firms are driven out, geographic concentration of the industry persists in the mature stage.

On the other hand, the founding mechanism does not play such a significant role in shaping geographic concentration in the mature stage. First, the industry clusters that emerge in the growth stage gradually reach the limit of their carrying capacity. Due to resource constraints, sometimes well-established industry clusters can no longer host additional new business establishments. This is particularly true for the winemaking industry. When early winemakers had already occupied the lands best suitable for grape growing, subsequent entrants would have had to locate their winery in other relatively inferior places, as evidenced in Argentina’s wine industry (McDermott, 2007). Second, even if an industry cluster still has resources available for new entrants in the mature stage (e.g., arable lands), the industry cluster will not be as attractive for investors as in the growth stage. As profit margins keep decreasing in the mature stage, competition among existing firms within an industry cluster heats up. Fierce competition among these well-established incumbents, sometimes in the form of price wars, becomes a deterrent to potential new entrants, who often suffer from the liability of newness and/or smallness (Freeman, Carroll and Hannan, 1983). New entrants will therefore hesitate to locate their businesses too close to these ‘unfriendly’ incumbents. Third, besides the decreased attractiveness of well-established clusters, entrepreneurs also become more confident to invest in less explored places as knowledge, business models, and techniques gradually become standardized and diffused. In the winemaking industry, after many years of experiments, winemakers discovered the ideal grape variety for Ontario, i.e., the Concord, in the early 1900s (Aspler, 1999). The Concord grape and its hybrids became the backbone of the Canadian wine industry up until the 1940s (Aspler, 1999). Adoption of this winter-hardy and disease-resistant grape variety, along with a better understanding of local microclimates across Ontario, reduced the winemakers’ risk of establishing wineries in some previously underexplored places.

Taken together, the prediction that more new firms will be established within industry clusters no longer holds in the mature stage. We hypothesize that an industry’s geographic concentration in its mature stage is driven by the survival mechanism rather than the founding mechanism.

Hypothesis 2: In the mature stage, the survival mechanism rather than the founding mechanism drives geographic concentration: the higher the degree of collocation of a place in which a firm is located, the less likely the firm will perish.

**METHODS**

**Research setting and data**

The origin of commercial wine production in Ontario can be traced back to 1865. Our data covers all Ontario wineries from 1865 to 1974. It consists of three datasets. The first dataset is obtained from a special report of the Liquor Control Board of Ontario (LCBO) published in 1966, which records the early history of Ontario’s wine industry with detailed information for every winery. The main dataset comes from LCBO annual reports (1927–1974). According to Ontario’s liquor laws, all wineries are required to apply for a license. The LCBO was established in 1926 by the Ontario government to execute its liquor regulations. In its annual reports, the LCBO reported to the government the winery’s name, address, and the time when it was established, dissolved, or acquired. Any winery is allowed to obtain only one license, even after the winery’s owner purchases a competitor’s winery. Hence, the winery location data actually tells the researcher how many wineries there were and where they were located. Additionally, we collected data about the Census Subdivision (CSD) from Census of Canada (1871–1971), which provides basic demographic information at the CSD level at the
beginning of each decade. The CSD is defined by Statistics Canada as an area that is a municipality or an area that is deemed to be equivalent to a municipality for statistical reporting purposes. A CSD could be classified into different types, like village, town, and city. A CSD can be generally regarded as the equivalent of the U.S. geographical definition of a Metropolitan Statistical Area (MSA) (i.e., the municipality CSD) or a Metropolitan Area (MA) (i.e., the nonmunicipality CSD). As for the volume of grape production and population, we also collected data at the Census Division (CD) level—an intermediate geographic area between CSD and the provincial level—to control for the effects of natural advantage and the size of local consumers. Additionally, we also collected data from the Census of Canada (1871–1971) on the volume of wine produced in Ontario and sold to Canadian and overseas markets each year to control for the market dynamics.

