Reconciling Design and Evolution in Economic Development: Methods to Map Entrepreneurial Ecosystems

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DEDICATION

This dissertation is dedicated to my loving wife Ami, my son Avyaan, my mother Minal, my father Moreshwar, and my brother Keshav.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF ABBREVIATIONS AND/OR SYMBOLS

America Community Survey .... ACS
Business to Business B2B
Business to Consumer B2C
Current Population Statistics .... CPS
Interdependence .... ζ
Location Quotients .... LQ
Metropolitan Statistical Area .... MSA
North American Industry Classification System .... RD
Related Density .... RD
Related Density, Industry-specific .... RDI
Supply Chain .... SC
Set of Specializations .... SS
Quarterly Census of Employment and Wages .... QCEW
Quarterly Workforce Indicators .... QWI

ABSTRACT

RECONCILING DESIGN AND EVOLUTION IN ECONOMIC DEVELOPMENT: METHODS TO MAP ENTREPRENEURIAL ECOSYSTEMS

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Are entrepreneurial ecosystems designed or evolved? Considered as a social construct, entrepreneurial ecosystem practitioners embrace the notion that qualitative entrepreneurship can be fostered through the right combinations of ecosystem factors. This leads to the expectation that entrepreneurial ecosystems can be built, and the appropriate ecosystem factors can be replicated from one context to another. Yet, rooted in geography, many entrepreneurial ecosystem scholars identify the sources of economic novelty as embedded in a region's capabilities and conditioned by its history—that an entrepreneurial ecosystem cannot be stripped away of its context. These two views have opened debate to more questions; Are entrepreneurial ecosystem boundaries open or closed? What are the appropriate levels of analysis? What, if any, is the role for policy?

In this dissertation, I offer a novel entrepreneurial ecosystems framework that integrates both the designed and evolved views and provides a pathway for practitioners

to identify areas for targeted policy making that improve regional entrepreneurial outcomes. I do so by distinguishing between the social construct of an entrepreneurial ecosystem and the regionally evolved structure of an economic ecosystem. I argue that entrepreneurial ecosystems are embedded in economic ecosystems and thus entrepreneurship policies must be considered within their regional context. To operationalize this connection between the entrepreneurial and economic ecosystems, I develop a methodology for mapping a region's entrepreneurship space that identifies industry clusters with the most entrepreneurial potential. Finally, I also provide an example policy assessment of Ventura County, California's entrepreneurial ecosystem to demonstrate the applicability of this framework at multiple scales of geography and its usefulness for identifying the unique character of any entrepreneurial ecosystem.

CHAPTER 1. INTRODUCTION

Entrepreneurial ecosystems as a strategic initiative for regional innovation and economic growth have been adopted broadly by organizations concerned with economic development. Where only a decade ago the concept was still emergent, in the past few years it has become a hot-topic in both research and practice, attracting several special editions in top economics and policy journals[1] as well as major convenings by leading policy organizations such as the Ewing Marion Kauffman Foundation and the World Bank.

This increasing popularity of entrepreneurial ecosystems is a result of a continued alignment in the business strategy and regional industrial policy literature on supporting small high-growth firms as a core economic development initiative (Brown & Mawson, 2019; Brown, Mawson, & Mason, 2017; Stam, 2015).

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[1] Notable recent prominent special editions include; “Entrepreneurial Ecosystems” in Small Business Economics (Acs, Stam, Audretch, & O'Connor, 2017); “Entrepreneurial Ecosystems in Cities” in the Journal of Technology Transfer (Audretsch & Belitski, 2017); “Entrepreneurial Ecosystems” in the Strategic Entrepreneurship Journal (Dushnitsky, Graebner, & Zott, 2019); “Entrepreneurial ecosystems: economic, technological, and societal impacts” in the Journal of Technology Transfer (Audretsch, Cunningham, Kuratko, & Menter, 2019); “Entrepreneurial Ecosystems in Cities” in the Journal of Technology Transfer (Audretsch & Belitski, 2017); “Measuring Entrepreneurial Ecosystems” issued by the Ewing Marion Kauffman Foundation (Bell-Masterson & Stangler, 2015); “Building Sustainable Entrepreneurship Ecosystems” (Simatupang, Schwab, & Lantu, 2015); “Entrepreneurial innovation: The importance of context” in Research Policy (Autio, Kenney, Mustar, Siegel, & Wright, 2014); “Entrepreneurial Ecosystems” in the Strategic Entrepreneurship Journal (Dushnitsky, Graebner, & Zott, 2018); and “Sustainable Entrepreneurial Ecosystems” in Small Business Economics (Volkmann, Audretsch, Fichter, & Klofsen, 2017).

However, scholars remain critical of the current ambiguity in fundamental definitions in the entrepreneurial ecosystems approach (Cavallo, Ghezzi, & Balocco, 2018) and emphasize the need for more clarity on foundational theoretical arguments (Alvedalen & Boschma, 2017) to avoid making potentially harmful policy choices (Oh, Phillips, Park, & Lee, 2016).

The most consistent criticisms of the entrepreneurial ecosystems approach are; it remains fuzzy as a theoretical concept (Oh, Phillips, Park, & Lee, 2016); it lacks a common definition (Scaringella & Radziwon, 2018); it is misrepresented in its policy implications (Isenberg D. , 2014); and, it is underdeveloped for real policy applications (Bell-Masterson & Stangler, 2015). Nonetheless, there is a high and increasing demand on the scholarly literature for recommendations on designing and implementing entrepreneurial ecosystem policies and initiatives that will foster resilient and innovative high-growth economies (Audretsch, Cunningham, Kuratko, & Menter, 2019).

The objective of this dissertation is to resolve enough of the theoretical ambiguity around entrepreneurial ecosystems theory to provide regional development practitioners with a policy framework that revises the traditional economic development thinking to include new features introduced in the entrepreneurial ecosystems approach. My goal is to synthesize key theoretical foundations in the literature to explain certain advantages of the entrepreneurial ecosystems approach that differ from its antecedent innovation systems or systems of innovation approach, while also providing an empirical methodology based on these theories that better informs targeted policy making for regional entrepreneurship development.

As a starting point, I focus on a core topic of contention in the entrepreneurial ecosystem literature–are they designed, or do they evolve? This distinction challenges the very nature of the entrepreneurial ecosystems approach and implicitly questions the appropriateness of using biological metaphors to model social and economic phenomenon. Some innovation scholars reject the notion that innovation systems can evolve naturally. Calling it biomimicry, they chide the adoption of ecosystems language into innovation studies as naïve and having gained in popularity for its mimetic quality and appeal to the news media rather than any sound scientific reasoning (Oh, Phillips, Park, & Lee, 2016; Papaionnou, Wield, & Chataway, 2009). Scholars in favor of the biological metaphor instead argue that entrepreneurship occurs in evolutionary systems analogous in complexity to biological systems (Auerswald P. E., 2008; Alvedalen & Boschma, 2017).

Importantly, the debate on the role of design vs evolution has not been to question if entrepreneurial ecosystems are artificial or natural – they are man-made – but to question if they are apart from nature. As Herbert Simon frames the distinction early in his book *The Sciences of the Artificial*:

> So too we must be careful about equating 'biological' with 'natural.' A forest may be a phenomenon of nature; a farm certainly is not. The very species upon which we depend for our food – our corn and our cattle – are artifacts of our ingenuity. A plowed field is no more a part of nature than an asphalted street – and no less. These examples set the terms of our problem, for those things we call artifacts are not apart from nature. They have no dispensation to ignore or violate natural law.

At the same time they are adapted to human goals and purposes… As our aims change, so too do our artifacts – and vice versa." (Simon H. A., 1996, p. 3)

If apart from nature, an entrepreneurial ecosystem's design can fully and functionally define its outcomes. If more entrepreneurship is the desired outcome, the strategy would simply be to emulate a system already successful at being entrepreneurial. Attempts to emulate the Silicon Valley model are prime examples of such entrepreneurship development strategies and have faced significant limitations (Audretsch, 2019). In reality, entrepreneurial ecosystems face constraints that are unique to their own environments, be these resource constraints or institutional barriers that condition the availability and extent of entrepreneurial opportunity.

Nonetheless, the discussion on design vs evolution questions the role for policy in the entrepreneurial ecosystems approach. At one extreme, the design camp argues that entrepreneurship is an outcome of the purposeful machinations of ecosystem managers (venture capitalists, investors, start-up owners, university technology transfer offices, research and development agencies, etc.) in well-organized systems, while the evolutionary extreme argues that economic novelty is a product of the system's economic history unfolding over time. At the first extreme, there is no entrepreneurship without policy, while at the other, there is no clear role for policy in fostering entrepreneurship.

The reality is somewhere in between. The term entrepreneurial ecosystem literally posits the individualistic act of recombining economic resources for opportunistic 'gap-filling' in its environment. In so doing, the term emphasizes the co-determination of entrepreneurial activity realized through the actions of individual agents interacting with their environment. To recount another passage from Simon (1996), “Human beings, viewed as behaving systems, are quite simple. The apparent complexity of our behavior over time is largely a reflection of the complexity of the environment in which we find ourselves” (p. 53).

This artificial nature of entrepreneurial ecosystems leaves a role for design at the level of directing and coordinating individual action, and evolution in understanding the available resources of economic development.

In this dissertation, I elaborate on this dual nature of entrepreneurial ecosystems by drawing a distinction between the social interactions and economic co-ordinations that enable individual entrepreneurs to bring their innovations to market, and the evolved industry structure of regional economies that contains the building blocks for innovation – the latter I refer to as an economic ecosystem.[2]

I operationalize this perspective into a policy framework by embedding the entrepreneurial ecosystem completely in its regional economic ecosystem. The entrepreneurial ecosystem in this sense consists of an institutional system that resides in a network of evolved regional industrial capabilities. As such, no two entrepreneurial ecosystems are the same and each is determined by its own unique history and institutions.

[2] Generally, I use the same definition of an economic ecosystem as Auerswald and Dani (2017); “a dynamically stable network of interconnected firms and institutions within bounded geographical space” (p. 254).

I also offer a means for measuring entrepreneurial ecosystems, both along the design element of the key factors that enable entrepreneurial processes measured by entrepreneurial ecosystem indicators, and along the evolutionary component mapped as an industry space revealing niches of entrepreneurial opportunity. I structure these arguments in a policy framework intended as a direct update of economic development practice. I also provide a case-study example of Ventura County, California.

The dissertation is structured as follows. In chapter 2, I elaborate on core ideas of entrepreneurial ecosystems that the extant scholarship coalesces around. I provide an overview of the entrepreneurial ecosystem's theoretical antecedents, disentangle some conceptual knots, and lay out critical features of entrepreneurial ecosystems. I focus on three select theoretical areas in the entrepreneurial ecosystems approach that are necessary for bridging the gap between theory and practice – the purpose of entrepreneurial ecosystems; their geographical boundedness; and, their measurement. I also devote a section to the notion of interdependencies of production activities in economic ecosystems that provides an intuitive basis for the evolutionary perspective of entrepreneurial ecosystems proposed here and underlies the empirical methodology introduced in the next chapter. I conclude this chapter by outlining a framework for translating these theoretical advances into actionable knowledge for policy and decision-making.

In chapter 3, I provide an empirical methodology for identifying the economic interdependencies in regional industry clusters and mapping the U.S. national and sub-national industry spaces. I propose this methodology as an empirical update for economic developers to go beyond a narrow focus on regional industry specializations to also include regional industry interdependencies as these represent resource complementarities needed for innovation and entrepreneurship. Expanding upon the interdependence measure, I also develop a Related Density index for ranking regional entrepreneurial ecosystems based on the revealed alignment of their regional industry mix. I provide empirical evidence in support of the measure and discuss its usefulness for identifying entrepreneurially competitive clusters. I conclude this chapter with a discussion on how these measures can be applied in entrepreneurial ecosystems policy.

In chapter 4, I provide an example application of the entrepreneurial ecosystems policy framework developed in this dissertation. Rather than a focus on different geographies or scales of analyses, the example of Ventura County, California is provided to emphasize different questions practitioners of regional development are often faced with, such as; how to evaluate the strengths and weaknesses of an entrepreneurial ecosystem? how to identify competitive differentiators vs structural gaps in an entrepreneurial ecosystem? and, how to align regional policy to produce proposed entrepreneurial and innovation outcomes?

In the concluding chapter 5, I discuss how the theory and methods developed in this dissertation address the main challenges to entrepreneurial ecosystems research stated by leading scholars in the area today.

CHAPTER 2. THE THEORY OF ENTREPRENURIAL ECOSYSTEMS

In recent years, the entrepreneurial ecosystems approach to driving regional economic development has become a hot topic in academia, industry, and government. The entrepreneurial ecosystems approach has generally gained favor among development practitioners as prior waves of initiatives have failed to yield desired results.[3] From a research standpoint, it has developed from a diverse scholarship in the economic development, industrial policy, management and business strategy fields as a practical convergence of theories for fostering high-growth entrepreneurship. Yet the entrepreneurial ecosystems approach is criticized as being built upon weak theoretical foundations.

