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An Enduring Regional Industrial Cluster: How Temporal and Organizational Heterogeneity Drive Post-Shock Recovery

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Abstract

This paper develops and tests theory on when and how regional industrial clusters evolve. Drawing on several research streams, we argue that the mechanisms that contribute to advantages of locating in a regional industrial cluster vary in strength as the cluster evolves before and after experiencing a major shock. Our approach conceives of regional industrial clusters as complex adaptive systems and emphasizes the roles of endogenous and exogenous mechanisms at the firm, industry, and regional levels in pulling a cluster through various stages of development. We model organizational founding as a function of regional industrial identity, localized competition, specialization, regional diversity, and cluster industrial identity, contingent on evolutionary stage. Our analysis covers organizations, industries and regional clusters (Silicon Valley) in California from 1993 to 2007.

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ABSTRACT

This paper develops and tests theory on when and how regional industrial clusters evolve. Drawing on several research streams, we argue that the mechanisms that contribute to advantages of locating in a regional industrial cluster vary in strength as the cluster evolves before and after experiencing a major shock. Our approach conceives of regional industrial clusters as complex adaptive systems and emphasizes the roles of endogenous and exogenous mechanisms at the firm, industry, and regional levels in pulling a cluster through various stages of development. We model organizational founding as a function of regional industrial identity, localized competition, specialization, regional diversity, and cluster industrial identity, contingent on evolutionary stage. Our analysis covers organizations, industries and regional clusters (Silicon Valley) in California from 1993 to 2007.

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Firms and industries often cluster or agglomerate densely within particular regions (Krugman, 1991; Porter, 1998; Saxenian, 1994). Inspired by areas such as Silicon Valley (high technology), Milan (fashion), and Houston (petroleum), scholars have examined how regional industrial clusters influence the behavior and success of individual or groups of firms (Alcacer, 2006; Shaver & Flyer, 2000) and the innovativeness and growth of regions (Bresnahan, Gamberdella & Saxenian, 2001; Delgado, Porter & Stern, 2010, 2011; Feldman and Audretsch, 1996, 1999; Saxenian, 1994). Formally, regional industry clusters are defined as groups of geographically proximate firms operating in the same industry or in related industries (Porter, 1998, 2003). Much of the prior work focuses on understanding the mechanisms or factors that yield increasing (decreasing) returns to co-location, such as agglomeration economies, knowledge spillovers, or cluster identity (e.g., Feldman & Audretsch, 1996, 1999; Malmberg & Maskell, 2002; Romanelli & Khessina, 2005). Despite the large stream of work, findings regarding the advantages (disadvantages) associated with regional industrial clusters vary.

One explanation for the variance in findings stems from differences in how studies treat the temporal dimension of clusters. Several scholars suggest that the mechanisms generating cluster benefits differ in strength as a cluster evolves (Pouder & St. John, 1996; Martin & Sunley, 2011; Maskell & Malmberg, 2007; Menzel & Fornahl, 2009). Although numerous studies examine cluster emergence or formation, few empirical studies analyze the multiple stages of a cluster's evolution (exceptions, Audretsch and Feldman, 1996; Bresnahan et. al., 2001). Consequently, studies spanning short time windows may observe clusters in different stages of development (such as growth or maturity) and in turn, yield divergent results. If geographically clustered firms experience an evolutionary cycle similar to that of industries (Pouder & St. John, 1996) and mechanisms that support a cluster's emergence differ from those that enable its persistence or convergence (Bresnahan et. al., 2001; Delgado et. al., 2010;),

examining how the strength of these mechanisms varies over time may inform our understanding of a cluster's development (Maskell & Malmberg, 2007). In addition, the bulk of the extant empirical work ignores major events that might disrupt a cluster's evolution and reset its clock. Yet, work in strategy and industry evolution shows that major shocks or punctuations to an industry, whether technological, institutional or market-based, have significant ramifications for the composition of firms operating in the industry and for its subsequent development (Madsen and Walker, 2007; Tripsas, 1997; Tushman and Anderson, 1986).

Differences in research designs also may account for the heterogeneity in results across studies. Dating back to Marshall (1920), scholars examine at least five related categories of mechanisms that yield positive externalities or agglomeration benefits (see Breschi & Malerba, 2001; Feldman & Audretsch, 1999; see Rosenthal & Strange, 2003, for a review)¹: 1) knowledge spillovers, specialized labor pools, and input/output linkages (Marshall, 1920); 2) returns to specialization ((industry) localization economies) (Glaeser et al., 1992) and returns to diversity in a region (urbanization economies) (Feldman & Audretsch, 1999; Jacobs, 1969; Loasch, 1954); 3) local competition and the 'struggle for ideas' (Feldman & Audretsch, 1999; Glaeser et al., 1992; Jacobs, 1969; Saxenian, 1994); 4) symbiosis and commensalism (the degree of cooperation with similar and with different firms) (Audia, Freeman & Davidson Reynolds, 2006); and 5) cluster identity (Romanelli & Khessina, 2005). Researchers in different disciplines however, typically analyze mechanisms that are salient to their fields, overlooking the full set of potential mechanisms driving cluster evolution. For instance, several studies examine specialization, diversity and competition effects but omit other effects (see Rosenthal & Strange, 2003). Other studies focus on localization economies and the asymmetric benefits of agglomeration but

1. Space limits preclude a detailed review here; the full paper discusses the theoretical roots, and interrelationships, of the various mechanisms and highlights the core empirical results (for additional background see Feldman, 1994, 1999; Clark, Gertler & Feldman, 2003; Rosenthal & Strange, 2003).

overlook diversity (e.g., Shaver and Flyer, 2000). Second, the notion of regional industrial clusters is by definition multilevel and multidimensional. The empirical heavy lifting required to examine multilevel outcomes necessitates unusually comprehensive data and successive analyses. As a result, the extant work also varies widely in the operational designs employed for the various mechanisms and in the context under analysis (single industry or sector vs. multiple industries or sectors, single cluster vs. all clusters in a country or region). Differences in the research and operational designs obscure whether the various mechanisms affect firms or clusters constantly or only at particular periods in time.