**The two-stage life cycle of Ontario’s wine production**

To the best of our knowledge, a consensus for measuring different stages of an industry’s life cycle does not exist. Early research has often defined the stages of an ILC in terms of sales growth (Vernon, 1966) and the number of firms in an industry (Klepper and Graddy, 1990). Klepper and Graddy (1990) define the first stage as the period in which the number of firms grows and the second stage as the period in which the number of firms declines. This widely used measurement of life-cycle stages is deemed inappropriate when applied to models with firm survival as the dependent variable, because the independent variable (i.e., life-cycle stage) is functionally related to the dependent variable of interest, i.e., firm survival (Agarwal et al., 2002). A remedy for this is to measure the life-cycle stage using the rate of new firm entries and, generally, to define the growth stage as the period when entry increases and the mature stage as the period when entry declines (e.g. Agarwal and Gort, 2002; Agarwal et al., 2002; Hannan, 1997). A weakness of the above endogenous measurements of life-cycle stages, we believe, is the lack of predictive validity. Researchers can confidently decide *post hoc* on the basis of these measures to divide an industry’s life-cycle stages, after a long enough period of time. However, on an ongoing basis, it is difficult to tell *a priori* whether these fluctuations are temporary jolts or long-term trends.

As a result, we conducted a comprehensive historic analysis of Ontario’s wine industry and used major exogenous, historic shocks to divide the industry’s life-cycle stages. The first commercial winery in Ontario was established in 1865 (Schreiner, 2005). The industry experienced slow but steady growth until 1916, when Canada entered the Prohibition era. Ontario’s grape growers managed to persuade the government to exempt wine production from Prohibition for scientific and medicinal purposes. A doctor could prescribe alcohol to a patient if the doctor felt that the patient might benefit from such ‘medicine’ (Aspler, 1999). Ironically, rather than discouraging wine consumption, Prohibition triggered a major boom in the industry by protecting it from foreign wines and domestic spirits and beers. During the eleven years of Prohibition in Ontario, the only alcoholic beverage that could be sold legally was wine (Aspler, 1999). The industry experienced rapid growth during Prohibition. Wine production rocketed so rapidly that wineries in Ontario even imported grapes from the United States (Schreiner, 2005). Once Prohibition ended in 1927, however, the industry entered into a long period of consolidation. Two major reasons contributed to this long-term shakeout. First, the growth of the industry during Prohibition was based on low quality that seldom reached international standards. Once the restriction on importing European wine and producing beer and spirits ceased, Canadian alcohol consumers either switched to imported wines, despite their greater price, or returned to beers and spirits. Second, but more importantly, Canada entered into the Great Depression in 1929, the worst economic disaster in Canadian history. The plummeting economy hit the wine industry hard. Wine sales dropped 67 percent from 1929 to 1935 and, except for one or two years, only after World War II did wine sales regain its 1929 value. When the war ended, Ontario winemakers tried to upgrade wine quality by introducing European vine varieties but failed repeatedly. The domestic industry’s share of wine sales in Ontario, once as high as 95 percent, dropped to 45 percent in the 1970s (Schreiner, 2005).

Given the above history, we divided the life cycle of Ontario’s wine production into two stages: the growth stage from 1865 to 1928 and the mature stage from 1929 to 1974. It is widely
acknowledged that the industry was reborn in 1975 when new practices such as ice-wine making were introduced (Aspler, 1999).

Independent variable and dependent variables

Collocation, the independent variable, is measured as the number of wineries in a CSD in a given year. In other words, we treat a CSD as a cluster of wineries and test the collocation effect on winery founding and mortality. We expect that the more wineries collocate in one place, the stronger the effects of collocation on winery founding and mortality. Consistent with previous research, which includes only places where at least one firm has been founded (Sorenson and Audia, 2000), we include only the CSDs where at least one winery had been established during the observation period. We understand that CSDs with very few or only one winery are arguably not as well established as others to be called winery clusters. Nevertheless, to examine the clustering phenomenon during an entire ILC, which necessarily includes entrepreneurs’ idiosyncratic selection of locations, it is appropriate to include these inchoate clusters in our sample. In total, 36 CSDs, or 36 industry clusters, are included in the study.

Winery founding, a dependent variable, refers to the counts of new winery establishments in a CSD in a given year. Considering that key factors for winery founding, such as population, are distributed unevenly throughout Ontario, we define CSDs in the province as the unit of analysis. This practice is consistent with previous research, which usually sets the unit of analysis at geographically meaningful areas such as the zip code (Chung and Kalnins, 2001; Stuart and Sorenson, 2003) and the state (Sorenson and Audia, 2000). In total, our analysis includes 142 founding events in 3,960 yearly observations, spread out over 36 CSDs. Winery mortality, another dependent variable, is the hazard rate at which a winery perishes. Our data involves 142 wineries over 109 years. Only 8 wineries continued operating after 1974 and are therefore right censored. In total, we have 1,673 winery-year observations at risk.