At the root of these contentions is the question: Are entrepreneurial ecosystems designed or are they evolved? To answer this question, I first describe the core theoretical precepts underlying the entrepreneurial ecosystems approach, and then undertake to disentangle some conceptual knots. I argue that the two viewpoints are not mutually exclusive—indeed, that both are in fact embedded in institutional and evolutionary economic theories. However, the design view treats entrepreneurial ecosystems as closed systems while the evolved view treats them as open systems, leaving practitioners unclear

[3] Entrepreneurship and the focus on high-growth firms has come to prominence in economic development only in the past few decades. Classically, economic development practice has strove to attract large firms to the region with tax and policy incentives. These strategies have recently been challenged as ineffective in contributing towards job growth or even more broadly towards economic development outcomes.

on the appropriate levels and units of analysis. To resolve this confusion, I propose a novel policy framework for practitioners that accounts for the place-based complexity of interactions in the evolved-ecosystems approach, while also permitting purposeful formulations of targeted policy interventions.

1. Design vs Evolution

The entrepreneurial ecosystems approach has gained momentum in recent years in academia, industry, and government (Audretsch, Cunningham, Kuratko, & Menter, 2019; Brown & Mawson, 2019; Cavallo, Ghezzi, & Balocco, 2018; Stam, 2015). In policy circles, entrepreneurial ecosystems are presented as an update to the Innovation Systems literature (Acs, Stam, Audrestch, & O'Connor, 2017), but key theoretical gaps remain in measuring entrepreneurial ecosystems and building actionable policies around empirical assessment (Bell-Masterson & Stangler, 2015; Brown & Mason, 2017; Malecki, 2018).

One key contention in the scholarship points to a fundamental debate on the very nature of entrepreneurial ecosystems; are they designed? Or, are they evolved? (Colombo, Dagnino, Lehmann, & Salmador, 2017). These questions strike at the heart of the role of policy in entrepreneurial ecosystems.

On the surface, this argument belies a general discomfort with adopting a biological metaphor for explaining social phenomenon (Papaionnou, Wield, & Chataway, 2009). Such skepticism is not new. Writing in a time when positivist thought dominated the philosophical discourse, Schumpeter famously rejected this type of "metaphysical reasoning"[4]:

> To the reproach of unscientific and extra-scientific mysticism that now surrounds the "evolutionary" ideas, is added that of dilettantism. With all the hasty generalisations in which the work "evolution" plays a part, many of us have lost patience. I must get away from such things. (Schumpeter, 1934, p. 58)

Yet, even Schumpeter in his later years himself referred to economic development as an evolutionary process:

> The changes in the economic process brought about by innovation, together with all their effects, and the response to them by the economic system, I shall designate by the term Economic Evolution. (Schumpeter, 1939, p. 86)

Importantly, Schumpeter applied the biological term because he saw the processes of economic growth to be 'evolutionary' in that they explain technical change over time as constrained by history. Schumpeter did reject adopting Darwinian mechanisms of evolutionary change as he saw the specific social mechanisms of economic growth were distinct from the biological mechanisms of change (Hodgson, 1997) but he nonetheless adopted the analogy of evolutionary processes.

[4] By 'metaphysical reasoning', Schumpeter in his words was referring to, "… going beyond the reach of both "reason" and "facts", beyond the realm, that is, of science." (Schumpeter, The theory of economic development. An inquiry into profits, capital, credit, interest and the business cycle., 1934, p. 57)

In a similar vein, the adoption of 'ecosystems' into economics can hardly constitute a "flawed analogy" (Oh, Phillips, Park, & Lee, 2016) given scholars call on it to underscore the role of the environment on conditioning growth in a system of interdependent related parts (Smith & Smith, 2015), while being fully cognizant that economic mechanisms of division of labor, competition, firm survival, knowledge spillovers, are distinct mechanisms from Darwinian selection. Biological ecosystems are fundamentally about the co-existence and co-evolution of resident species, making them a powerful analogy for understanding complex networks or interdependencies in social systems as well (Iansiti & Levien, 2004).

On a deeper level however, those who disavow the biological analogy caution that economic systems "… differ from natural ecosystems in (i) the presence of intention and teleology, and (ii) the acknowledged importance of governance." (Oh, Phillips, Park, & Lee, 2016, p. 2).

1.1. Governance Theories in Entrepreneurial Ecosystems

First, on governance, the debate between "design vs evolved" is a substantial question that has had a polarizing effect on the perceived role of policy in entrepreneurial ecosystems. At one extreme is the top-down approach that posits entrepreneurial ecosystems can be built, and are by nature, designed. The role of policy is to provide the specific inputs for entrepreneurial ecosystems that allow them to grow and flourish (Audrestch & Belitski, 2017). At the other extreme is the bottom-up view of ecosystem dynamics as self-regulating processes that provide little explicit rationale for policy intervention (Isenberg & Onyemah, 2016). Critically, this is a distinction between how coordination and allocation is understood to occur within an ecosystem; either by a Chandlerian "visible hand" or, the Smithian "invisible hand" (Colombo, Dagnino, Lehmann, & Salmador, 2017). Accordingly, top-down approaches imply more tractable policies where the intent of the policy, be it more entrepreneurship or innovation, can be readily aligned with performance outcomes (Acs, Autio, & Szerb, 2014), whereas bottom-up approaches face the potential complication of unforeseen adverse effects arising out of the complex network of interactions within an ecosystem (Colombo, Dagnino, Lehmann, & Salmador, 2017).

Yet, despite these differences, both views adhere to an evolutionary perspective[5] and in so doing reject the traditional role of policy intervention as being narrowly interpreted to address market failures from events such as externalities, abuse of market power, and asymmetric information (Stam, Entrepreneurial Ecosystems and Regional Policy: A Sympathetic Critique, 2015). Both perspectives also support that non-market interactions are a necessity to innovate (Teece, 1992) and thus policies should be cognizant of broader social processes, such as culture and norms (Szerb, Acs, Autio, Ortega-Argiles, & Komlosi, 2013). In fact, both perspectives explicitly promote policy frameworks for entrepreneurial ecosystems governance (Isenberg & Onyemah, 2016; Acs, Autio, & Szerb, 2014), albeit they disagree on the appropriate level, extent, and purpose of the policy intervention.

[5] Evolutionary economic theories date back explicitly to Veblen (Veblen, 1898) and Herbert Spencer (1857), and implicitly at least to Marx and Malthus (Marx, 1930). Examinations of evolutionary economic processes arguably even date back to Adam Smith's famous exposition on pin making (Nelson, 2002).

These differences and similarities in entrepreneurial ecosystem governance approaches can be traced back to the dual lineage of ecosystems in the heterodox institutionalist and evolutionary economic theories. In the institutionalist tradition, the context that enables competition and cooperation between entrepreneurial agents is paramount (North, 1990). While in the evolutionary tradition, the learning and adaptation that occurs within firms to produce technical change is at the core of growth (Nelson & Winter, 1982). Yet, these two theoretical approaches to ecosystems are not mutually exclusive.

Richard Nelson (2002) proposes that, "… before modern neoclassical theory gained its present preponderant position in economics, much of economic analysis was both evolutionary and institutional" (p. 18). Citing Douglass North's (1990) adoption of the evolutionary perspective in 'Institutions, Institutional Change, and Economic Performance', Nelson further promotes that the recent resurgence in both evolutionary and institutional theories shows a re-convergence in explanations of the mechanisms of economic growth,"… many of the scholars who did the early work on the new evolutionary economics recently have become focused on such subjects as "national innovation systems", which is an institutional concept par excellence." (Nelson, 2002, p. 19).

This re-convergence, along with the adopted 'neo-' updates of neo-institutionalist and neo-evolutionary theories into ecosystems are also the likely source for the biological analogy becoming a 'messy metaphor' (Brown & Mawson, 2019), lacking in empirical explanations of the causal relationships driving technical change in ecosystems

(Borissenko & Boschma, 2016) and, lacking a satisfactory translation of ecosystem theories to update industry policy (Brown & Mawson, 2019). As Nelson (2002) frames it:

> Increasingly evolutionary economists are coming to see “institutions” as molding the technologies used by a society, and technological change itself. However, institutions have not as yet been incorporated into their formal analysis. On the other hand, institutional economists tend to focus exactly on these institutions. Many would be happy to admit that the influence of a country’s institutions on its ability to master and advance technology is a central way that institutions affect economic performance. However, institutionalists have yet to include technology and technological change explicitly into their formulation. The arguments for a marriage I think are strong. (p. 20)

The marriage of these two influences in the theory of regional economic ecosystems considered more broadly has become more evident in the recent decade. The influence of neo-Schumpeterian theories (Hanusch & Pyka, 2007) has pushed economic geographers to pay closer attention to the micro-foundations of growth (Neffke & Henning, 2013; Muneepeerakul, Lobo, Shutters, Gomez-Lievano, & Qubbaj, 2013; Neffke, Hartog, Boschma, & Henning, 2017). At the same time, neo-evolutionary theories that draw more directly on the biological analogy are increasingly emphasizing the environmental context (Auerswald P. E., 2015; Boschma, 2015; Auerswald & Dani, 2017).

Addressing the question on the importance and role of governance in entrepreneurial ecosystems is then a question of constructing a policy framework that builds on the complementarities between the top-down and bottom-up governance approaches. This discussion constitutes the main efforts in sections 3 and 4 of this chapter.

1.2. The Teleology of Entrepreneurial Ecosystems

The second major contention in the literature against the use of biological metaphors relates to the teleological question of entrepreneurial ecosystems. This is also not distinct from the 'design vs evolution' question. Those in the design camp argue entrepreneurial ecosystems are artificial systems constructed as a result of human aspirations and intent (Oh, Phillips, Park, & Lee, 2016; Papaionnou, Wield, & Chataway, 2009). This view is held in contrast to natural ecosystems where no individual or species is aware of the ecosystem, leave alone an organism taking conscious action to re-shape the environment they are a part of, rather than adapt to it. This is an important and old question on the difference between human aspirations informing social intent from natural intent, as what differentiates humans from the rest of the animal kingdom. Or, as Karl Marx (1930) put it in his seminal work *Das Kapital*:

> A spider carries on operations resembling those of a weaver, and many a human architect is put to shame by the skill with which a bee constructs her cell. But what from the very first distinguishes the most incompetent architect from the

best of bees, is that the architect has built a cell in his head before he constructs it in wax. (pp. 169-170)

This ‘design’ thinking is predominant in the business, management, and strategy literatures’ use of the term ‘ecosystem’ (Adner, 2017). Although biologically motivated (Moore, 1993), studies in this group start with a specific value proposition, or purpose for the ecosystem, and then derive the interactions of interest and the formal boundaries of the ecosystem. For instance, Adner and Kapoor (2010) explicitly model the upstream and downstream connections around a focal firm to demonstrate a firm’s relative location along a value chain impacts its innovation potential. Isanti and Levien (2004) promote that firm strategic initiatives should extend to their networks which define the boundaries of the ecosystem in which the firm is embedded. In this literature, value creation in ecosystems is either investigated in terms of, ‘ecosystem-as-affiliation’, where ecosystem boundaries are defined by, “communities of associated actors defined by their networks and platform affiliations”, or as ‘ecosystem-as-structure’, where ecosystem boundaries are identified by, “configurations of activities defined by a value proposition” (Adner, 2017, p. 40). In either case, a common value proposition or purpose defines who and what comprises the ecosystem.

Such artificial constructs of ecosystems delineate clear boundaries for a closed system (Colombo, Dagnino, Lehmann, & Salmador, 2017) and the ecosystem is defined according to its purpose (Adner, 2017). However, such a conception of entrepreneurial ecosystems is problematically tautological in that, “entrepreneurial ecosystems are systems that produce successful entrepreneurship, and where there is a lot of successful entrepreneurship, there is apparently a good entrepreneurial ecosystem" (Stam, 2015, p. 4). The closed and rigidly determined nature of these systems is more convenient for policy making but tends to produce long lists of factors relevant to entrepreneurial ecosystems functioning and provides little insight on the appropriate level of analysis that range from global geographies to networks and communities not strictly defined in space (Zahra & Nabbisan, 2011; Malecki, 2018).

As noted earlier, all entrepreneurial ecosystem scholarship to some degree ascribes to an evolutionary and an institutionalist perspective. However, the entrepreneurial ecosystems literature emergent from a regional development and industrial policy background is strongly rooted in economic geography where location is the first determinant of an ecosystem. These approaches are evolutionary and 'history-friendly' in their emphasis (Malerba, Nelson, Orsenigo, & Winter, 2016). They hold that technological progress cannot be studied irrespective of its geographic context that comprises of direct and indirect interdependencies, both formal and informal, economic and social, that condition evolution in the ecosystem. In fact, this literature rejects the design-assumptions of the institutionalist approach. Brown, Mawson, and Mason (2017) provide empirical evidence on the nature and performance of high-growth firms to 'myth-bust' commonly held assumptions that inform institutionalist entrepreneurial ecosystems policies. Importantly they argue that high-growth firms are not the same irrespective of location and they are not distributed evenly across geography, but instead cluster spatially. Furthermore, firm performance, innovativeness, and productivity are described in an industry clusters context. This literature has its antecedents in concepts such as industrial districts, clusters, and innovation systems. In this vein, Stam and Spigel (2017) explicitly define entrepreneurial ecosystems as “a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship within a particular territory” (p. 407).