Bridging these various gaps in the literature, we examine how the mechanisms that contribute to advantages (disadvantages) of locating in a regional industrial cluster vary in strength as the cluster evolves before and after experiencing a major shock. Our data cover all organizations and industries in three metropolitan areas in California from 1993 to 2008. The time period allows us to explore the economic progress of a regional industrial cluster, Silicon Valley, before and after a major shock or disruption (the Internet bust) and thus, sets the stage for a natural experiment. As a result, we are able to observe three stages of a cluster's evolution: a period of growth before the shock and a period of reorganization post-shock followed by a period of unwavering growth. We concentrate on the following research questions: How do the effects of the different mechanisms on founding vary as a cluster evolves? Do some forms play a more prominent role in the cluster's pre-shock growth stage as compared to its post-shock reorganization and renewal stage? Our hypotheses compare the effects of each mechanism across stages of the cluster's evolution. The paper proceeds as follows. We begin with a brief review of the literature on the evolution of regional industrial clusters and the role of separate agglomeration mechanisms. We then present the theory underlying our hypotheses. Subsequent

sections discuss the data, method of analysis, and findings. We conclude with the implications for theory and practice.

REGIONAL INDUSTRIAL CLUSTERS & EVOLUTION

Many studies on cluster evolution focus on cluster formation. This work is motivated, in part, by an interest in understanding how to build or mimic a productive cluster. Yet, analysis suggests that mechanisms crucial to a cluster's emergence differ from those that are critical to other stages of a cluster's development (Bresnahan et. al., 2001; Audretsch & Feldman, 1996). Consistent with these observations, studies explore how clusters evolve from at least three different vantage points. One view suggests that a cluster's lifecycle stages mimic those underlying a traditional industrial technology lifecycle (Audretsch and Feldman, 1996; Klepper and Graddy, 1990). An alternative view is that mechanisms specific to clusters, such as those associated with agglomeration, inform the stages of a cluster's evolution and distinguish it from that of an industry lifecycle (Iammarino & McCann, 2006; Pouder & St. John, 1996). For instance, when faced with similar market and technological conditions, some clusters thrive whereas others fade (Menzel & Fornahl (2009) thus, a technology's lifecycle may not explain a cluster's evolution (Martin & Sunley, 2011). Although these views identify similar lifecycle stages for a cluster (emergence, growth, maturity and decline), the mechanisms pre-scribing each stage and influencing a shift from one stage to another differ.

A third approach, and the one adopted here, describes regional industrial clusters as complex adaptive systems (Carbonara, Giannoccaro, McKelvey, 2010; Martin and Sunley, 2011). These open, non-linear dynamic systems are comprised of heterogeneous actors whose functions and self-reinforcing interactions give rise to the system's identity and fuel its evolution (Carbonara et. al., 2010). Importantly, this model emphasizes the roles of endogenous and

exogenous mechanisms at the firm, industry, and regional levels in pulling a cluster through various stages of development. Thus, reciprocal interactions between micro and macro level factors influence a cluster's progress. Guided by this self-organizing process of adaptation, the effects of different mechanisms that underlie the system may change over time depending on the stage of its development. For example, at one point, interconnectedness among firms may promote innovation and growth, but subsequently, high levels of interconnectedness may reduce innovation and trigger stagnation. Thus, this view emphasizes that agglomeration mechanisms may not have stable effects. In other words, what fosters advantage in a cluster will change as the cluster evolves.

Following Martin & Sunley (2011), we characterize a cluster's evolution as an adaptive cycle involving emergence, "growth, conservation, decline & release, and reorganization" (labels adapted from Martin & Sunley, 2011: 1307). In our study, a cluster experiences a disruptive shock during a growth or hyper growth phase (pre-Internet bust). As a result, our analysis examines the mechanisms crucial to the economic progress of a cluster during a pre-bust growth phase as compared to a post-bust reorganization phase. The growth phase entails a process of gradual, and relatively predictable, development fueled by the entry of firms, the accumulation of resources, an increasing interconnectedness among actors, and high adaptability. The shock we observe occurs during the cluster's growth phase, destabilizing the industrial structure. As a result, firms and resources depart, interconnections among actors erode, and the system's heterogeneity declines. Subsequently, the system enters a reorganization phase, initiating a process of renewal and a new growth cycle. We suggest that differences in the attributes of a cluster during the pre-shock growth stage as compared to the post shock reorganization stage will contribute to variance in the effects of agglomeration mechanisms on the cluster's growth.

THEORY & HYPOTHESES

Cluster Industrial Identity. Cluster (or regional) industrial identity constitutes a shared understanding among regional industry actors and outside observers about the legitimacy of a regional industrial cluster (e.g., a set of shared norms, expectations and roles of the regional industrial cluster) (Romanelli and Khessina, 2005). Within a cluster, this legitimacy particularly benefits resource-constrained entrepreneurs who must convince a variety of actors, (buyers, suppliers, partners, institutions and advisors) to transact with them. Moreover, the firm and industry composition convey to internal and external audiences the type of firms likely to be successful in the region. As a result, a region's industrial identity affects perceptions about the cluster's suitability for particular activities (Romanelli & Khessina, 2005).