Control variables

To control for economic and sociological dynamics during our more than 100-year investigation period, we add four dummy variables. First, the Ontario Temperance Act was passed in 1916, signaling the start of Prohibition in Ontario. We include Prohibition as a dummy variable (coded as 1 if the observation year \( \geq 1916 \) and \( \leq 1927 \)). Second, the Great Depression (1929–1939) ranks as the worst economic disaster in Canada’s history. Although we do not have data to show how badly the wine industry was hit, it is necessary to control for the impact of the economic disaster on Canadians’ daily lives and, by extension, their wine consumption. (The Great Depression dummy is coded as 1 if the observation year \( \geq 1929 \) and \( \leq 1939 \).) Third, the impact of the two world wars on wine consumption and production is undeniable. Many Canadian soldiers were sent to battlefields and the war economy resulted in turbulence in both overseas and domestic wine consumption. Thus, we add two dummy variables: World War I and World War II.

At the industry level, we include wine sales (i.e., the number of gallons of Ontario wine sold each year) to control for market demand. We expect that entrepreneurs would be encouraged to establish wineries when the market is booming. We also include provincial density, i.e., the number of wineries in Ontario, to control for the ecological dynamics. Both the linear and the quadratic terms of provincial density are included. Additionally, our models include CD population, the number of individuals living in a CD in a given year, to control for potential entrepreneurs, who are distributed unevenly across the province, and for the demand of the local market.

At the cluster level, first, our model controls for a location’s natural advantage. Grape supply is measured by the volume of grape production (lbs.) in a Census Division, which consists of several CSDs. Census of Canada reports grape production for each Census Division. Grape supply in a Census Division is meaningful because a winery can save on transportation costs by purchasing grapes produced in the region where it is located. Second, since locations differ in terms of experience of, and reputation for, wine production, we add cluster age, defined as the length (i.e., years) of wine production in a CSD. Third, a shorter distance to the United States, the largest export market of Ontario’s wine industry, could be a source of competitive advantage. Thus, we include the U.S.–Canada border dummy variable, coded as 1 if the CSD is located less than 20 miles away from the U.S.–Canada land
border. In total, 14 out of 36 CSDs are coded as bordering the United States. Fourth, Statistics Canada classifies CSDs into city, town, and village, according to the distinct characteristics in terms of economic activities, use of land, etc. Given the potential impact of these factors, we include two CSD-type dummies: city and village.

At the winery level, we add two additional firm-level variables in the winery mortality models to control for firm heterogeneity. First, we add winery size, measured by the wine production capacity (gallons), to control for economies of scale in production. Second, as wineries founded in different periods may exhibit distinct characteristics, we add entry prior to 1929, coded as 1 if the winery entered the industry prior to 1929, to control for the initial founding condition.

Table 1 reports descriptive statistics of the variables used in the winery mortality models. We checked Variance Inflation Factors (VIF) to test the presence of multicollinearity. A value below 10 is generally accepted as an indication that no significant impact of multicollinearity exists. VIF values for all variables in the mortality model range from 1.07 to 2.88 with a mean value at 2.03. Additionally, the correlation coefficients for each of our independent variables were under 0.7. Table 2 reports descriptive statistics of the variables used in the founding models, which include all control variables except a winery’s size and year of founding. VIF values for all variables in the founding model range from 1.08 to 3.35, except provincial density and its squared term (at 10.03 and 6.09, respectively), with the mean value at 2.76. Thus, multicollinearity is not a problem in the regression analyses.

Estimation methods

Winery founding models

Poisson regression is often an appropriate method to use when the dependent variable is a count variable. It assumes that the dependent variable has a Poisson distribution in which the conditional variance and mean are equal. This assumption is violated in our data where the variance of founding is greater than the mean. Following previous research (e.g. Simons and Ingram, 2003), we first used the negative binominal regression model to account for variance overdispersion. However, despite the overdispersion issue, the Poisson regression is less sensitive to outliers than the negative binominal regression model. Considering the existence of outliers in our dataset, we used Poisson regression for the winery founding analysis. The reported results are consistent with results obtained from the Poisson regression analysis.