In the ‘entrepreneurial ecosystems are evolved’ literature, entrepreneurship is not the given purpose of an entrepreneurial ecosystem, rather it is the functional instrument intended to drive toward intended policy outcomes. The research literature acknowledges that the output of entrepreneurial effort is not always productive (Baumol, 1990) and entrepreneurial ecosystems policies seek to identify and promote the processes that facilitate productive high-growth entrepreneurship as a function of regional competencies (Mason & Brown, 2013; 2014). The teleological argument for entrepreneurial ecosystems in the ‘evolved’ perspective is not relevant. There is no specific formula or design that produces productive entrepreneurship, and policy should instead be guided by overarching principles on fostering high growth firms (Isenberg D. J., 2010).

The biggest limitation to the perspective that ‘entrepreneurial ecosystems are evolved’ lies in measuring the complexity of interactions in any ecosystem (Nguyen, Mariussen, & Hansen, 2020). Different ecology-informed frameworks have been borrowed to fill this gap (Auerswald & Dani, 2017; Auerswald P. E., 2015; Auerswald & Dani, 2017; Boschma, 2015; Alvedalen & Boschma, 2017) and the use of graph theory and network models been recommended as ideal tools for these analyses (Alvedalen & Boschma, 2017; Auerswald P. E., 2015), but a useful synthesis for entrepreneurial ecosystems practice, beyond case-study analyses, has yet to be proposed, with most attempts relying on the explicit modeling of interactions among ecosystem agents, closer in practice to the design-viewpoint (Roundy, Brockman, & Bradshaw, 2017).

1.3. Towards a Policy Synthesis for Entrepreneurial Ecosystems

Despite the apparent polarity of views in the top-down and bottom-up approaches, policy makers, charged with an agenda for action, in reality are limited by the knowledge and computational resources they have available. Simon (1997) expounded on the idea of ‘bounded rationality’ through its implications to decision making. Specifically, he argued that individuals have incomplete knowledge of events and thus make decisions considering only the most closely connected factors in cause and time:

> The human being striving for rationality and restricted within the limits of his knowledge has developed some working procedures that partially overcome this difficulty. These procedures consist in assuming that he can isolate from the rest of the world a closed system containing only a limited number of variables and a limited range of consequences. (p. 94)

As such, any policy formulation in the entrepreneurial ecosystems approach necessitates a reduction of the open systems of the evolutionary view into closed systems delineated by the institutions, organizations, individuals, and processes that most closely relate to the policy conversation in cause and time.

In *The Science of the Artificial,* Simon (1996) further elaborates on the characteristics and complexities of designing "artifacts on a social scale". He says, "The success of planning on such a scale may call for modesty and restraint in setting the design objectives and drastic simplification of the real-world situation in representing for purposes of the design process" (p. 141)

The discussion so far has focused on two polarizing, yet overlapping, viewpoints in the entrepreneurial ecosystems approach – are entrepreneurial ecosystems designed, or evolved? I have argued that both viewpoints take an evolutionary and institutionalist view to entrepreneurial growth and performance. However, they differ in their conceptions of ecosystems as closed or open systems and differ in representing entrepreneurial ecosystems as global networks independent of place, or highly localized structures embedded in geography. I also argue that these viewpoints influence a practitioner's preference for a top-down or bottom-up approach to entrepreneurial ecosystems governance. My next endeavor is to synthesize a policy framework around these viewpoints that provides a practical update of entrepreneurial ecosystems policymaking.

The goal of such a synthesis is to identify a generalizable methodology that produces practicable intelligence for practitioners of the entrepreneurial ecosystems approach. Although, the focus in this chapter is explicitly on entrepreneurial ecosystems, the proposed framework is aligned with the conceptual adoption of the biological term 'ecosystem', and with little effort is translatable to evaluate other types of innovation, business, university, or other regionally embedded economic ecosystems (Auerswald & Dani, 2017).

The remainder of this chapter is devoted to developing a policy framework that integrates the two viewpoints. The aim is to apply developments in the neo-evolutionary literature to inform the specification of ecosystem boundaries and the ecosystem structure as revealed through its own unique history, and then to apply practices from the entrepreneurial ecosystems business, management, and strategy literature for fostering entrepreneurship in these evolutionarily competitive niches.

Accordingly, in section 2 I elaborate on the conceptual origins of the evolutionary nature of entrepreneurial ecosystems. In section 3, I concentrate on place-based theories of entrepreneurial ecosystems as the appropriate level of analysis to capture the complexity of economic and social interactions. In section 4, I introduce the notion of economic interdependencies and the principle of relatedness as applied to developing an entrepreneurial ecosystems policy framework. In section 5, I discuss different dimensions of measurement that are important to policy makers and necessary for developing actionable intelligence. In section 6, I conclude with a policy framework for evaluating entrepreneurial ecosystems and future scope for research.

2. Conceptual origins

As Acs, et. al. (2017) point out, the antecedents of entrepreneurial ecosystems theory have two dominant lineages: the strategy literature and the regional development literature. However, the influences that dominate the current entrepreneurial ecosystems approach trace back to a myriad of theoretical founding concepts including complex systems (Spencer, 1857), Marshallian dynamics (Marshall, 1920), Schumpeterian entrepreneurship (Schumpeter, 1934), and evolutionary economics (Nelson & Winter, 1982).

These foundational theories rejected static equilibriums and mechanistic models of physical systems with homogenous agents and argued that processes of economic change are complex and evolutionary. Each of these theories has stemmed its own branches of economic theories but they have recently come to re-converge in the entrepreneurial ecosystem's literature. In the following section, I draw upon the congruencies between these theories to establish an essential basis which can inform a significant update to entrepreneurial ecosystems practice.

2.1. Entrepreneurial Ecosystems as Complex Evolutionary Systems

Herbert Spencer (1857) argued that systems of all types—natural and social—tended to grow from simplicity to complexity through stages of differentiation, a process he characterized as "an advance from homogeneity of structure to heterogeneity of structure" (p. 234).

He argued that progress in all aspects of natural and social life were dictated by processes that evolved from the simple to the complex.

> [The] law of progress is the law of all progress. Whether it be in the development of the Earth, in the development of Life upon its surface, in the development of Society, of Government, of Manufactures, of Commerce, of Language, Literature, Science, Art, this same evolution of the simple into the complex, through a process of continuous differentiation, holds throughout. (p. 234)

Spencer's theories on the laws of progress have been foundational across multiple fields and his contributions towards viewing natural and social phenomenon in terms of complex systems can hardly be understated. Afterall, it is Spencer, and not Darwin who is considered to have popularized the term 'evolution' in the 19th century (Hodgson, 2009). Yet, what is meant by 'evolution' is not consistent across scientific paradigms, and different evolutionary interpretations have been a source of significant debate and concern. For instance, just as Spencer's contributions to complexity are seminal, his contributions to Social Darwinism and scientific racism can hardly be understated (Freeman D. , 1974; Jackson & Weidman, 2005). Both Darwin and Spencer stressed the idea of natural selection in evolutionary processes, both biological and social, and in so doing propagated the notion of 'survival of the fittest' as a central evolutionary thesis to explain qualitative change over time, and the perceived superiority of some races over others. This loose and unvalidated adoption of evolutionary processes theorized in biology and analogized into the social sciences, especially anthropology, had disastrous outcomes for society and the biological analogy in economics was disavowed for most of the 20th century (Hodgson, 1998). However, Spencer also stressed the inheritability of traits as a general evolutionary phenomenon driving the move from simplicity to complexity. In this latter evolutionary conception, he was more Lamarckian than Darwinian (Hodgson, 1998), and this evolutionary concept is more closely adopted into the recent economic sciences by other economic evolutionists such as Marx, Veblen, Schumpeter, Nelson and Winter (Hodgson, 1998).

This goes to say, ‘evolution’ and ‘evolutionary processes’ are not finally determined in every context and the study of evolution remains, broadly defined, the study of qualitative change, with different theories emergent in varied fields of study tied more closely to the phenomenon of change under consideration (Hodgson, 2009). Thus, the adoption of any biological analogy on evolution must be reframed in terms of the mechanisms of interaction driving change in that system. Schumpeter was critical of this fact, and although he and the translators of his early work, used the terms “development” and “evolution” interchangeably, Schumpeter explicitly rejected the biological analogy and Darwinian evolution as a reasonable explanation for economic development which he instead explicated as a process of technological change (Hodgson, 1997). Nonetheless evolutionary economics has coalesced around some prominent themes that are useful for developing a more theoretically rooted policy framework for entrepreneurial ecosystems. These themes include a rejection of equilibrium thinking prominent in the neo-classical approach; an emphasis on technical change, learning, and innovation as the driving forces of change; and the “recognition of the complexity of social phenomenon and the fact that outcomes are often the result of an unpredictable process” (Hodgson, 2009, p. 168).

Importantly, in entrepreneurial ecosystems, evolutionary change starts within the firm and is propagated systemically through the heterogeneity in firm performance, i.e. markets exert a selection pressure on firms that is reflected in the dynamics of industries. Standard theories of industrial organization suggest that firms with greater than average productivity will grow over time within a given industry, while low-productivity firms are likely to shrink or exit (Ericson & Pakes, 1995; Foster, Haltiwanger, & Syverson, 2008; Hpenhayn, 1992; Jovanovic, 1982). However, contrary to the predictions of Viner (1932), productivity differences among industries in different geographies, among firms within industries, and even among plants within firms, are large and tend to persist over time. Sources of these differences are varied but focus on a firm's capacity to produce economically relevant knowledge. To name a few, Bloom and van Reenen (2010) singled out the influence of management practices on cross-country variations in firm productivity. Earlier studies have emphasized the influence of learning by doing (Arrow, 1962), as well as the appropriability of relevant knowledge (Appleyard M. M., 2003; Asheim & Isaken, 2002). These studies foundationally argue that technical change is endogenous to firms and a result of internal mechanisms and processes.

The notable conceptual formulation of such 'production algorithms' (Auerswald P. E., 2008) is the firm-level "routine" (Nelson & Winter, 1982), or those firm-specific functions that relate inputs to outputs given the internal context and the external environment of the business operations. Nelson and Winter (1982) proposed that routine plays "the role that genes play in biological evolutionary theory." (p. 17). Auerswald, Kauffman, Lobo, and Shell (2000) refer to the economically relevant knowledge encoded within a firm as its "production recipe" which represents "the complete description of the underlying engineering process." Employing a culinary rather than biological analogy, the notion of recipes emphasizes that a firm's production plan extends well beyond the mapping of ingredients (inputs) to outputs, that is the focus of standard production theory, to incorporating the specific list-order for routinization of the production plan. More importantly, the production algorithm consists of the "how", i.e. the knowledge of the production process—the code that specifies the distinct operations required to convert inputs into outputs. Invoking the Coasean notion that firms exist to internalize externalities (Coase, 1937), it follows naturally that the production recipes that are most likely to survive under evolutionary pressure are complex and cannot be easily imitated.

Accordingly, the entrepreneurial ecosystems policy framework must consider that the evolutionary process begins within the production processes of firms and that firms are heterogenous and complex. The implication of this fact is that no two entrepreneurial ecosystems can be qualitatively the same and each is distinguished by the history of the firms that comprise and determine the entrepreneurial ecosystem. This means entrepreneurial ecosystems cannot be conceived as abstracted structures of interactions super-imposed upon a loosely defined group of organizations and institutions. Instead, entrepreneurial ecosystems should be considered emergent, greater than the sum of interactions and exchanges consequent of firm behaviors and practices that have emerged over time in response to the technical growth of the firms in the ecosystem.

This purely evolutionary perspective emphasizes the micro-foundations of technical change and is more acutely interested in causal mechanisms. But much discussion in the entrepreneurial ecosystems literature also focuses on the entrepreneurial environment and the macro influences that condition firm behavior and present firms with opportunities, or constraints, to growth. These environmental sources of opportunity in entrepreneurial ecosystems is the emphasis of the next section.

2.2. The Institutionalist View

Entrepreneurship is at the heart of economic change (Schumpeter, 1939), yet it takes an entire ecosystem to help entrepreneurs bring innovations to market. Novelty in an economic ecosystem is a result of coordinated activities both within firms as well as with agents external to the firm. Similarly, innovation is a dynamic non-linear process. Some innovations can have a radical impact on the market, while most others are incremental (Freeman & Soete, 2009), but innovation is far from a well-defined phenomenon and requires the coming together of many factors to produce the right opportunity for commercialization. For instance, many inventions never make it to market because complementary factors or vital inputs for production and commercialization may not be available yet (Fagerberg, 2005). Feldman and Zoller (2011) found evidence that the presence of dealmakers in regional economies played an influential role in fostering regional entrepreneurship. Dealmakers acted as brokers who functioned to shape the network, manage structural holes, and "connect disparate actors to social networks" (Feldman and Zoller, 2011: p. 27).

The evolutionary perspective in entrepreneurial ecosystems has been quick to reject any teleological argument, however the entrepreneurial ecosystems institutionalists have produced lists of many ecosystems factors identified as necessary for successful entrepreneurship from case studies (Cohen, 2006; Feld, 2012; Spigel B. , 2017; Isenberg D. J., 2010). Nicotra, Romano, Del Giudice, and Schillaci (2018) provide a framework for assessing the causal linkages between such factors within the context a given entrepreneurial ecosystem, however generalizable estimation of causal mechanisms in the institutionalist approach are still under-developed. More recently, Roundy and Fayard (forthcoming) develop a framework for assessing the cost-reduction mechanisms of entrepreneurial ecosystems.