A regional cluster's industrial region's industrial identity may be strong or weak, depending (in part) on its stage of evolution. For instance, a regional industrial cluster may lack legitimacy at birth but, as it grows, actors inside and outside the region interact and develop a common set of norms and expectations regarding the region's activities. Theory suggests that this type of social code or shared understanding is strongest when informed by frequent interactions among actors (Kogut & Zander, 1992). It follows that when the interactions among actors in a region subside, such as due to the exit of firms from a region, the region's legitimacy and in turn, identity may erode or weaken. To the extent that a major disruption to a region gives rise to the exit of firms and resources, it may stain a region's identity, relative to the pre-disruption time period, and reduce its attractiveness to entrepreneurs. As a result, we expect that the effects of regional industrial identity on the founding of entrepreneurial organizations will be stronger during the pre-shock growth stage as compared to the post-shock reorganization stage. Formally:

Hypothesis 1: The positive effects of a regional cluster's industrial identity on organizational founding are weaker during a cluster's post-shock reorganization stage relative to its pre-shock growth stage.

Localized Competition. Extant literature offers competing views of the effects of localized competition on cluster development and innovation. Studies building on Marshall's (1920) insights argue that monopoly power favors innovation because it limits the flow of ideas across firms and thus, maximizes the firms' abilities to capture value from innovation (Glaeser et. al., 1992). In this tradition, localized competition dampens innovation activity. In contrast, other studies building on Jacob's (1969) work argue that local competition may promote knowledge externalities and in turn, innovation and growth (Saxenian, 1994). In particular, Jacobs points out that competition is fundamentally about the "struggle for ideas". Even though the competition for ideas increases with a larger number of firms, it also may stimulate the entry of small, niche-based firms offering goods and services in complementary and/or non-core categories that are not initially attractive to established, and often "vertically integrated firms" (Christensen, ; Feldman & Audretsch, 1999:). Empirical studies also vary in their support of the competing views. For instance, Feldman and Audretsch (1999) show that local competition positively affects innovation activity whereas others find support for Marshall's model – local competition dampens innovation activity (e.g., van der Panne & van Beers, 2006; van Oordt, 2002).

We argue that the effects of localized competition may vary across stages of a cluster's evolution. As firms flood into a cluster during its period of rapid growth, the pool of ideas in the cluster expands dramatically relative to other stages of the cluster's evolution. Under these conditions, firms may tradeoff the ability to appropriate value from innovation activity for the potential benefits from knowledge spillovers (Saxenian, 1994). In addition, as Feldman and Audretsch (1999) argue, these conditions set the stage for the emergence of new, entrepreneurial

firms attempting to fill gaps in product markets not addressed by established firms. Thus, in our construal, localized competition may provide positive economies during a cluster's pre-shock growth stage. However, as the density and scale of the cluster contracts after the shock, the size of the cluster's idea pool declines. Under these conditions, the competition for ideas may become more intense, as firms scramble and retrench to survive. Furthermore, when the benefits to agglomeration are asymmetric, established firms gain less from knowledge spillovers relative to emerging firms (Shaver & Flyer, 2000). The rising scarcity of ideas coupled with asymmetric agglomeration benefits may motivate firms to take a more cautionary approach to knowledge sharing, reducing the potential for fostering innovation related to spillovers. As a result, the Marshallian effects of localized competition may prevail in a cluster's post-shock reorganization stage and may dampen the likelihood of startups entering the cluster. Combining these ideas, we propose:

Hypothesis 2: Localized competition will have a positive effect on organizational founding during the cluster's pre-shock growth stage and a negative effect on organizational founding during the cluster's post-shock reorganization stage.

Urbanization (Diversity-related) Economies. Urbanization or diversity related economies arise from having a concentration of many different types of activities in one geographic region (Loesch, 1954). The diversity in activities underlies the heterogeneity among firms and industries in a region. The core idea is that interactions among diverse actors facilitate the sharing and exchange of complementary knowledge and in turn, foster knowledge creation and experimentation (Jacobs, 1969). The diversity of actors in a region also may make it easier for firms to access resources or capabilities that are distinct from those they already hold, thereby reducing search costs. It follows that, within a region, access for entrepreneurs to complementary knowledge, resources and innovation may facilitate organizational foundings. Several studies support this idea (for example: Glaeser et. al., 1992; Rosenthal & Strange, 2003) and

demonstrate that the effects of diversity on regional innovativeness are more prominent for high tech sectors (Paci & Usai, 1999; Henderson et. al., 1995).

As noted above, a transformative shock to a region triggers an outflow of firms and resources. As heterogeneity in activities and firms declines, the opportunities for accessing complementary knowledge and for building valuable interconnections also erodes. These conditions reduce the potential for achieving the benefits described above. Consistent with these ideas, research shows that innovative activity is more likely to cluster during an industry's early development (Feldman & Audretsch, 1996). We therefore predict:

Hypothesis 3a: The positive effects of diversity related economies on organizational founding are weaker during a cluster's post-shock reorganization stage as compared to the pre-shock growth stage.

Nonetheless, several ideas suggest an important counter argument to H2a. First, as the diversity in a region grows, it may become difficult for a firm to monitor the activities of other firms and industries (Porter, 1980). To benefit from a region's diversity, managers must identify and connect with actors in the region that provide complementary relationships and resources. As diversity increases, the scope of this task may exceed the cognitive capacities of managers and in turn, dampen their abilities to identify the most efficacious sources of knowledge and resources. This effect may be particularly salient for resource constrained entrepreneurial firms. Further and analogous to an industry, after a dramatic shock, robust firms and industries sustain a presence whereas fragile firms and industries tend to die off (Madsen & Walker, 2007). This shift in a region's composition may make it easier for new firms to identify legitimate and efficacious sources for accessing and building complementary knowledge-enhancing interconnections. In sum, to the extent that a regional industrial cluster experiences higher diversity among actors during a growth stage as compared to a post-shock period, we expect that the diversity related

benefits of locating in a cluster will be greater during the post-shock reorganization stage as compared to the pre-shock growth stage.