Winery mortality models

Following previous studies (e.g. Sorenson and Audia, 2000), we used event history analysis to test the hypothesis of winery survival. We started with the Cox proportional hazards regression model, which has the advantage that the baseline hazard is given no particular parameterization. However, this model produces biased and inefficient estimates when the dataset is left-censored. Although our dataset is not left-censored, we introduce the problem by splitting the dataset into two stages. To produce unbiased estimates under censoring, we used the piece-wise exponential model. We used a calendar year as a piece, or the window length, in splitting our sample and added an indicator variable named ‘entry prior to 1929’ to control for left-censored wineries. Regression analysis using the Cox proportional hazards models yields consistent results. Additional sensitivity tests by fitting the piece-wise exponential models with shared frailty and using robust error estimation also yields consistent results.

RESULTS

Mortality of Ontario’s wineries

Panel A in Table 3 presents the results of the piece-wise exponential regression analysis of winery mortality in Ontario from 1865 to 1974. To test the survival rationale in two stages separately, we split the data into two sets—the growth stage (1865–1928) and the mature stage (1929–1974) —and test the collocation impact on survival in each stage. For both stages, we first introduce a baseline model with control variables. We then add the collocation variable to the baseline model. Models 1a and 1b cover the growth stage while Models 2a and 2b cover the mature stage. As Models 1a and 1b show, the coefficient of collocation is not significant and Model 1b does not improve on Model 1a, indicating that the survival mechanism is not supported in the growth
Table 1. Ontario winery mortality analysis: descriptive statistics and correlations \((N = 1673)\)

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<tr>
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<td>-0.07</td>
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<td>0.56</td>
<td>-0.14</td>
<td>-0.04</td>
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<td>(7) Provincial density(^2)</td>
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<td>0.56</td>
<td>-0.13</td>
<td>-0.04</td>
<td>0.00</td>
<td>-0.44</td>
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<td>(8) Population/1,000,000</td>
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<td>0.08</td>
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<td>(9) Grape supply/1,000,000</td>
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<td>14.76</td>
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<td>(10) U.S. to Canada border</td>
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<td>(13) Cluster age</td>
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<td>(15) Entry prior to 1929</td>
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<td>0.09</td>
<td>0.02</td>
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<td>(16) Collocation</td>
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All correlations with absolute values greater than 0.045 are significant at \(p < 0.05\).
Table 2. Ontario winery founding analysis: descriptive statistics and correlations ($N = 3960$)

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<tr>
<td>Prohibition</td>
<td>0.11</td>
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<tr>
<td>World War I</td>
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<td>Great Depression</td>
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<td>1.00</td>
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<td>Sales/1,000,000</td>
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<td>Provincial density</td>
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<td>0.10</td>
<td>0.19</td>
<td>1.00</td>
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<tr>
<td>Provincial density</td>
<td>1.00</td>
<td>1.68</td>
<td>0.20</td>
<td>0.34</td>
<td>-0.11</td>
<td>0.60</td>
<td>-0.13</td>
<td>-0.04</td>
<td>0.86</td>
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<td>Population/1,000,000</td>
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<td>0.16</td>
<td>0.03</td>
<td>-0.02</td>
<td>-0.03</td>
<td>0.04</td>
<td>0.05</td>
<td>0.36</td>
<td>0.07</td>
<td>-0.01</td>
<td>1.00</td>
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<tr>
<td>Grape supply/1,000,000</td>
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<td>-0.01</td>
<td>0.01</td>
<td>0.05</td>
<td>0.28</td>
<td>0.05</td>
<td>-0.03</td>
<td>-0.03</td>
<td>1.00</td>
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<tr>
<td>U.S. to Canada border</td>
<td>0.39</td>
<td>0.49</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.09</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.08</td>
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<td>-0.10</td>
<td>0.03</td>
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<td>-0.08</td>
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All correlations with absolute values greater than 0.03 are significant at $p < 0.05$. 