Despite the emergent literature studying the causal mechanisms, the importance of the external environment for entrepreneurial success is not debated and instead is at the core of the literature on industrial districts, innovation systems, industry clusters, and management and strategy studies, with each approach emphasizing a different dimension of the entrepreneurial environment. Classically, industrial districts have focused on the division of labor (Marshall, 1920); the clusters approach typified by Michael Porter (1996; 2003) focused on the interconnections of companies due to production processes and supply chains (Delgado & Mills, 2019); the innovations systems literature has emphasized the role of knowledge networks in generating economic novelty (Cooke, Gomez Uranga, & Etxebarria, 1997); and, the management and strategy literature around entrepreneurial ecosystems cast institutions as necessary for qualitative value-creation (Pitelis & Runde, 2017; Bailey, Pitelis, & Tomlinson, 2018).

Notably, the innovation systems, industrial, and cluster policy approaches start with a geography and then identify factors that impact entrepreneurial outcomes, while the management and strategy literature promotes identifying features of entrepreneurial ecosystems that can be extricated from the environment and replicated or applied in a new context. As Van de Ven, Polley, & Venkataraman (1999) frame the necessary institutional conditions for qualitative entrepreneurial value-addition:

Entrepreneurship is a collective achievement that resides not only within the parent organization of the innovation but also in the construction of an industrial infrastructure that facilitates and constrains innovation. This infrastructure includes (1) institutional arrangements to legitimize, regulate, and standardize a new technology; (2) public-resource endowments of basic scientific knowledge, financing mechanisms, and a pool of competent labor; (3) development of markets, consumer education, and demand; and (4) proprietary research and development, manufacturing, production, and distribution functions by private entrepreneurial firms to commercialize the innovation for profit. (p. 149)

Such coordinated activities across various organizations within institutional frameworks allude to multi-level, networked, and interdependent relationships that define and enable the innovative process. Entrepreneurial action is essential to evolution in economic ecosystems as it provides a selection mechanism that effects structural change. Importantly, the evolutionary and the institutionalist view are not in disagreement that entrepreneurial ecosystems contribute toward enabling high-growth entrepreneurship, rather the explicit mechanisms are under-evaluated. Under these conditions a policy framework can be synthesized using the congruencies between the two approaches without undermining either of their core theoretical tenants. Such a synthesis requires that any entrepreneurial ecosystems be first defined by its geography. This is because the local economic resources are a necessary source for evolution and the institutional frameworks have developed in a historical context to facilitate these interactions.

3. Place-based Ecosystems

In economic geography the periphery is often contrasted with the core. Agglomeration arises from the locational choices of manufacturing firms in the presence of transport costs, thereby determining how the core and periphery grow over time (Krugman, 1991). More generally, economies are defined within specific geographies by internal linkages and external boundaries. Just as biological habitats comprise ecosystems which in turn make up biomes, entrepreneurial ecosystems are also nested within larger hierarchies of regional, national, and global systems. While ecologists are able to rely on the physical and topographical characteristics of space to define the boundaries of ecosystems (Bailey R. G., 2009), similar methods have remain underdeveloped in identifying the boundaries entrepreneurial ecosystems. Importantly, the ability to identify internal linkages and define boundaries is a necessary condition for entrepreneurial ecosystems to synthesize the theoretical precepts of evolutionary process with the teleological arguments for policy to become actionable. Furthermore, to specify interactions that contribute to defining ecosystem boundaries, they must be complemented with methods to map knowledge networks, strategic alliances, and other outcomes of processes that develop social, cultural and economic ties.6

One approach, suggested by Gunderson and Holling (2001) recommends mapping entrepreneurial ecosystems in a manner similar to the biological approach of the "controlling factors method" (Bailey R. G., 2009). They suggest that "the complexity of

[6] An interesting recent development along these lines is the application of satellite imaging and big data to study how economic systems grow or shrink over relatively short timeframes **Invalid source specified.**. Such methods underscore practical approaches to delineating the physical boundaries of social systems.

living systems of people and nature emerges not from a random association of a large number of interacting factors rather from a smaller number of controlling processes. These systems are self-organized and a small set of critical processes create and maintain this self-organization." (Holling, 2001, p. 391)

The Gunderson and Holling approach has developed alongside theoretically similar applications of evolutionary theories in the multi-level perspective, particularly to the study of technological transitions (Geels, 2002; Genus & Coles, 2008). In an outcome-based approach to specifying the internal interactions that correlate with the overall performance of economic ecosystems, Stangler and Bell-Masterson (2015) recommend evaluating the overall performance of economic ecosystems based on a set of four regional entrepreneurship specific indicator variables: density; fluidity; connectivity; and diversity.

Ecosystem boundaries are characterized by an exchange of energy and information between neighboring ecosystems and are termed "transition zones" (Banks-Leite & Ewers, 2009). In natural ecosystems, these transition zones may be abrupt, such as the boundary between a marine and terrestrial ecosystem, or a field and an adjoining forest. Alternately the transition zones may be more gradual, incorporating a series of overlapping structures, such as in estuaries and marshes. While the width of the transition zone depends largely on the geography of the region, these zones provide spaces through which one ecosystem influences another, what is termed an "edge effect" (Murcia, 1995). These edge effects are primarily driven by abiotic conditions and pose a strong influence on the environmental conditions of the transition zones, creating unique habitats to which species are specifically adapted. Accordingly, the greater the contrast between the habitats sharing an edge, the stronger will be the edge effect.

Boundaries of entrepreneurial ecosystems should similarly be geographically based and resemble transition zones that are socio-political in nature, as they represent the edges of policy action. For instance, a common boundary definition in regional policy making is the delineation of metropolitan statistical areas (MSAs) that are updated every few years to reflect population changes along border counties and largely follow commuting patterns and labor market areas (Office of Management and Budget, 2013). These changes can include the reassigning of counties from one MSA to an adjacent one based on commuting zones, or the addition or exclusion of a county from an MSA based on population change. Although MSA definitions are political boundaries, they reflect the socio-economic relationships between interior and boundary regions of a common physical system.

4. Economic Interdependencies

Jane Jacobs (1961; 1969) made early and seminal advancements on the hypothesis that increasing economic diversity is key to the vitality of cities. She described the engines of growth for regions to be enabled by increasing connectivity to cities as well as increasing economic diversity within the region itself. Glaeser, et al. (1992) studied a cross-section of U.S. cities and found that, “at the city-industry level, specialization hurts, competition helps, and city diversity helps employment growth.” Work by Feldman and Audretsch (1999) similarly emphasized the importance of economic diversity in innovative activity. Saxenian (1994) documented the relative success of Silicon Valley in developing its technology sector in the 1980s as compared to Boston Route 128. She argued that inter-firm and inter-industry networks in Silicon Valley played a significant role in providing it with regional technological advantage as a result of knowledge externalities leading to greater innovative outputs.

Hidalgo, et al. (2007) studied the co-occurrence of products in the export portfolios of countries to identify a relatedness measure across products, based on the expectation that countries are more likely to produce goods together that require "similar institutions, infrastructure, physical factors, technology, or some combination thereof" (Hidalgo, Klinger, Barabasi, & Hausman, 2007, p. 484). The revealed network of products, called the "product space," showed that more sophisticated products were located in denser regions of the network, while less sophisticated products were on the periphery. Furthermore, they also found that advanced countries tended to have more diverse and densely networked product spaces as compared to the less developed countries. They explain the developmental constrains on countries in terms of the connectedness of their product space and the co-evolutionary patterns of their firms. Hidalgo, et al. (2007) apply a biological analogy similar in intent as the adaptive walks of firms along "holey adaptive landscapes" (Gavrilets & Gravner, 1997):

Think of a product as a tree and the set of all products as a forest. A country is composed of a collection of firms, i.e., of monkeys that live on different trees and exploit those products. The process of growth implies he process of growth implies moving from a poorer part of the forest, where trees have little fruit, to better parts of the forest. This implies that monkeys would have to jump distances, that is, redeploy (human, physical, and institutional) capital toward goods that are different from those currently under production. Traditional growth theory assumes there is always a tree within reach; hence, the structure of this forest is unimportant. However, if this forest is heterogeneous, with some dense areas and other more-deserted ones, and if monkeys can jump only limited distances, then monkeys may be unable to move through the forest. If this is the case, the structure of this space and a country's orientation within it become of great importance to the development of countries. (Hidalgo, Klinger, Barabasi, & Hausman, 2007, p. 482)

Regions develop comparative advantage by having diverse but related economic structures. Neffke and Henning (2013) studied the flows of labor across industries to identify an "industry space". They define a skill-relatedness measure based on the expectation that workers are more likely to move across jobs that have similar skill requirements. Consequently, industries that have similar skill requirements should show greater cross-industry flows after controlling for other industry dynamics. Applying the industry space to study regional diversification, they find that firms are 100 times more likely to diversify into industries that have are more skill-related.

Many economic new combinations fail to survive in the market because complementary factors or vital inputs for production and commercialization may not yet be available. Fagerberg (2005) gives the example of Leonardo da Vinci who had presented designs of advanced technologies, including airplanes, but he lacked the adequate materials or production processes to realize them during his time. A contemporary example is the recent explosion in the fields of computational sciences.

Although much of the mathematics behind pattern recognition algorithms was well established more than a century ago, it took the computational power of modern computers to allow researchers to fully apply the programming methods that today are branching out new technological fields in augmented reality, artificial intelligence (AI), and cybernetics. In this sense, it is hard to conceive of the structure of innovation without also considering how the structure evolves over time. When looking at a static representation of the innovation system I would be hard pressed to identify the relevant components that have led up to the current opportunity for commercialization.

Spencer (1857) long ago described how different components of an economy, when connected, become mutually dependent and begin to differentiate themselves by assuming different functions: "When roads and other means of transit become numerous and good, the different districts begin to assume different functions, and to become mutually dependent." Economic complexity in this sense is a result of increased interdependence within systems where more complex interactions imply more complex social arrangements. These complex interdependencies in ecosystems are multi-dimensional and can be measured in a number of ways. Most often they are studied in terms of the number of parts to a technological artifact (Strumsky, Lobo, and van der Leeuw, 2012), but they may also be reflected in terms of organizational complexity of production processes within firms (Auerswald, Kauffman, Lobo, and Shell, 2000), the diversity of teams required to develop new technological innovations (Kash and Rycroft, 1999; Adams, Black, Clemmons, and Stephan, 2005), as well as the in the intricacies of buyer-supplier networks and peer-production networks (Appleyard, 2003; Auerswald and Branscomb, 2008).

These complex interdependencies in ecosystems are multi-dimensional and can be measured in a number of ways. Most often they are studied in terms of the number of parts to a technological artifact (Strumsky, Lobo, & van der Leeuw, 2012), but they may also be reflected in terms of organizational complexity of production processes within firms (Auerswald, Kauffman, Lobo, & Shell, 2000), the diversity of teams required to develop new technological innovations (Kash & Rycoft, 2000; Adams, Black, Clemmons, & Stephan, 2005), as well as the in the intricacies of buyer-supplier networks and peer-production networks (Appleyard M. M., 2003; Auerswald & Branscomb, 2008). Similarly, workforce and skills-related policies are likely interested in skills agglomeration that can be mapped according to an 'occupation space' (Muneepeerakul, Lobo, Shutters, Gomez-Lievano, & Qubbaj, 2013); economic development and industry cluster policies can be mapped according to an ecosystem's 'industry space' or 'product space' (Hidalgo, Klinger, Barabasi, & Hausman, 2007); regional stratification and diversification questions rooted in both industrial and occupational change may model an 'industry-occupation space' (Hartmann, Jara-Figueroa, Kaltenberg, & Gala, 2019; Dani, 2017); and, innovation strategists may map knowledge or 'technology spaces' based on patents (Youn, Betterncourt, Strumsky, & Lobo, 2015; Strumsky & Lobo, Using data on patents to build and study technology spaces, 2013).

Given the importance of economic interdependencies in understanding the economic structure of regions and their role in productive economic output, regional scientists for long have questioned if industrial specialization or industrial diversification is ideal for maximizing economic stability and regional productivity (Conroy, 1975; Jackson R. W., 1984; Malizia & Ke, 1993; Simon C. J., 1988). However, the results have been mixed with some studies finding economic diversity significantly contributing to regional stability (Conroy, 1975; Kort, 1981; Trendle, 2006) and lower unemployment (Simon C. J., 1988; Malizia & Ke, 1993), and others not finding significant results (Attaran, 1986; Jackson R. W., 1984).

Wagner and Deller (1998) suggest three principle reasons for the inconsistency of results; (1) economic activity being measured at a highly aggregated level; (2) inappropriate measures of economic structure; and, (3) overly simplistic modeling methods (Wagner & Deller, 1998; Wagner, 2000). In the next chapter I detail a method for mapping a regional industry structure and its related interdependencies that addresses each of these three concerns. However, in this next section, I initiate the discussion with the basic theoretical approach and similar methods applied in related scholarship.