Hypothesis 3b: The positive effects of diversity related economies on organizational founding are stronger during a cluster's post-shock reorganization stage as compared to the pre-shock growth stage.

Localization (Specialization) Economies. Localization economies derive from the spatial concentration of an industry. Since knowledge tends to be industry specific, the geographic concentration of an industry fuels knowledge spillovers among firms and promotes the development of specialized labor and suppliers (Arrow, 1962, Romer, 1986). These conditions reduce the search costs for industry-specific labor and resources, increasing the attractiveness of a location to new ventures. Several studies provide support for this idea, finding that specialization, to some point, enhances the innovative productivity or growth of a region (for example, van der Panne & van Beers, 2006; Rosenthal & Strange, 2003) whereas others find the opposite (Feldman & Audretsch, 1999; Glaeser et al., 1992; Henderson et. al., 1995). However, a question remains regarding whether specialization economies vary in strength as a cluster evolves, and in particular, whether their benefits sustain following a major shock to a cluster.

A major environmental jolt may shift patterns of competitive advantage, exposing firms to different competitive pressures. As noted above, after a significant shock, a cluster's scale contracts due to the loss of firms and resources. Under these conditions, surviving firms, those resilient to the shock, may revert to core reliable and accountable practices in order to sustain legitimacy relative to other economic actors (Hannan & Freeman, 1984). This narrower scope of activities and resources in a cluster's industries may dampen innovative activity (Feldman & Audretsch, 1999) and place the cluster at risk of technological lockin (Maskell & Malmberg, 2007). In addition, if valuable resources become scarce, firms may devote more attention to protecting their knowledge versus sharing it with others. This approach may compromise the

flow of ideas in the cluster and in turn, dampen the cluster's innovative productivity. The process of reorganization and renewal may shift the cluster out of this negative path (Pouder & St. John, 1996; Menzel & Fornahl, 2009; Martin & Sunley, 2011). When new firms enter, entrepreneurs maintain little commitment to the pre-shock normative practices, embracing instead an organizing logic aligned with the demands of the current post-shock environment (Bradley, Aldrich, Shepherd & Wiklund, 2010). Entrants' innovative practices therefore, may benefit less from the specialization economies built up before the shock or immediately thereafter. Taken together, we propose that localization (specialization) economies will have a more prominent positive influence on the founding of entrepreneurial organizations during a cluster's pre-shock growth stage as compared to its post-shock reorganization stage.

Hypothesis 4: Localization (specialization) economies will have a stronger, positive influence on founding during the pre-shock growth stage as compared to the post-shock reorganization stage.

DATA & METHOD

Data. To examine how the influence of agglomeration mechanisms shifts over the lifecycle of an industrial organizational cluster, we analyze the emergence or founding of new organizations prior to and after the dot-com bust. We use the National Establishment Time-Series (NETS) Data to observe establishments both inside and outside of the Silicon Valley, the epicenter of the dot-com bust. The history of Silicon Valley as a technology and innovation hub, and the disruption to this region circa 2000, make it ideal for studying the variation in agglomeration mechanisms across the evolution of an industrial cluster. Moreover, California's industrial diversity and size provide substantial empirical leverage. In addition to the high tech sector, a wide variety of industries (such as agriculture, arts, media and entertainment, and financial services) occupy an important presence in the state. To wit, the Californian economy surpassed \$1 trillion in 1997, exceeding all but 6 nations (Legislative Analyst's Office, 1998;

Bureau of Economic Analysis, 2012). Studying industrial cluster evolution in Californian thus bears valid similarities to industries across the U.S. and the world, making this context highly generalizable.

The NETS data derives from annual snapshots of the Dun's Marketing Information files, identifying which establishments were active in January of each year and includes a establishment's location (city, county and metropolitan region); founding date; SIC codes; and firm-specific attributes (number of employees, governance structure, size of parent firm, etc.). We obtained data on California counties and cities from the U.S. Census Bureau to define the geographic communities in California and to specify the Silicon Valley region (consistent with extant work, e.g., Saxanian, 1994). In addition, we collected annual data on: state and industry employment from the State of California Employment Development Department (EDD) (State of California EDD, 2012), venture funding activity from the NVCA (NVCA, 2012), and industry relationships from the US Commerce (benchmark input/output accounts by sector). The time span of our data (1993– 2007) coincides with the beginnings of the commercial uses of the Internet (e.g. the launch of Mosaic Communications Corporation's browser), exposing the public to its the vast possibilities and fueling its sudden growth. We end our analysis in 2007. This allows for a natural experiment by covering approximately 7 years before the dot-com bust in March, 2000 and approximately 7 years after the bust. Ending in 2007, additionally insulates our examination from the significant events associated with the Great Recession. Following our hypotheses, we evaluate the separate agglomeration mechanisms for the two time periods, before the year 2000 (Pre-bust) and after 2001 (Post-bust).

[Insert Figure 1 about here]

Variables. The dependent variable is the annual count of the number of foundings (new entrants) in each industry within each city. Thus our unit of analysis is industry-city year. There

are 390 industries represented in the data, but not all city-years include all industries. In total our analysis includes over 137,000 founding events across 227 communities (cities) within three MSAs in Northern California. Of note, Figure 2 shows the number of founding events, exit events, and organizations operating (density) in Silicon Valley during the time period of our analysis.