### Table 3. Regression analysis of Ontario winery mortality and founding (1929–1974)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Panel A. Piece-wise exponential regression analysis of winery mortality</th>
<th>Panel B. Poisson regression analysis of winery founding</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>(-1.81 (1.08))</td>
<td>(-1.96 (1.09))</td>
</tr>
<tr>
<td>Prohibition</td>
<td>(-0.06 (0.42))</td>
<td>(-0.02 (0.43))</td>
</tr>
<tr>
<td>World War I</td>
<td>1.11 (0.70)</td>
<td>1.09 (0.70)</td>
</tr>
<tr>
<td>Great Depression (\times 100)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>World War II (\times 100)</td>
<td>0.28 (0.38)</td>
<td>0.31 (0.38)</td>
</tr>
<tr>
<td>Wine sales/1,000,000</td>
<td>0.80 (0.43)</td>
<td>0.74 (0.44)</td>
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<td>Provincial density</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Provincial density(^2)</td>
<td>(-1.29 (0.38)***)</td>
<td>(-1.27 (0.38)***)</td>
</tr>
<tr>
<td>Population/1,000,000</td>
<td>(-1.53 (1.01))</td>
<td>(-2.07 (1.23))</td>
</tr>
<tr>
<td>Grape supply/1,000,000</td>
<td>(-0.05 (0.03))</td>
<td>(-0.05 (0.03))</td>
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<td>U.S. to Canada border</td>
<td>0.17 (0.27)</td>
<td>0.09 (0.29)</td>
</tr>
<tr>
<td>Village</td>
<td>1.11 (0.51)*</td>
<td>1.13 (0.52)*</td>
</tr>
<tr>
<td>City</td>
<td>0.08 (0.31)</td>
<td>0.04 (0.31)</td>
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<tr>
<td>Cluster age</td>
<td>(-0.00 (0.01))</td>
<td>(-0.00 (0.01))</td>
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<tr>
<td>Winery size/1,000</td>
<td>0.07 (0.04)</td>
<td>0.07 (0.04)</td>
</tr>
<tr>
<td>Entry prior to 1929</td>
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<td>—</td>
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<td>Collocation</td>
<td>—</td>
<td>0.06 (0.07)</td>
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<td>Number of observations</td>
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<td>102.91</td>
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<td>d.f.</td>
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<td>70</td>
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<tr>
<td>Log likelihood</td>
<td>(-119.82)</td>
<td>(-119.47)</td>
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</table>

\(^* p < 0.05; ^{**} p < 0.01; ^{***} p < 0.001\). Standard errors are in parentheses. In total, 134 out of 142 wineries exited and 142 wineries were founded across 36 Census Subdivisions.
stage. However, the coefficient of collocation ($\beta = -0.27, p < 0.01$) is negative and significant in Model 2b. Additionally, the Likelihood Ratio Chi-square test shows that Model 2b fits better than Model 2a. Therefore, Hypothesis 2 is supported. Taken together, we find a positive impact of collocation on winery survival (i.e., a negative impact on winery mortality) only in the mature stage, suggesting that clustered wineries are more likely to survive than nonclustered ones but this advantage only holds in the mature stage. In all models, grape supply does not have a significant effect on winery mortality.

**Founding of Ontario’s wineries**

Panel B in Table 3 presents the results of the Poisson regression analysis of winery founding in Ontario from 1865 to 1974. Again, we split the dataset into two parts and examine the impact of collocation on winery founding in two stages of the industry’s life cycle. Models 3a and 3b capture the growth stage (1865–1928) whereas models 4a and 4b capture the mature stage (1929–1974). For both stages, we first provide a baseline model with control variables (i.e., Models 3a and 4a) and then add collocation, the independent variable, to the baseline models in Models 3b and 4b. As Model 3b shows, Collocation has a positive and significant coefficient ($\beta = 0.23, p < 0.001$), supporting the proposition that new wineries are more likely to be established within more clustered places in the growth stage. However, as Models 4a and 4b show, this positive effect disappears in the mature stage: the coefficient of collocation is no longer significant. Likelihood Ratio Chi-square tests indicate that, for the growth stage (see Models 3a and 3b), the founding model improves when the independent variable collocation is added. However, for the mature stage (see Models 4a and 4b), adding the independent variable does not make the founding model fit significantly better, suggesting that collocation does not have a significant impact on winery founding. Taken together, we find that the founding mechanism (i.e., a higher founding rate with a higher degree of collocation) holds only in the first stage but not in the second stage. Hypothesis 1 is therefore supported. Interestingly, while the coefficient of grape supply is not significant for the growth stage, it does have a positive and significant impact on winery founding in the mature stage, suggesting that being close to a grape supply becomes a more important factor in the mature stage for entrepreneurs to decide where they would locate their wineries. Given that a grape supply does not have a significant impact on winery mortality, we conclude that natural advantage helps a location to attract entrepreneurial activities, but it does not necessarily help established wineries survive longer. This partly confirms the existence of intense competition within clusters.