5. <u>An Entrepreneurial Ecosystems Policy Framework</u>

In the context of the discussion so far on understanding the role and scope for policy making in the entrepreneurial ecosystems approach, I summarize an ideal entrepreneurial ecosystems policy process as follows:

• Step 1: Specify the geographic boundaries of the entrepreneurial ecosystems in question.

In the evolutionary perspective, entrepreneurial ecosystems are embedded in geography and the local economic history strongly pre-conditions future growth opportunities. Furthermore, the institutional view underscores the roles of policy managers and their mandates to their stakeholders in defining the strategic role of the policy. As such, I propose that the first step in the policy framework is to identify the who and where of the entrepreneurial ecosystems – i.e. who are the policy managers involved in the entrepreneurial ecosystems project and what is the scope of their jurisdiction.

• Step 2: Estimate and map the 'related space' of interdependent economic activities.

In the evolutionary perspective, there are any different sources of agglomeration that drive economic alignment. Labor and skill agglomerations are more relevant to workforce or labor related policies. Or, technical similarities in production processes may be of more importance in evaluations of regional stability to shocks. Importantly, entrepreneurial ecosystems policy makers should select the type of agglomeration most relevant to their domain of action and estimate the regional economic interdependencies accordingly. In entrepreneurial ecosystems the economic relatedness of supply chains and value chains are arguably the most relevant. Chapter 3 of this dissertation details the process for such a mapping and provides examples of the policy intelligence that may be derived from this estimation.

Step 3: Identify dominant nodes in the network that occupy the most interdependent place in the ecosystem.

The graph location of dominant nodes in the ‘related space’ reveal the historical relevance of each node. These nodes can be ecosystem actors, agents, organizations, or assets such as skills or technologies. Critically, identifying these nodes enables policy makers to bridge the gap between the evolutionary and institutionalist approaches. For instance, knowing that a biotechnology sector is the most economically networked sector in a region can help policy makers then identify the specific constraints and opportunities for entrepreneurial growth around that sector and its related activities.

• Step 4: Collect metrics for ecosystem indicators and engage with dominant actors, agents, or organizations to perform a needs assessment.

The estimated related industrial structure of entrepreneurial ecosystems changes very little over time. However, traditional entrepreneurship outcomes indicators such an entrepreneurship rate, proportion of new and young firms, venture capital investments, etc. (Bell-Masterson & Stangler, 2015) are more sensitive to policy and strategy changes. Importantly, they provide a means to take the pulse of an entrepreneurial ecosystem. Usually, it is difficult to interpret the relationship between any of these measures taken at the regional level and entrepreneurial ecosystem output, since it is mediated by the industry mix of a region, making cross-regional or cross- entrepreneurial ecosystem comparisons difficult. However, in this framework these entrepreneurial ecosystem outcome metrics can be selected based on the specific industry mix of a region, and as shown in Chapter 3, the mapping of a related industry space allows for comparisons entrepreneurial output at the industry level across different regions.

• Step 5: Design policy recommendations with buy-in from stakeholders

Any entrepreneurial ecosystem policy initiative must take into consideration available resources, time, and convergence on the motivations of the various ecosystem managers. Resource and time constraints dominate the feasibility and scope of any policy plan and action. This is no less true for entrepreneurial ecosystem policies. A central argument, be it from the evolutionary or the institutionalist view, has been that of economic history and the availability of resources, especially human and strategic capital. Without the right motivations and leadership, entrepreneurial ecosystem policy managers will face many barriers to co-ordination. Given the complexity of entrepreneurial ecosystems, no extensive entrepreneurial ecosystem policy approach can be formulated and fulfilled without the buy-in and coordination of many different organizations and actors.

Although the above policy framework has been modeled as a linear 5-step process, its practice is not linear but iterative and circular. Nonetheless, the five steps represent core aspects derived from both an evolutionary and institutionalist entrepreneurial ecosystem perspective and go hand-in-hand to merge a region's economic reality, with a policymaker's regional vision.

6. Embedding Entrepreneurial Ecosystems in the Regional Industrial Structure

"The main difference between ecology and ecosystem lies in focus. While the former focuses on interactions between living organisms and between living organisms and their environment, the latter focuses on systemic interconnections generated through these interactions. Therefore, ecology might be seen as the basis of ecosystem. This implies that a particular theory of ecosystem presupposes a particular concept of ecology." (Papaionnou, Wield, & Chataway, 2009) p. 321.

This argument aligns strongly with the industrial clusters and economic geography scholarship but goes a step further in connecting the complexity of biological systems with that of the social organization. Accordingly I also argue that an entrepreneurial ecosystem analysis should begin with identifying the geography of concern and then mapping the broadest set of economic interconnections that elucidate the agglomerations that contribute to regional entrepreneurship and reflect the economic structure resulting from the region's unique history.

Similar attempts to map the evolutionary structure of an economy have successfully informed policy making in different contexts, defined by the type and level of agglomeration under consideration. For instance, workforce and skills-related policies interested in skills agglomeration were mapped according to an 'occupation space' (Muneepeerakul, Lobo, Shutters, Gomez-Lievano, & Qubbaj, 2013); economic development and industry cluster policies mapped according to an ecosystem's 'industry space' or 'product space' (Hidalgo, Klinger, Barabasi, & Hausman, 2007); regional stratification and diversification questions rooted in both industrial and occupational change mapped in an 'industry-occupation space' (Hartmann, Jara-Figueroa, Kaltenberg, & Gala, 2019; Dani, 2017); and, innovation strategists have mapped knowledge or 'technology spaces' based on patents (Youn, Betterncourt, Strumsky, & Lobo, 2015; Strumsky & Lobo, 2013).

In the next chapter I develop a specific mapping of the U.S. industry space that uses entrepreneurial output as the basis to identify a unique industry structure of the nation and its industry sub-space for any given region. This provides an informative background for the evolutionary resources available for regional entrepreneurship.

7. Conclusion

At the time when Alfred Marshall stated that "the Mecca of the economist lies in economic biology rather than in economic dynamics," the concept of the ecosystem had not yet been developed; the "modern synthesis" in evolutionary biology had not occurred; and mathematical models of evolutionary processes did not exist. Nearly a century has passed since then. Economists today have access to powerful analytical tools that have the potential to be directed toward the study of entrepreneurial ecosystems.

In this chapter I have argued that the entrepreneurial ecosystems approach has developed, through a re-convergence of the evolutionary and institutional economics perspectives. This convergence although introducing some theoretical dissonance on the appropriate level of analysis and role of policy, in fact provides unique insight on why the entrepreneurial ecosystem approach is a significant update of prior entrepreneurship policy.

I have argued that, combining both the evolutionary and institutionalist entrepreneurial ecosystems perspective allows us to study entrepreneurship in regional economies within their economic context by focusing on the region's own unique evolved economic history and industry structure, while also identifying space for designing strategic policy making geared toward producing goal-oriented outcomes.

CHAPTER 3. RELATEDNESS IN ECONOMIC ECOSYSTEMS[7]

In this chapter, I provide an empirical methodology for identifying the interdependencies in regional industry clusters. Expanding upon the interdependence measure, I also develop a "Related Density" metric for ranking regional economic ecosystems based on the revealed alignment of their regional industry mix. I use this measure to map the U.S. national and sub-national industry spaces as a necessary update for economic developers to go beyond a narrow focus on regional industry specializations to also include the regional agglomerations supporting these specializations. By explicitly incorporating economic exchanges and agglomerations into an empirical assessment of an economic ecosystems I am able to provide methods that elucidate the unique character of economic ecosystems and methods for comparing different economic ecosystems to one another.

1. <u>Introduction</u>

Economic activity concentrates in geography due to the advantages of economies of scale and the increasing returns from economic agglomerations. Bettencourt, Lobo,

[7] In keeping with the theoretical distinctions drawn in the previous chapter, I differentiate between an entrepreneurial ecosystem and an economic ecosystem in that, the economic ecosystem has an evolutionary basis and reflects the industry structure that has evolved as a consequence of the region's economic history and assets. The entrepreneurial ecosystem is embedded in the economic ecosystem and is further comprised of institutional features and processes that enable and facilitate regional entrepreneurial outcomes.

Strumsky and West (2010) studying the relationship between city population size and urban metrcs of innovation, wealth, and crime found that a city's infrastructure and performance is associated nonlinearly with its population size:

For material infrastructural quantities the exponent is sublinear…expressing economies of scale, whereas for socioeconomic quantities it is superlinear…expressing increasing returns to scale. (p. 2)

These relationships between city population and urban performance metrics go well beyond statistical association and even suggest universality in how human settlements have developed (Lobo, Bettencourt, Smith, & Ortman, 2019). For instance, figure 1 below shows the relationship Bettencourt, Lobo, Strumsky and West (2010) identified between a city's wealth and its population size.

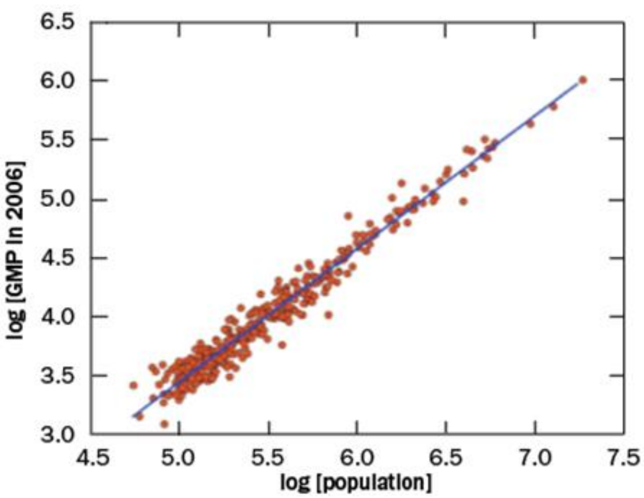


Figure 1 Urban scaling from Bettencourt, Lobo, Strumsky, and West (2010).

Importantly, the mechanism driving this relationship is the ability of people to solve problems and increase aggregate value through frequent and heterogenous social and economic interactions, and thus it is individual city characteristics that explain deviations from the mean for an aggregate urban metric of city performance. To put it in Schumpeterian terms, a city's capacity for recombining assets to produce higher-value output is intrinsically tied to its economic performance.[8] In this manner, the growth and resilience of a region is tied intrinsically to the dynamism of its entrepreneurial ecosystem, which in turn is embedded within its broader economic ecosystem.

However, the nonlinearities associated with city size underscore the difficulties in producing informative comparisons of regional economies to one another. As the current standard, comparisons between regions are derived from per-capita accounting that presupposes a linear relationship between size and outcomes. A more informative ranking of regional economic indicators must account for such nonlinearities, and Bettencourt, Lobo, Strumsky, and West (2010) accordingly propose the use of Scale-Adjusted Metropolitan Indicators (SAMIs) which provide a more realistic comparison of cities to one another. Building on this intuition, I argue in favor of using a measure of industry agglomeration to identify city characteristics that are tied to its economic performance.

Identifying such system-level characteristics is a difficult task because entrepreneurship both results from, and responds to, gaps and opportunities in the structure of economic ecosystems. Nonetheless, policy makers have developed a variety of techniques—ranging from cluster analysis to qualitative case studies of regional

[8] E.g. Markusen (1996) and Feldman and Audretsch (1999), among early contributions.

economic activity—to target the appropriate economic communities for policy action and to design programs to enable entrepreneurial ecosystems and, by so doing, drive the development of regional economic ecosystems.

In this chapter, I derive a measure of industry interdependence based on co-specializations of 6-digit NAICS industries in 388 U.S. MSAs. I estimate the density of these industry interdependencies for each MSA, termed an MSAs 'related density' (RD) and show that it strongly correlates with regional performance metrics of entrepreneurship, regional wealth, innovation in number of patents, and its job creation rate.

After controlling for MSA size, I find a one percent increase in a region's RD is associated with a 0.16 percent increase in its wealth and a 0.15 percent increase in its entrepreneurship rate and, increasing a region's alignment in economic ecosystem resources requires a significant ecosystem-wide coordination of regional policies across multiple stakeholders over time.

In addition, I propose an approach for assessing the vitality of entrepreneurial ecosystems along two dimensions:

(1) the mix of economic capabilities that comprise the substrate from which entrepreneurs and other actors create Schumpeterian "new combinations"; and,

(2) indicators that assess how well institutional features within the ecosystem are aligned to facilitate entrepreneurial opportunity and success.

The following section begins with a discussion on how industrial activity is distributed across metropolitan areas using a simple categorization of how rarely or commonly industries concentrate in metropolitan areas. This provides the basis for exploring why certain industries may cluster in proximity to one another and helps develop the intuition for understanding the interdependence between industries.

I next introduce a method of estimating the pair-wise interdependence of industries using their co-specialization probabilities in U.S. metropolitan areas and provide initial support for the revealed economic interdependencies. Next, I map the U.S. Industry Space, discuss the implications for the location of industries in the network space, and assess some graphical properties of the network. This discussion of U.S. industry space provides the baseline reference for estimating a metropolitan-level related density measure that provides an indicator of an economic ecosystem's potential for recombinant growth. I conclude this chapter by ranking Metropolitan Economic Ecosystems according to their related densities.