Explanatory Variables To test our hypothesis on the influence of regional identity, we classified each city’s geographic location as either part of the Silicon Valley region (1), or not (0). Building on prior work (Saxenian, 1994), the communities that constitute Silicon Valley are (approximately from north to south) Redwood City, Menlo Park, Palo Alto, Mountain View, Sunnyvale, San José, Santa Clara, Fremont, Milpitas, Cupertino, Campbell, Los Gatos and Los Altos. While some previous work relies on Metropolitan Statistical Areas (MSAs) to determine a regional industrial cluster (e.g. Klepper, 2010), our measure more validly reflects the clustered Silicon Valley cities because it does not rely on the arbitrary geographic borders of county units and more closely matches to previous studies of the region. Specific to hypothesis 2, we measure localized competition as the sum of all establishments in the same industry-city-year. We lag these counts to avoid simultaneity. Recall that urbanization-related economies stem from the underlying heterogeneity among firms and industries in an area. To measure urbanization (diversity) economies, we constructed a Blau Index, which quantifies variety among entities in different groups. The Blau Index is defined as:

$$BI_{it} = 1 - \sum_{j=1}^S p_{jit}^2$$

Where BI_{it} is the Blau index for the city, i in year t , j is the number of industries located within the city and p is the proportion of the establishments that in city, i in year t , that belong to

the each industry, j . The possible range is from 0 to 1, where the Blau Index for cities with more industrial diversity approaches 1.

Localization economies stem from the accumulation of a specialized labor pool in a regional industrial cluster. Following extant research (Feldman & Audretsch 1999; Delgado et. al., 2010), we measure this specialization relative to the rest of the US with:

$$S_{ijt} = \frac{\text{Employment}_{jt} / \text{TotalEmployment}_t}{\text{USEmployment}_{jt} / \text{USEmployment}_t}$$

Where i identifies the city, j the focal industry and t the year.

Control Variables. To distinguish between the effects of high tech industries (associated with Silicon Valley) and the separate dynamics of the agglomeration mechanisms fostering the cluster's industrial lifecycle, we constructed a variable to flag high tech industries. The categorization is based on the level of technological intensity specific to the industry measured by the ratio of R&D expenditure to value added and the technology embodied in purchases of intermediate and capital goods and was developed by Hatzicronoglou (1997) for the Organization for Economic Co-operation and Development (OECD). As such, the industry control is a dummy variable set to 1 if an industry is defined as high-tech and 0 otherwise. Examples of high-tech industries include: Electronic Computers, Computer Storage, Computer Peripherals and Equipment, Aircraft and Space Equipment, Semiconductors and Related Devices, Telecommunications Equipment, and Instruments, Radio, TV and Communications Equipment, and Medical, Precision and Optical instruments.

Our study also includes a number of time-varying (annual) control variables. At the state level, we include the annual amount of venture capital investments in California as reported by the National Venture Capital Association (NVCA, 2012). We also control for the state's annual

unemployment rate.² At the community level, we control for competition effects using industry density defined as the number of organizations operating in an industry within a community and for industry dynamics using a sum of the number of exits from an industry within a community. Table 2 contains summary statistics and pairwise correlations for all the variables.

Method. We specify a zero-inflated Poisson model to predict annual foundings of establishments within each city-industry-year. While we observe over 70,000 founding events in our data, these represent only 22-26% of the observations. Zero-inflated poisson regression appropriately accommodates an abundance of zero counts (Green, 1990). Using a Vuong test, we verified that the zero-inflated Poisson approach was superior to the usual Poisson regression. We also utilized a Vuong test to confirm that zero-inflated Poisson regression was a better fit than zero-inflated negative binomial regression. We specify city-industry as the inflate specification and (following Cameron and Trivedi, 2009) include robust standard errors to accommodate the panel structure of the data and avoid biased estimates of the standard errors (and tests for significance).

RESULTS

Tables 3 and 4 present the results of the zero-inflated Poisson regression analysis of foundings in the three Californian metropolitan regions. Again, we split the dataset into two parts and examined the impact of agglomeration mechanisms on entrants in two stages of the industrial cluster's life cycle. Table 3 shows the pre-bust time period whereas Table 4 captures the post-bust time period. For each time period, we initially provide a baseline model with control variables (i.e., Models 1 and 8) and then add the explanatory variables, step by step, to

² Close readers will observe that these models contain no dummy variables for years. We do not include these variables as the amount of venture capital funding and level of unemployment capture the time-varying macro-economic trends that year dummies typically measure. Indeed in preliminary analysis, we observed that these variables are highly correlated to year indicator variables and models that included both suffered from multicollinearity.

the baseline models. We begin by discussing the stepwise results associated with each hypothesis; we then review the comparative results using the full models for each time period.

Beginning with H1, Model 2 shows that regional identity (Silicon Valley) has a negative and significant coefficient prior to the dot-com bust ($\beta = -0.089$, $p < 0.001$) whereas, in Model 9, post-bust, the coefficient is not statistically significant ($\beta = 0.030$). While these results do not support the hypothesis as to the direction of the main effect for regional identity, but they do demonstrate that the importance of the identity of the regional industrial cluster on foundings changed significantly before and after the shock. In Models 3 and 10 we interact the regional identity indicator variable with the indicator variable for high tech industry. This measures the effect of a Silicon Valley identity (of a city) on the chances of founding a high tech firm.