**DISCUSSION AND CONCLUSION**

Our study examines the temporal boundaries of the existing theories on agglomeration that explain why most industries are geographically concentrated in a limited number of places. We divided the history of Ontario’s wine production (1865–1974) into a growth stage and a mature stage and separately examined the driving forces of geographic concentration in each stage. The results suggest that, although industry clusters attract more new entrants in the growth stage, this is not the case in the mature stage. On the other hand, clustered firms are more likely to survive than less clustered ones in the mature stage but not so in the growth stage. This reflects both that more demanding competitive conditions in well-established clusters in the mature stage deter new entrants and that selection pressures are weak in the growth stage. Taken together, the study suggests a dynamic model of geographic concentration: clusters enjoy a higher firm-founding rate in the growth stage only and a higher firm-survival rate in the mature stage only. These findings make three contributions: (1) they demonstrate that temporal dynamics shape the forces underlying geographic concentration; (2) they suggest that industry-wide patterns suggested by the ILC theory may differ from local patterns; and (3) they shed light on the conditioning effect of geography on the population density dependence.

First of all, the findings have important implications for research on industry clusters in general and cluster dynamics in particular. Our review of previous studies reveals two driving forces of geographic concentration, i.e., survival and founding, which entail very different theoretical implications. In contrast to the survival mechanism, which emphasizes the existing benefits that allow clustered firms to outlive less clustered ones, the focus of the founding mechanism is
on the perceived benefits that attract more new entrants to industry clusters. Whereas the former is primarily concerned with exogenous factors underlying the location decision, such as an abundance of natural resources, the latter also incorporates endogenous factors that are less passive and allows room for active agency, such as social networking. Indeed, active networking among clustered firms can not only lead to local competitiveness but can also enhance the reputation of a place for investors. It is therefore important to clarify which mechanism is the major driving force of geographic concentration at a particular time.

However, as discussed earlier, this crucial aspect has been largely overlooked in the existing literature. When examining geographic concentration, most previous studies do not control for temporal dynamics. Some pioneering studies (e.g., Klepper, 2010) have begun to pay attention to cluster dynamics and allude to the notion that industry clusters likely experience different dynamics at a different point in time. However, the question of how the fundamental mechanisms of geographic concentration are possibly shaped by temporal dynamics remains open. By teasing out and empirically scrutinizing the forces that drive geographic concentration across an ILC, we establish through our results that the conditioning aspect of time clearly matters. Our study extends the existing literature by demonstrating that both the founding and survival mechanisms drive geographic concentration, yet their salience varies significantly over time.

Second, our study also answers the recent call to examine the conditioning factor of geography on ILC. Except for a few studies (e.g., Krafft, 2004), most empirical studies of ILC set the level of analysis at the industry level and overlook the fact that most industries are geographically concentrated in a very few places. By ‘treating industries as homogeneous’ (Klepper and Thompson, 2006: 875), the ILC literature in effect assumes away the likelihood that the same industry can take distinct evolutionary paths in different places. By ‘treating industries as homogeneous’ (Klepper and Thompson, 2006: 875), the ILC literature in effect assumes away the likelihood that the same industry can take distinct evolutionary paths in different places. This explains why McGahan et al. (2004: 17) explicitly urged empirical studies of ILC to examine ‘where geographic boundaries should lie’. As our study shows, when an entire industry is subject to life-cycle dynamics, an individual firm’s likelihood of founding and survival can be different, depending on location. Our findings thus extend the literature by demonstrating that the industry-wide temporal pattern differs across places. Or, in Krafft’s (2004: 1688) words, ‘global patterns of evolution differ from local patterns’.

Third, our study sheds light on the conditioning effect of geography on population density dependence. As one of the underpinnings of the industry life-cycle literature (Agarwal et al., 2002), the population ecology literature posits an inverted U-shaped relationship between population density and firm founding and a U-shaped relationship with firm exit (Hannan and Carroll, 1992). Notably though, population density is usually defined as the size of the entire population, and no particular emphasis is put on place. Consequently, the density dependence argument assumes that ‘all members of a population are equivalent, with each member assumed to compete for the same scarce resources and to contribute to and experience competition equally’ (Baum and Amburgey, 2002: 315). In contrast, our study finds that different locations of firms in the same industry matter in a significant way. In particular, when a population-wide shakeout occurs after the population reaches its carrying capacity, agglomeration helps local firms endure the overall shakeout; that is, shakeout occurs at a faster rate outside of industry clusters. On the other hand, places with a higher degree of agglomeration attract more new entrants in the early days, meaning that the population-wide legitimation effect is stronger in industry clusters. Thus, whereas the population ecology literature mainly revolves around the role of the temporal dimension in an industry’s vitality rates (i.e., founding and mortality), our study emphasizes the geographic dimension. In this way, our study complements more recent research in population ecology, which has begun paying more attention to variation in density dependence across different levels of geographic aggregation (e.g., Carroll and Wade, 1991; Hannan et al., 1995).