2. Diversity of Industries in U.S. Metropolitan Areas

I use location quotients (LQs) to identify industry specializations at the level of Metropolitan Statistical Areas (MSAs).[9] Using 6-Digit NAICS codes in the Quarterly Census of Employment and Wages (QCEW) data for year 2018, I find that the average MSA in the U.S. is specialized in about 332 of the total 1045 NAICS industries. The Grand Rapids–Wyoming, MI MSA has the most specializations with 524 industries with

[9] LQs are commonly used in regional economics to show the concentration of industrial activity in a region relative to that of the nation. I use establishment LQs which reflect a higher proportion of establishments in a regional industry, relative to the national proportion for that industry. As such, an $LQ < 1$ indicates a lower concentration of that industrial activity relative to the national, while an $LQ > 1$ indicates a concentration greater than the nation and is suggestive of some regional advantage for that industry.

LQ>1, while the Sacramento-Roseville-Arden-Arcade, CA MSA has the fewest specializations with 104 industries with LQ>1. Of the 388 MSAs considered here, half have over 332 industries specialized in their region. Figure 5 shows a histogram of number of industry specializations in U.S. MSAs.

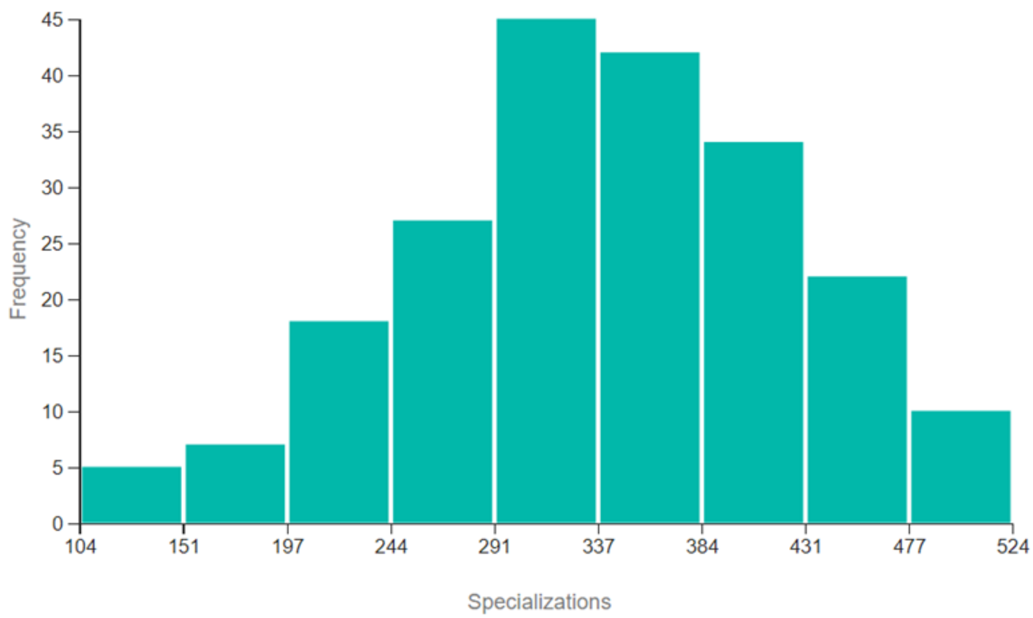


Figure 2 Histogram of Industry Specializations in U.S. MSAs, 2018.

We may expect that economic ecosystems with a larger number of industry specializations would report better economic outcomes than ecosystems with fewer industry specializations. However, I do not find evidence to support such a claim. A correlation between the number of industry specializations that an MSA possesses and its establishment entry or exit rates yields a very small magnitude but no statistical significance to the relationship. When I control for size and wealth of an MSA, the relationship turns negative and statistically significant.[10] I interpret these results as suggestive that the number of economic specializations a region has is less entrepreneurially relevant than which industries the MSA is specialized in and how these capabilities are related to one another, i.e. their agglomerative potential. I return to this question in section 6 of this paper, where I introduce a measure of relatedness of an ecosystem's economic capabilities and show that inclusion of our relatedness measure improves the explanatory power of the model but also makes the specialization variable statistically insignificant in our regressions.

In the next section I propose that I are better able to understand a region's entrepreneurial capacity by looking not at the overall number of industry concentrations it possesses, but rather by focusing on the density of such concentrations that are infrequently occurring on a national scale—which is to say, those industry concentrations that are relatively rare.

3. Rare, Common, and Ubiquitous Industries

In the U.S. some industries are ubiquitously present in most all metropolitan areas, while others concentrate only in a handful of MSAs. Examples of such ubiquitous industries include, hobby toy and game stores, department stores, new car dealers, building equipment contractors, and gasoline stations, among others. Their ubiquity can

[10] I used data for year 2015 to estimate our regressions as it is the most recent year available for data from the Bureau of Economic Analysis (BEA). Regression coefficients show a 1% increase in an MSA's number of specializations was associated with a 0.13% decrease in its new business formation rate, holding all else constant.

be explained by there being a local demand for their products and services in all metropolitan areas.

On the other hand, rare industries such as, mining activities, power generation, motion picture industries, seafood packaging, sheep and goat farming, and apparel and piece goods merchant wholesalers specialize only in a few MSAs because they benefit from some locational advantages like access to natural resources, labor pools of skilled workers, or even proximity to other industries and markets. This idea of the ubiquity or rarity of industries across the country provides U.S. with some insight on how productive activity in the U.S. is dispersed across MSAs.

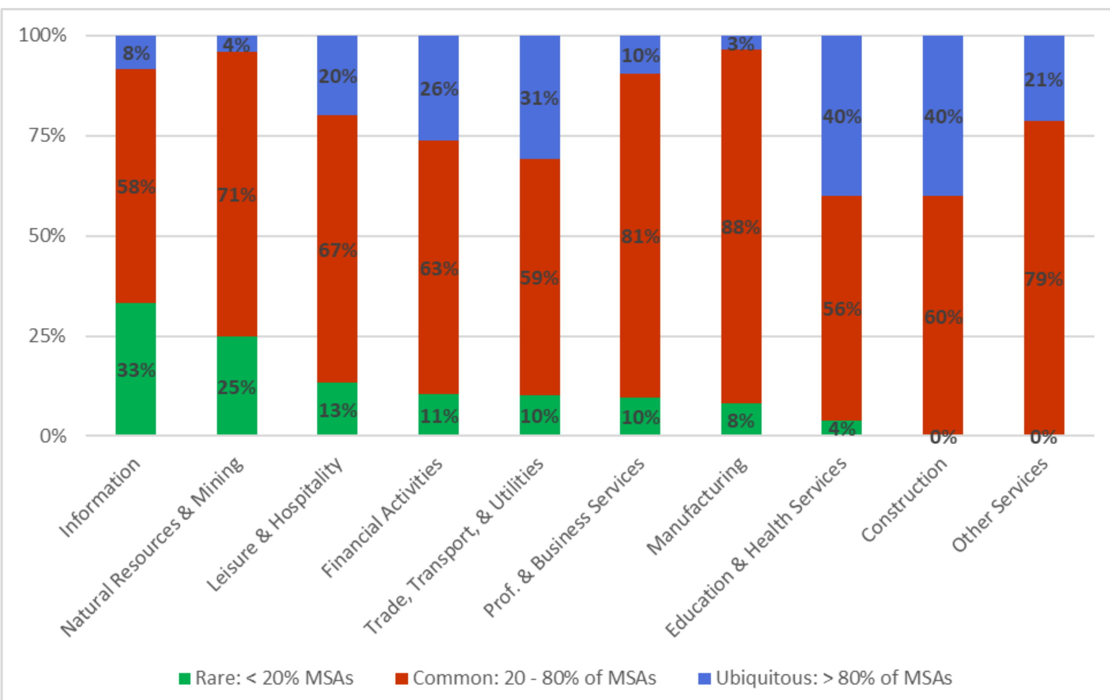


Figure 3 Ubiquitous, Common, and Rare Industry Specializations.

For instance, as represented in Figure 3, categorizing 6-Digit NAICS industries by how rarely (less than a third of MSAs); commonly (between a third and two-thirds of MSAs); or ubiquitously (more than two-thirds of MSAs) they specialize in U.S. MSAs, and grouping them by their Super Sector[11] of activity, reveals some interesting information about how industries distribute across the US:

- Rarest industries are concentrated in mining and resource extraction activities, followed by agriculture and forestry. Rare industries are the least likely to be found in education, healthcare, and construction related activities.
- Common industry specializations are inversely related to rare specializations such that education, healthcare, and construction are amongst the most commonly specialized industries, while natural resource extraction and farming super sectors have the smallest proportions of commonly specialized industries.
- Ubiquitous industries, although the most widely specialized across MSAs, are concentrated primarily in the trade and transportation industries, and in the arts, entertainment, and accommodation and food service sectors.
- Majority of manufacturing NAICS codes (288 out of 360) classify as rare industry specializations. This is likely because manufacturing activity tends to cluster tightly in different regions of the US. Examples of rare manufacturing include "Beet sugar manufacturing"; "Motor home manufacturing"; and, "Newsprint Mills", while the most common Manufacturing activities include, "Sign

[11] NAICS super sectors have different number of 4-Digit NAICS industry codes under each hierarchy. For example, the Manufacturing sector has 86 different 4-Digit NAICS codes while the Information sector and Construction each have 12 and 10 4-Digit NAICS sub-codes respectively.

manufacturing"; "Commercial screen printing"; and, "Wood kitchen cabinet and countertop manufacturing".

- Most professional services and management of companies are rarely specialized. Rarest among these are "Custom computer programming services"; "Public relations agencies"; and, "R&D in biotechnology", while the most common professional services include, "Tax preparation services"; "Other surveying and mapping services"; and, "Offices of certified public accountants". In addition, "Veterinary services" is the only ubiquitously specialized industry in this super sector.

The implication of these observations is that industries may concentrate in some metropolitan areas over others for different reasons, and the rarest occurring industry specializations are not only those that depend on natural resources, but also those that rely heavily on the local presence of other related economic activities, such as in manufacturing.

Furthermore, skilled capabilities such as those in high-tech industries are commonly or ubiquitously found in MSAs, so their presence alone is not likely elucidating the uniqueness of a metropolitan ecosystem's economic capabilities. This is important because policies broadly targeting high-tech industries for entrepreneurship development may not be capturing the true sources of competitive advantage in those metropolitan areas.

In the following section, I use this feature of how industries specialize across the U.S. to develop a measure of economic interdependence. Particularly, I assume that industries that are more likely to co-specialize within the same MSA are more likely to share some economic interdependencies with one another. As evidenced by the discussion above, the expectation follows that pairs of rare industries that co-specialize have the greatest interdependence, while those that never co-specialize will be unrelated, or not interdependent.

4. Pairwise Industry Interdependence

To characterize the structure of an entrepreneurial ecosystem defined at the scale of an MSA I introduce a measure of industry interdependence.[12] I calculate this measure as the pairwise probability that two industries will be concentrated together in the same metropolitan area. I can think of this measure as capturing the overlap between the locally embedded capacities employed in the two industries respectively. This overlap may exist because the two industries share access to the same natural resources; tap into the same labor pools or require access to similar skilled workers; or share common markets. As the measure is derived from a probability, I set a high cut off to identify when this co-specialization of industries is likely to occur: I define two industries as sharing a high degree of interdependence if, given that one industry is concentrated in the MSA, the second industry is at least 75 percent likely to be also concentrated in the same metropolitan area.

[12] Industry interdependence here is similar in its conception as occupational interdependence in Munnerpeerakul, et. al. (2013), and is a notion developed from the seminal work on the "product space" of nations formalized by Hidalgo, et. al (2007).

More formally, I estimate interdependencies (ζ) between industry specializations for every pairwise combination for 1045 6-digit NAICS industries at the national level using the ratio of their conditional probability to their independent probabilities.[13] If the specialization of some industry *i* is partly determined by the specialization of some other industry *j*, their conditional probabilities would be different from the product of their independent probabilities. Accordingly, I estimate interdependence (ζ) as:

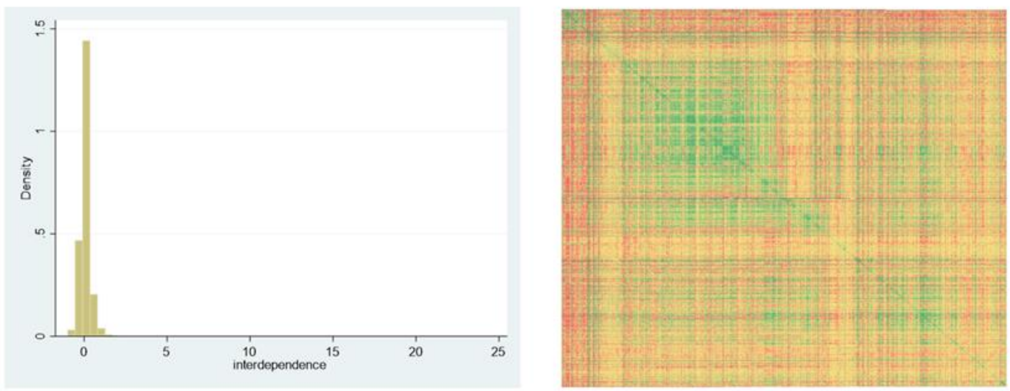
Equation 1 Pair-wise industry interdependence

$$\zeta_{i,j} = \frac{P[LQ_i^M > 1,\ LQ_j^M > 1]}{P\left[LQ_i^{M'} > 1\right]P[\ LQ_j^{M''} > 1]} - 1$$

Where M, M', and M'' are random metropolitan areas and LQ is the establishment location quotient for industries *i* and *j*. Subtracting by 1 allows for better interpretability where, ζ = 0 suggests industries *i* and *j* are independent, and a positive interdependence suggests the two industries are more likely to co-specialize in metros than if they were independently distributed across metropolitan areas. Negative values of ζ (with the minimum being -1, by construction) conversely indicate pairs of industries that are very unlikely to co-specialize in the same metropolitan area. Intuitively, positive values are indicative of economic complementarities while negative values suggest a disincentive to co-specialization, or at the least, a lack of any complementarities. Figure 4

[13] In our estimation I applied a cut-off of location quotient greater than 1 at the MSA level when estimating the co-specialization probabilities.

provides some descriptive statistics for the interdependence measure calculated at the scale of the entire U.S. economy.