Although we did not make any hypotheses about this interaction, we include it to show the importance of the regional identity specifically for high tech industries. In the lead-up to the year 2000, the interaction term has a positive and significant parameter estimate ($\beta = 0.431$), $p < 0.001$). This same effect seems cut by at least half in the later, reorganization period and the difference in the coefficients is statistically significant ($X^2 = 587.26$, $p < .05$).

Next, we examine the effects of urbanization (diversity) economies, localization (specialization) economies and localized competition. The results for the urbanization economies are reported in Models 4 and 11. As predicted, urbanization economies are positively related to foundings in the early period and this effect is smaller (although not significant) after the shock. A Wald test indicates the differences in the magnitude of the coefficients is statistically significant ($X^2 = 1378.44$, $p < .05$). The next set of results indicate (in Model 5) that specialized labor (localization economies) is negatively associated with foundings pre-bust and that this effect persists afterward (Model 12). This is contrary to our hypotheses. Similarly, localized

competition seems to have a small, stable effect across the time periods, although it does have a positive effect.

[Insert Tables 3 and 4 here]

Finally, Models 7 and 14 present the results from the full models for the two time periods and Table 5 reports the Wald statistics associated with the comparative hypotheses tests. Taken together, we find that the main effect for regional identity in industries that are not high tech is negative, controlling for other explanatory variables. Both before and after the dot-com bust, the identity for the regional industrial cluster is only important for the industries that are associated with that cluster and the effect is positive. Importantly, the effect gains in magnitude during the reorganization period of the cluster (pre-bust $\beta = 0.282$), post-bust $\beta = 0.418$, both with $p < 0.001$) and the difference in coefficients is statistically significant as reported in Table 5 ($X^2 = 1378.44$, $p < .05$). This is of particular importance as it suggests, for industries associated with the cluster, identity is weaker in the growth period as opposed to the reorganization period. This aligns with the logic that motivated hypothesis 1. Considering other agglomeration effects, localized competition maintains a positive, small and stable effect on foundings in industry-cities before ($\beta = 0.002$) and after the shock ($\beta = 0.0006$). Hypothesis 2 proposed that localized competition would have a positive effect during the growth phase and a negative effect during the reorganization phase. As a result, although the difference in coefficients is statistically significant (Table 5, $X^2 = 3579.09$, $p < .05$), the findings only partially support hypothesis 2. Shifting attention to hypotheses 3a and 3b, the coefficient of urbanization (diversity) economies is significant and positive for the both stages, but it appears to sway a much greater influence in the pre-bust stage (with $\beta = 1.027$ as opposed to $\beta = 0.234$ post-bust, both with $p < .001$); the difference in the coefficients is statistically significant (Table 5, $X^2 = 2346.09$, $p < .05$). This result supports hypothesis 3a and suggests that diverse activities are more important when the

industrial structure of a cluster is growing, even controlling for other agglomeration mechanisms that may drive foundings in the cluster. Finally, the results in Models 7 and 14 suggest that a specialized labor pool (localization economies) is negatively related to foundings pre and post bust. The stronger effect during the later period does partially support hypothesis 4 and the difference in coefficients is statistically significant (Table 5, $X^2 = 1901.88$, $p < .05$).

[Insert Table 5 about here]

The results of the control variables are consistent in sign across the time periods. Not surprisingly, the results show that foundings increase as firms exit the region and this effect is stable and persistent over time. As expected, the amount of venture capital resources flowing into the region has a substantially larger positive effect on foundings prior to the shock as compared to after the shock. Last, counter to expectations, the California unemployment rate has a dramatically larger and positive effect on foundings in the region's growth phase as compared to its reorganization stage. The subsequent section explores the findings in more depth.

DISCUSSION

Other scholars have theorized that the benefits of clusters can be informed by examining their dynamics over time, but few empirical studies explicitly and comprehensively compare and contrast agglomeration effects within and across the stages of a cluster's evolution. The context we study allows us to define a clear breakpoint between two important stages in cluster's development, growth and reorganization and to highlight the differences within and without a regional industrial cluster. Our study contributes to the strategy literature by untangling cluster mechanisms that are temporally specific from those that persist over time. As such, the findings show how a shock shifts the evolution of industries within clusters. For instance, we find that cluster identity has a weaker influence on organizational foundings during the post-shock reorganization stage relative to the pre-shock growth stage, but that for industries associated with

the cluster the reverse is true. Likewise the magnitude of the positive effect of urbanizations (diversity) economies shifts between the two time periods, greatly altering the likely importance of diversity across cluster development stages. Further, while regional identity is important for high tech companies in the heady days before the bubble, the cluster identity effect seems nearly halved afterward, as the regional industrial cluster reorganizes.

Prior work explores how an industry's path of development is affected by a shock or disruptive event but directs less attention to the broader context in which industries are embedded. We address this void by examining how an exogenous disruption to the market for entrepreneurial funding affects the development of a region's industries pre and post disruption. The findings indicate that the effects of agglomeration mechanisms on a cluster's development vary before and after a fundamental shock. Surprisingly, prior studies ignore the influence of major exogenous events on a cluster's development (exceptions, Ingram and Parachuri, 2012; Bradley, et al., 2013). Our findings demonstrate that future studies of regional industrial clusters should control for such events that fundamentally change the composition of a cluster and its trajectory. Indeed, such controls may explain the mixed findings reported in prior work examining agglomeration mechanisms and cluster development. Future work might explore whether the pattern of recovery we observe is further conditioned by the source or form of a disruption, such as whether it is endogenous or exogenous.