Limitations and future research

One limitation of our study is its scope, with a single-industry design and the accompanying issue of generalization. Yet one significant advantage of situating the study in a single industry with unique features is that we were able to build a comprehensive dataset covering the entire history
of the industry and collect detailed qualitative evidence to contextualize the theory. This practice is consistent with previous studies of agglomeration (e.g., Canina et al., 2005; Chung and Kalnins, 2001; Kalnins and Chung, 2004; Klepper, 2007; McCann and Vroom, 2010). Despite the benefits of the single-industry setting, it is worth examining whether findings from this study are applicable to other empirical contexts. During our observation period, the Ontario wine industry was mostly composed of small and locally owned wineries without a dominant player. This type of industry cluster, where small and relatively atomistic firms collaborate and compete, is called a Marshallian industrial district by Markusen (1996). A priori, there is no particular reason to believe that our findings will not be found in similar empirical settings.

On the other hand, Markusen (1996) also identified hub-and-spoke clusters where most local firms revolve around a few key anchor firms. Since no winery was big enough to be called an 'anchor firm' in our data, our data only provides information about one type of industry cluster but not others. The formation of a hub-and-spoke cluster may, in particular, be better explained by a spinoff process; i.e., a high rate of competent spinoffs spawned from anchor firms resulting in the geographic concentration of an industry (Buenstorf and Klepper, 2009; Klepper and Sleeper, 2005). Such a spinoff process contributes to high founding rates in such industry clusters and can thus be part of the founding mechanism. Studies on the spinoff process have occasionally identified some dramatic changes during the evolution of the industries under investigation. For example, starting from 1909, the automotive industry ‘went through a prolonged and severe shakeout of producers’ (Klepper, 2007: 616). Nevertheless, despite the sporadic evidence, these studies have not explicitly examined the temporal dynamics of the spinoff process. By applying our findings, one can ask when, or at which stage of an ILC, the spinoff process will be more salient. It is also worth noting that the spinoff process would have limited external validity in empirical settings where leading anchor firms are absent, such as in Ontario’s wine production. Our study then behaves as a kind of boundary condition of the spinoff process. Yet, since coordination mechanisms can be quite different in different types of industry clusters, the theoretical model found in this paper should be examined in other empirical settings. An empirical design with multiple industries (e.g., Wennberg and Lindqvist, 2010) would allow researchers to examine how the clustering mechanisms of founding and survival possibly vary across different types of industry clusters.

Additionally, natural advantage certainly influences wine production, as quality grapes can grow only in places with appropriate weather and soil. Since natural advantage affects the geographic concentration of many industries, though to a varying degree (Ellison and Glaeser, 1997, 1999), our findings should have a reasonable degree of generalizability. In any case, our analysis overall does not find a significant impact of grape supply, a measure of natural advantage, except for its effect on winery founding in the mature stage. Future research should control for, and further explore, the effect of natural advantage in other empirical settings.

Lastly, our study uses the number of firms in a place (i.e., local density) as a proxy measure of agglomeration, rather than directly measuring the agglomeration effects. Our regression analysis also includes the density of the entire population to control for ecological dynamics. As density serves both as a proxy for legitimation and competition for the entire population as well as a proxy for agglomeration, although at a lower level, it is important to recognize the different underlying roles of density in population ecology and agglomeration. While our measure of agglomeration is consistent with previous studies (e.g., Chung and Kalnins, 2001; Folta et al., 2006; Shaver and Flyer, 2000), future studies can address this critical issue by more directly capturing the agglomeration effects.

Despite the above limitations, our study serves as a starting point for developing a dynamic model of geographic concentration. We anticipate that the key findings—that agglomeration attracts more new entry only in the growth stage and contributes to firm survival only in the mature stage—will stimulate further research into the crucial issue of industry cluster dynamics.

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REFERENCES


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