Mean ζ = 0.08; Min ζ= -1; Max ζ=24.87
10th percentile= -0.22; 50th percentile=0.04; 90th percentile = 1.16

1046 6-Digit NAICS industries along each axis.
Green colors = 90th percentile interdependencies
Yellow colors = 50th percentile of interdependencies
Red colors = 10th percentile of interdependencies

Figure 4 Interdependence (ζ) Estimated for U.S. Metropolitan Statistical Areas.
Note: Left panel shows a histogram of ζ. Right panel shows a heatmap of ζ using 1,046 6-digit NAICS industry codes along each axis.

An evaluation of this pairwise interdependence between industries in the U.S. reveals that 59 percent (615 6-digit NAICS industries out of 1045 industry codes) share a high degree of interdependence (ζ >= 0.75) with at least one other industry and of the total 546,535 industry pair interdependencies estimated, only 17,160 or 3.1 percent, were highly interdependent. Figure 5 below shows the degree distribution of interdependence between industries.

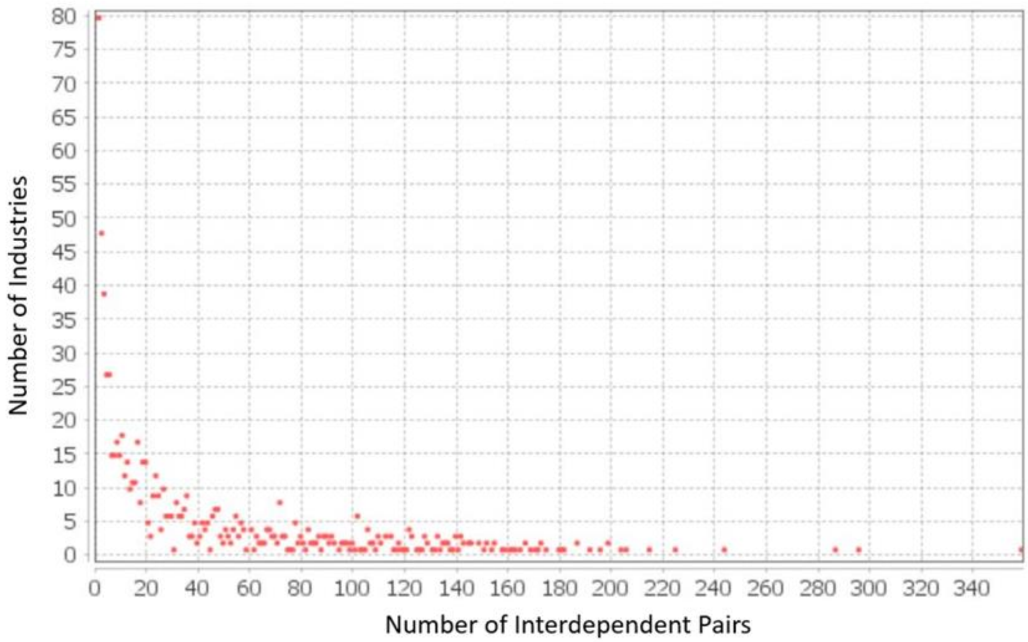


Figure 5 Degree distribution of industries with interdependent pairs.
Note: Only industry pairs with high interdependence (ζ >0.75) are included.

The highly interdependent industries share on average 30 interdependencies with other industries, but the distribution is skewed with a handful of industries being highly interdependent with a large number of industries, but the median being highly interdependent on 12 other industries.

'Silver Ore Mining'; and, 'Potash, Soda, and Borate Mineral Mining' are the most networked with 335 and 268 high interdependencies each. On the other hand, 'Motor Vehicle Electric Equipment Manufacturing'; and, 'Food Product Machinery Manufacturing' are the least networked with only 1 interdependency each.

This distribution suggests that some industries play a more connected role in economic ecosystems, while others may behave more independently. Within a network framework, this also suggests strong clustering of industries in the U.S. Industry Space, suggestive of underlying patterns of organization.

Table 1 below lists a sample of these pair-wise combinations for high positive, low positive, as well as negative values of interdependence.

Table 1 Pairwise Estimates of Highest and Lowest Interdependencies

High Positive Interdependence (ζ)		
Industry i	**Industry j**	**ζ**
Silver ore mining	Geothermal electric power generation	24.9
Silver ore mining	Potash, soda, and borate mineral mining	17.5
Iron ore mining	Phosphate rock mining	14.5
Sugar beet farming	Beet sugar manufacturing	12.6
Motion picture and video production	Independent artists, writers, and performers	8.8
Low Positive Interdependence (ζ)		
Industry i	**Industry j**	**ζ**
Gasoline stations with convenience stores	Child and youth services	<0.1
Radio networks	Veterinary services	<0.1
Credit unions	Telephone answering services	<0.1
Commercial printing, except screen and books	Audio and video equipment manufacturing	<0.1
Testing laboratories	Professional employer organizations	<0.1
High Negative Interdependence (ζ)		
Industry i	**Industry j**	**ζ**
Silver ore mining	Plastics bottle manufacturing	-1.0
Geothermal electric power generation	Other basic inorganic chemical manufacturing	-1.0
Dairy cattle and milk production	Interior design services	-0.9
All other pipeline transportation	Golf courses and country clubs	-0.9
Guided missile and space vehicle mfg.	Religious organizations	-0.9

The highest estimates of interdependence were in resource extraction and farming related industries and are driven by the rare specializations of one of the industries in only a handful of metropolitan areas. Nonetheless, the interdependence measure reveals synergies in production processes of industries as well. For instance, Silver Ore Mining is an energy intensive process and utilizes resources that co-occur with geothermal resources, allowing for co-production synergies (Patsa, Zyl, Zarrouk, & Arianpoo, 2015).

Low positive interdependencies show for industries that are more common across MSAs and are primarily comprised of local serving firms. For instance, the industries with $0 > \zeta < 0.1$ in Table 1 are 'Gasoline stations with convenience stores'; 'Credit Unions'; 'Veterinary service' etc.

High negative interdependence of -1 results from industry pairs that do not co-occur in the same MSA. This lack of interdependence of economic activity may result from negative externalities that the presence of one industry may impose on another, such as 'All other pipeline transportation' and 'Golf courses and country clubs', while the lack of interdependence between others such as 'Dairy cattle and milk production' and 'Interior design services'; or, 'Guided missile and space vehicle manufacturing' and 'Religious organizations', may result from no economic complementarities existing between the two industries. As such, for the analysis I develop in this paper, I focus on the high positive interdependencies evident of economic complementarities.

On this basis, I expect that MSAs with a higher density of economic complementarities will result in greater opportunities for growth through recombinant entrepreneurship, and thus a higher potential for robust economic ecosystems. To put it another way, adding a new Silver Ore Mine creates new demand for Geothermal energy, and similarly a new Geothermal plant increases supply of energy that may induce more mining activity. Similarly, production complementarities in the service sectors, such as those between ‘Motion picture and video production’ and ‘Independent artists, writers, and performers’ drive entrepreneurial activities in Los Angeles and Nashville, both movie and music centers of the US.

In the next section, I graph the network of industry interdependence of the U.S. national economy. This graphical representation provides a view of how regional activity clustered around economic interdependence and presents a ‘map’ of the U.S. Industry Space.

5. The U.S. Industry Space

The interdependence measure discussed above was estimated pairwise for 1,045 6-Digit NAICS industry specializations across 388 U.S. MSAs in 2018 to produce an adjacency matrix of interdependent economic activity. Using a cutoff of $\zeta = 0.75$, I produce a network representation of production activity in the U.S. (see Figure 6).

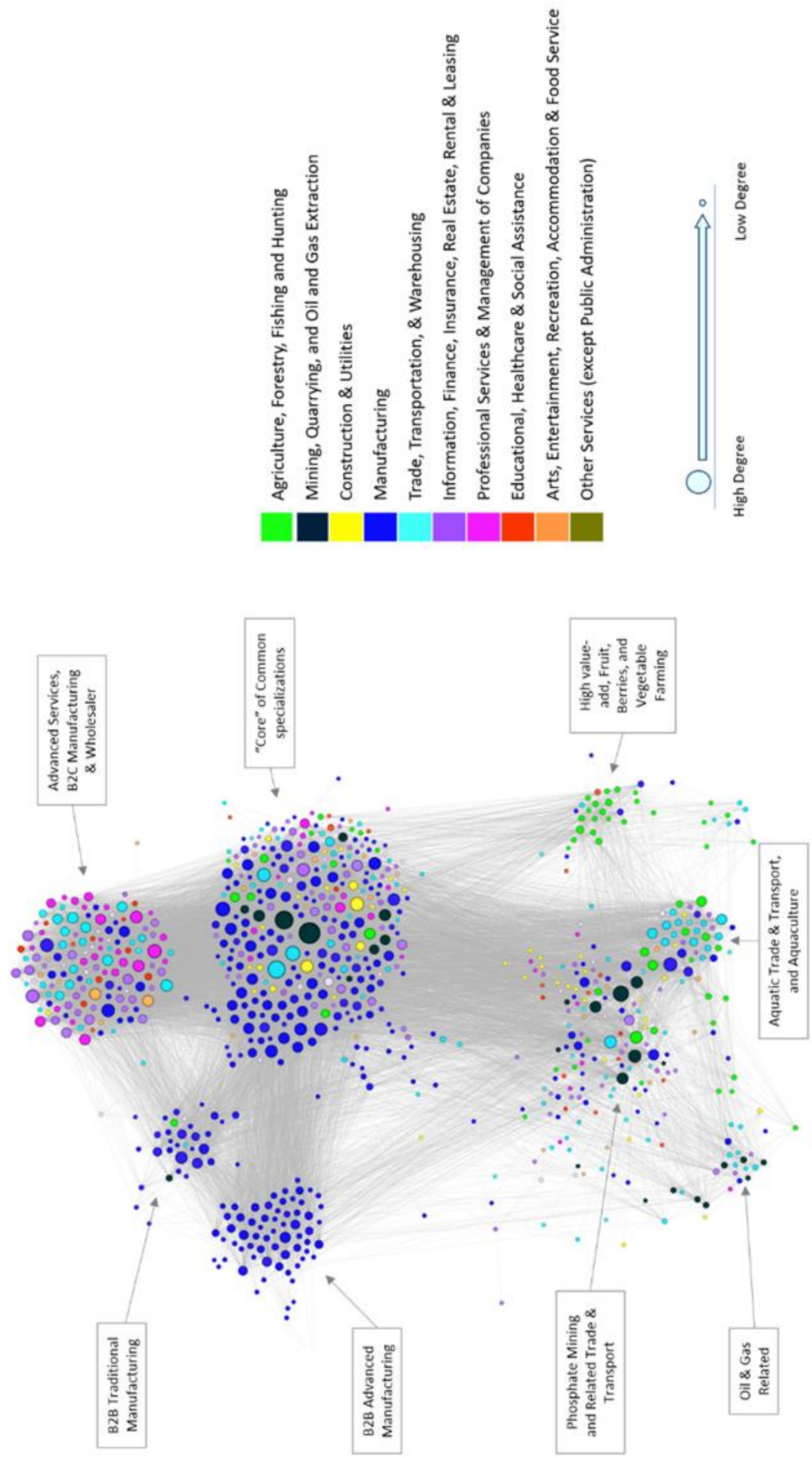


Figure 6 The U.S. Industry Space, by Industry Super Sectors.

In the network map, 822 private sector 6-Digit NAICS industry codes are represented by individual bubbles, or nodes. The nodes are colored according to their NAICS super sectors, while their size corresponds to the degree of each node, i.e. smaller nodes have fewer network connections, while larger nodes are interdependent with a larger number of industries. A few features are noticeable immediately:

- There is a core-periphery structure to the network. More specifically, there are visible clusters to the network, with the largest cluster being the most central. The rarest industries, such as "Silver Ore Mining" are located at the center of the clusters, surrounded by more commonly specialized industries. Ubiquitous industries are found along the periphery of the clusters.
- Manufacturing dominates the network with at least 2 distinct clusters where manufacturing activity is central. The first of these clusters concentrates around "B2B Advanced manufacturing"[14] activities at its core, such as, "Speed changer, drive, and gear manufacturing", "Printing machinery and equipment manufacturing", and "Abrasive product manufacturing". The second of these clusters concentrates around "B2B Traditional manufacturing", with industries such as, "Hosiery and sock mills", "Tobacco manufacturing", and, "Carpet and rug mills" at its core.
- The largest cluster visible in the network has the rarest industry specializations at its core, such as "Silver Ore Mining", "Potash, soda, and borate mineral mining",

[14] Advanced Manufacturing, Energy, and Services industries are composed of 50 4-Digit NACIS industries that are R&D, STEM, and knowledge intensive. I imputed Advanced industries at the 6-Digit NAICS level following Muro, et al. (2015).

and, “Geothermal electric production”, but are surrounded by common industry specializations such as “Commuter rail systems”; “Health and welfare funds”. This cluster also includes most construction and utilities related activities.