In conclusion, understanding what explains differences in a region's recovery following a fundamental disruption can assist entrepreneurs, organizations and institutional actors in identifying spatial patterns of opportunity development and value creation and, in turn, inform research on the dynamics of industry clusters. These results emphasize that studies examining how agglomeration mechanisms affect regional industrial clusters should consider the role of

fundamental disruptions to a cluster and the stage of a cluster's evolution separately from the industry's development.

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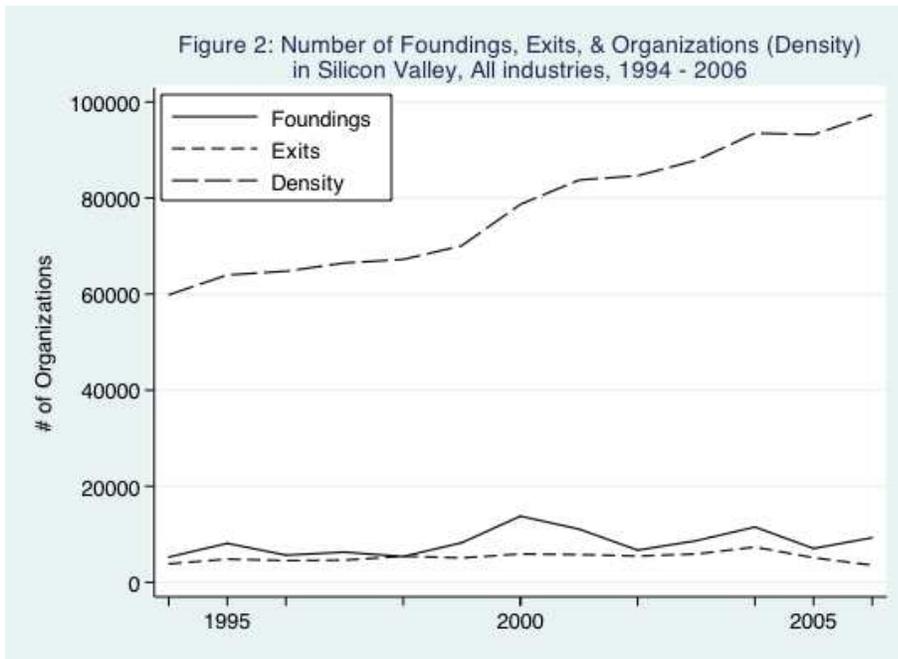
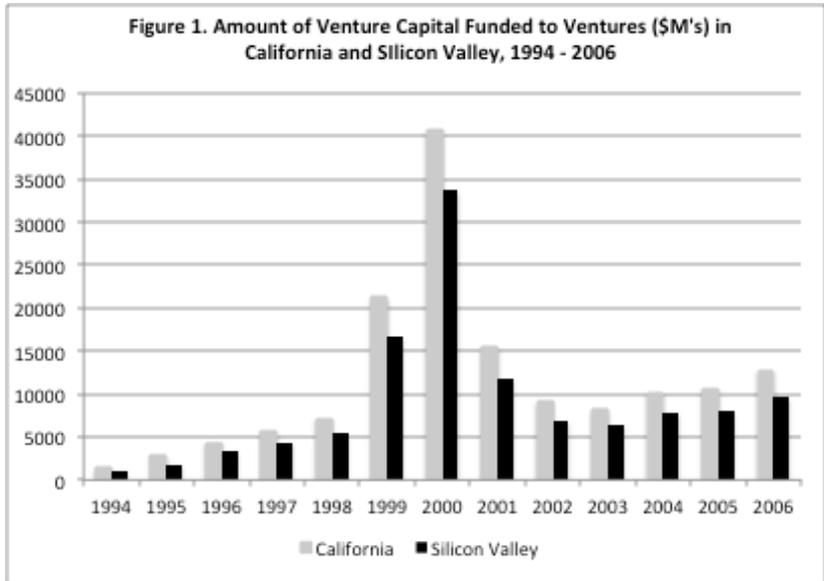


Table 2: Pairwise Correlations and Summary Statistics

Variables	Obs.	Mean	Std. Dev.	1	2	3	4	5	6	7	8
1 Foundings	740141	1.030	10.966	1							
2 Regional Identify (Silicon Valley)	740141	0.136	0.343	0.003	1.000						
3 High Tech Industry	740141	0.048	0.214	-0.013	0.053	1.000					
4 Urbanization (Diversity) Economies	740141	0.051	0.671	0.007	0.258	0.005	1.000				
5 Localization (Specialization) Economies	573086	431.941	2619.658	-0.011	-0.006	0.001	-0.030	1.000			
6 Localized Competition _{CI}	740141	10.725	59.611	0.676	0.004	-0.021	-0.017	-0.018	1.000		
7 # Exits _{CI}	740141	0.655	3.801	0.515	0.006	-0.018	0.009	-0.018	0.797	1.000	
8 VC Investment in CA	740141	10.910	9.242	0.018	-0.003	0.000	-0.119	0.024	0.005	-0.003	1.000
9 CA unemployment rate	740141	0.066	0.014	-0.020	0.005	0.001	0.199	-0.026	-0.011	-0.006	-0.700

Note: The table shows pairwise correlations of all variables of interest. The subscript CI refers to calculations made at the City-Industry level.

Table 3: Zero-Inflated Poisson Regression of Foundings in Industries in Three California Metropolitan Areas, Pre-Dot-Com Bust, 1993-1999

	1	2	3	4	5	6	7
	Pre-bust						
Regional Identity		-0.089*** <i>0.0184</i>	-0.107*** <i>0.019</i>				-0.272*** <i>0.034</i>
Regional Identity * High Tech			0.431*** <i>0.081***</i>				0.282*** <i>0.077</i>
Urbanization Economies				0.610*** <i>0.043</i>			1.027*** <i>0.067</i>
Localization (Specialization) Economies					-0.000** <i>0.000</i>		-0.00007** <i>0.00002</i>
Localized Competition _{CI}						0.002*** <i>0.000</i>	0.002*** <i>0.000</i>
High Tech Industry (=1)	-0.438*** <i>0.042</i>	-0.423*** <i>0.042</i>	-0.574*** <i>0.055</i>	-0.481*** <i>0.041</i>	-0.407*** <i>0.042</i>	-0.371*** <i>0.040</i>	-0.481* <i>0.050</i>
#Exits _{CI}	0.001*** <i>0.000</i>	0.001*** <i>0.000</i>	0.001*** <i>0.000</i>	0.002*** <i>0.000</i>	0.001*** <i>0.000</i>	0.001*** <i>0.000</i>	0.001*** <i>0.000</i>
VC Investment in CA (in \$US billions)	0.018*** <i>0.003</i>	0.018*** <i>0.003</i>	0.018*** <i>0.003</i>	0.018*** <i>0.003</i>	0.014*** <i>0.003</i>	0.024*** <i>0.004</i>	0.016*** <i>0.005</i>
CA unemployment rate	8.097*** <i>1.270</i>	8.070*** <i>1.270</i>	8.070*** <i>1.270</i>	7.451*** <i>1.273</i>	4.120** <i>1.353</i>	12.075*** <i>1.764</i>	6.403** <i>1.983</i>
N of observations	330499	330499	330499	330499	229069	330499	229069
N of non-zero obs.	86000	86000	86000	86000	59758	86000	59758
Log Pseudolikelihood	-521088.9	-520972.3	-520861.2	-518499.3	-357361.2	-450090.9	-308951.7

*p<.05; **p<.01; ***p<.001

Notes: This table presents Zero-Inflated Poisson regression of foundings in City-Industry-Years in three metropolitan (Core Based Statistical Areas) of California from 1993-2007. Robust standard errors are reported in italics below parameter estimates. The subscript CI refers to calculations made at the City-Industry level. All variables are lagged except the Regional Identity (Silicon Valley) and High Tech dummy variables. We omitted the coefficients for the constant and inflate variables in the tables for parsimony.

Table 4: Zero-Inflated Poisson Regression of Foundings in Industries in Three California Metropolitan Areas, Post-Dot-Com Bust, 2002-2007

	8	9	10	11	12	13	14
	Post-bust						
Regional Identity		0.030	0.0271429				-0.109
		0.053	0.0541355				<i>0.065</i>
Regional Identity * High Tech			0.1795658*				0.418***
			0.0892951				<i>0.088</i>
Urbanization Economies				0.2733946			0.234***
				0.0535606			<i>0.053</i>
Localization (Specialization) Economies					-0.001***		-0.0008***
					<i>0.000</i>		<i>0.0001</i>
Localized Competition _{ci}						0.001***	0.001***
						0.000	0.000
High Tech Industry (=1)	-1.083***	-1.087***	-1.146***	-1.059***	-0.407***	-1.077217***	-1.18*
	<i>0.042</i>	<i>0.042</i>	<i>0.0553</i>	<i>0.042</i>	<i>0.042</i>	<i>0.043</i>	<i>0.054</i>
# Exits _{ci}	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>
VC Investment in CA (in \$US billions)	0.193***	0.193***	0.193***	0.195***	0.195***	0.168***	0.016***
	<i>0.0219</i>	<i>0.0219</i>	<i>0.022</i>	<i>0.022</i>	<i>0.221</i>	<i>0.017</i>	<i>0.005</i>
CA unemployment rate	46.710***	46.725***	46.700***	41.468***	47.533**	42.413***	6.403**
	6.174	6.173	6.177	6.53	6.23	5.148	1.983
N of observations	321900	321900	321900	321900	260465	321900	260465
N of non-zero obs.	73450	73450	73450	73450	71786	73450	71786
Log Pseudolikelihood	-692676.1	-692658.3	-692648.4	-688893.6	-659895.8	-595866.7	-561665.4

*p<.05; **p<.01; ***p<.001

Notes: This table presents Zero-Inflated Poisson regression of foundings in City-Industry-Years in three metropolitan (Core Based Statistical Areas) of California from 1993-2007. Robust standard errors are reported in italics below parameter estimates. The subscript CI refers to calculations made at the City-Industry level. All variables are lagged except the Regional Identity (Silicon Valley) and High Tech dummy variables. We omitted the coefficients for the constant and inflate variables in the table for parsimony.

Table 5. Summary of Hypotheses Tests

Hypotheses	Comparison of Effects ¹	Wald χ^2	Outcome
All Firms			
H1: Regional Identity x High Tech Pre-Bust (+) < Regional Identity x High Tech Post-Bust (+)	0.282 < 0.418	298.85*	Supported
H2: Localized Competition Pre-Bust (+) & Localized Competition Post-Bust (-)	0.002 vs. 0.0006	3579.09*	Not Supported
H3a: Urbanization Economies Pre-Bust (+) > Urbanization Economies Post-Bust (+) H3b: Urbanization Economies Pre-Bust (+) < Urbanization Economies Post-Bust (+)	1.027 > 0.234	2346.09*	Supports H3a
H4: Localization Economies Pre-Bust (+) > Localization Economies Post-Bust (+)	(-0.00007) vs. (-0.00083)	1901.88*	Not Supported

*p<.05; 1. The coefficient listed in this column stem from Table 3, Model 7 and Table 4, Model 14.