- Another large cluster visible at the top of the graph concentrate in advanced services, B2C manufacturing and wholesale trade activities. Most advanced services industries are concentrated in this cluster as also education, healthcare, and social assistance related specializations.
- Agriculture and resource extraction related activities that are more commonly found cluster around the availability of resources the activity depends upon. For instance, at the bottom of the graph a cluster of water-related activities such as “Deep sea freight transportation”; “Seafood product preparation and packaging”; “Aquaculture”; and, “Shellfish farming” are concentrated. Similarly, certain types of mining activities, such as phosphate mining cluster together, as do oil and gas related activities, and high value-add agriculture such as that for fruits, berries, and vegetable farming.

This clustering of economic activity visible in the graph provides an intuitive validation of the interdependence measure. Importantly, the measure is reflecting the inter-connectedness of economic activity across NAICS sectors and is not limited by the type of production activity, rather builds on how complementary different production processes likely are to one another.

Figure 7 reproduces the U.S. industry space but highlights different types of industry classifications on the network graph to see how an interdependence based revealed network structure aligns with different types of production activities.

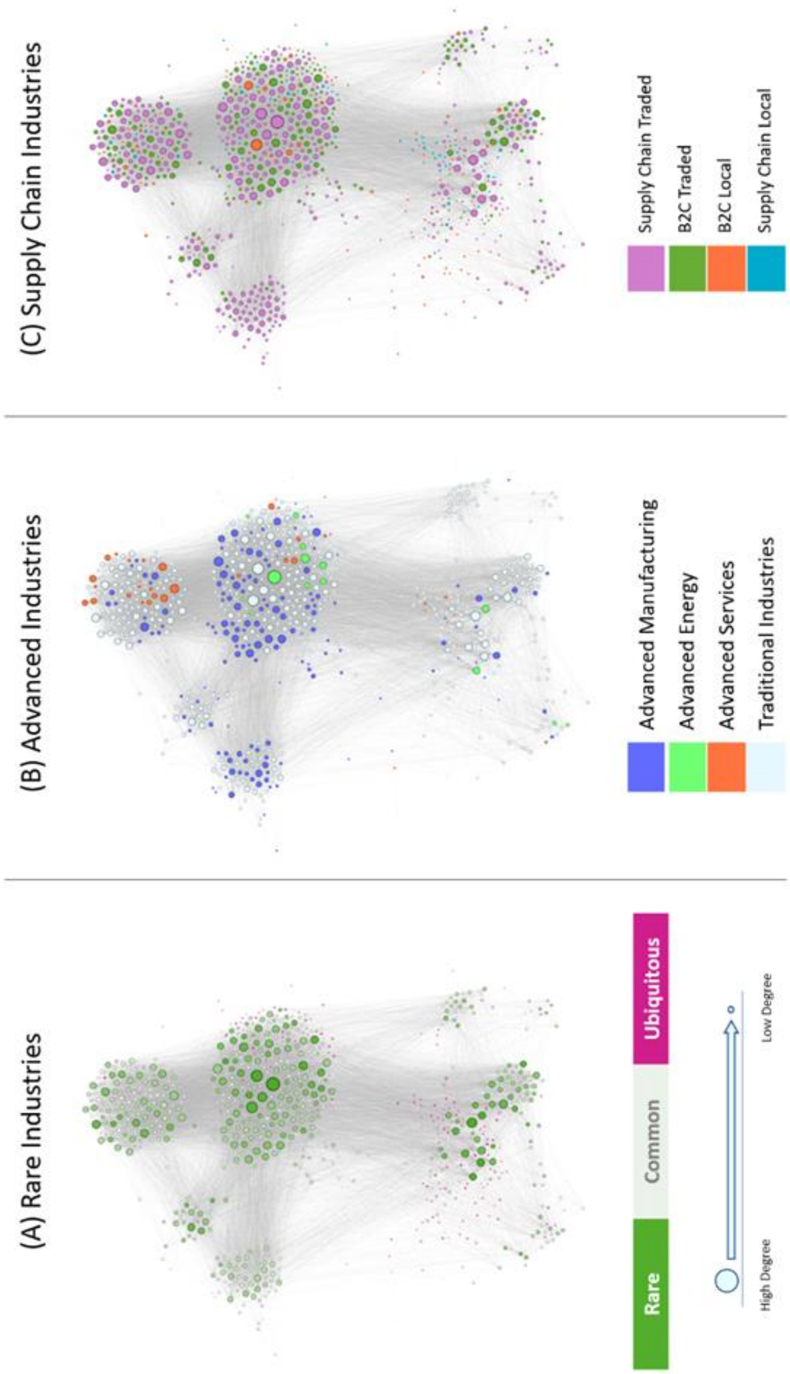


Figure 7 Rare, Advanced and Supply Chain Industries in the U.S. Industry Space.
Panel (A) rare, common, and ubiquitous industries defined as the first, second, and third tertile of the frequency distribution for industries specializing in 388 US MSAs. Panel (B) Advanced Industries are R&D and STEM knowledge intensive industries. Here I adopted NAICS classifications from Muro, et al. (2015). Panel (C) supply chain industries follow the classification method described in Delgado & Mills (2019).

Panel (A) in Figure 7 shows rare industry specializations make up the core of the clusters. Rarer industry specializations also have larger degree, i.e. they are more connected in the network space. An entrepreneurial ecosystem in this sense is uniquely identified and structured by its rare but highly interdependent production capabilities.

Panel (B) color codes the industry nodes according to the Advanced Industry classification developed by Muro, et al. (2015). These advanced industries are R&D and STEM knowledge intensive and associated with more innovative activities in the economy. As seen in the Figure 8, advanced industries are distributed across the network, present in or adjacent to all clusters. However, only 5 percent of Advanced industries are ubiquitously specialized, and a majority 53 percent are commonly specialized, and the remaining 42 percent are rare specializations.

Panel (C) color codes the industry nodes by their classification on Supply Chain Traded, B2C Traded, B2C Local or Supply Chain Local industries. I replicated this classification first developed by Delgado and Mills (2019) and applied it to the network graph. Most noticeable is the preponderance of Supply Chain Traded industries followed by the B2C Traded activity at the core of the clusters and the network. This shows the importance of traded production activities in defining the network structure of the industry space.

In the next section I examine some network statistics of the U.S. industry space to develop a baseline against which to compare the industry spaces of regional entrepreneurial ecosystems.

6. Topological Properties of the U.S. Industry Space

I report basic graph statistics of the U.S. industry space in Table 2. The network properties of the U.S. industry space were generally stable during the six-year interval (2013 to 2018) that I analyzed. I found the statistics to be sensitive to the NAICS industry definitions used. The QCEW data applies NAICS 2012 definitions between 2013 and 2016, and NAICS 2017 definitions for 2017 onwards. As can be seen in Table 2, the network statistics are more comparable within each NAICS classification structure than across. This sensitivity is likely a result of the high 6-Digit level of disaggregation used in this paper which is affected most directly by an update of the NAICS classification.

The U.S. industry space provides a baseline for comparatively assessing the properties of metropolitan entrepreneurship spaces later in the paper, so the changes observed warrant some discussion here.

Table 2 Network Statistics of the U.S. Industry Space

US National Industry Space	NAICS 2012				NAICS 2017	
	2013	2014	2015	2016	2017	2018
# of Industry Specializations	852	838	831	835	840	822
# of High Interdependencies	18998	19020	18796	18705	17165	17140
Average Degree	44.596	45.394	45.237	44.802	40.869	41.703
Network Diameter	5	5	5	5	5	5
Average Path Length	2.348	2.352	2.35	2.349	2.349	2.346
Network Modularity	0.27	272	0.258	0.266	0.281	0.289
Average Clustering Coefficient	0.515	0.512	0.517	0.499	0.491	0.508

Count of related nodes and edges: The related density threshold selected in this paper is 0.75 for graphing the networks. At this threshold, the number of nodes with at least one edge in the network decreased from 852 industry codes in 2013 to 835 in 2016. In the most recent years, the number of specializations decreased from 840 to 822 industries. Similarly, the number of related connections also decreased from 18,998 in 2013 to 18,705 in 2016, and from 17,165 to 17,140 in the most recent years. The count of highly interdependent nodes tells U.S. the proportion of industries that are effectively driving the structure of the network. For instance, in the NAICS 2012 definitions there are 1,054 6-Digit NAICS industries, and in NAICS 2017 definition there are 1,046 6-Digit NAICS industries. The proportion of industries driving the interdependent U.S. Industry space varies from the lowest in 2018 with 78.6 percent of nodes represented, to highest in 2013 with 80.8 percent of nodes represented in the highly interdependent network.

Average degree: This statistic provides a measure of graph density and calculates the average number of neighbors that nodes have in this network. The intuition here is that industry spaces with higher average degree have denser connections. Between 2013 and 2016 this statistic for the U.S. industry space stayed about the same — increasing in 2014 before decreasing again in 2016. In contrast, the average degree increased between 2017 and 2018 even though the number of industry specializations decreased by 2 percent, suggesting that although fewer industries are driving the network, industries became more clustered in the most recent year.

Network diameter: This statistic measures the length of the shortest path between the two most distant nodes in the network. This statistic is very consistent across all years, telling U.S. that each industry is related to any other industry within 5 connections.

Average path length: This is a measure of efficiency and tells U.S. the average of the shortest paths between any two nodes in the network. Between 2013 and 2018, the average path length stayed roughly the same at 2.35.

Network Modularity: A measure of clustering within a network, higher modularity indicates stronger communities within the industry space. This statistic does not change much between 2013 and 2016, at roughly 0.27. However, the modularity is slightly higher in the NAICS 2017 definitions at 2.9 in 2018.

Average clustering coefficient: The average clustering coefficient provides information on how connected each node's immediate neighborhood is on average and the statistic ranges from 0 to 1. Between 2013 to 2018 the average clustering coefficient has remained at about 0.5. This statistic provides a comparative basis for examining the network of metropolitan industry spaces, such that, if a metropolitan space has a higher average clustering coefficient than the national, this suggest the metropolitan ecosystem specializes in more interdependent industries, while a lower statistic would suggest the metropolitan ecosystem specializes in less interdependent industries.

In the past two sub-sections, I used the pair-wise interdependence measure to graph the U.S. Industry Space and provide some preliminary statistics on its network structure as it evolved over time. I next use the pair-wise interdependence measure at the MSA level to estimate an indicator of an ecosystems *related density*. This indicator allows U.S. to compare the recombinant opportunity available to businesses in an MSA, to compare MSAs against one another in their entrepreneurial potential. I also estimate this measure at the industry level for each MSA, allowing is to identify the most interdependent MSA for any given industry.

7. Related Density in Metropolitan Economic Ecosystems

I define *related density* as a measure of the concentration of high interdependencies between specialized industries in an MSA, relative to the national. Intuitively, if the U.S. Industry Space represents all plausible combinatorial economic interactions, an MSA's *related density* refers to the share of those interdependencies present within the MSA's mix of specialized industries.

For a metropolitan area M, I estimate its *related density* as the proportion of realized to possible counts of high interdependencies for its 'Set of Specializations' (SS). To operationalize this measure, I first calculate the number of high interdependencies ($\zeta > 0.75$) present between every pair of industries in the MSA, both having LQ>1. I refer to this as the "realized count of high interdependencies". I next calculate the number of high interdependencies present between a specialized industry in the MSA to all other industries in the national industry space. I refer to this as the “possible counts of high interdependencies” for a given SS of the MSA.

Equation 2 Related Density of the Industry Space

$$RD^{M} = \frac{(Realized\ counts\ of\ high\ interdependencies)_{SS}^{M}}{(Possible\ counts\ of\ high\ interdependencies)_{SS}}$$

Related density is a measure of the recombinant potential available in an economy. It accounts for an ecosystem’s comparative advantages and weighs how well the advantages are networked relative to the national baseline. Entrepreneurial ecosystems that are more tightly clustered and more closely reflect the economic agglomerations visible in the national industry space are rewarded with a higher score. This makes it possible to compare different MSAs to another and over time.

I tested the validity of this measure by correlating it to different ecosystem outcome measures for entrepreneurship and innovation, such as entrepreneurship rates, job creation by new establishments, patents per establishment, and GDP per Employee.

I find that an entrepreneurial ecosystem’s *related density* is strongly correlated with its entrepreneurial and innovative activity. Figure 8 illustrates the exponential relationship between an MSA’s *related density* and the different measures of entrepreneurial impact and innovative output. The log-log relationships plotted are non-linear and increasing with *related density*.

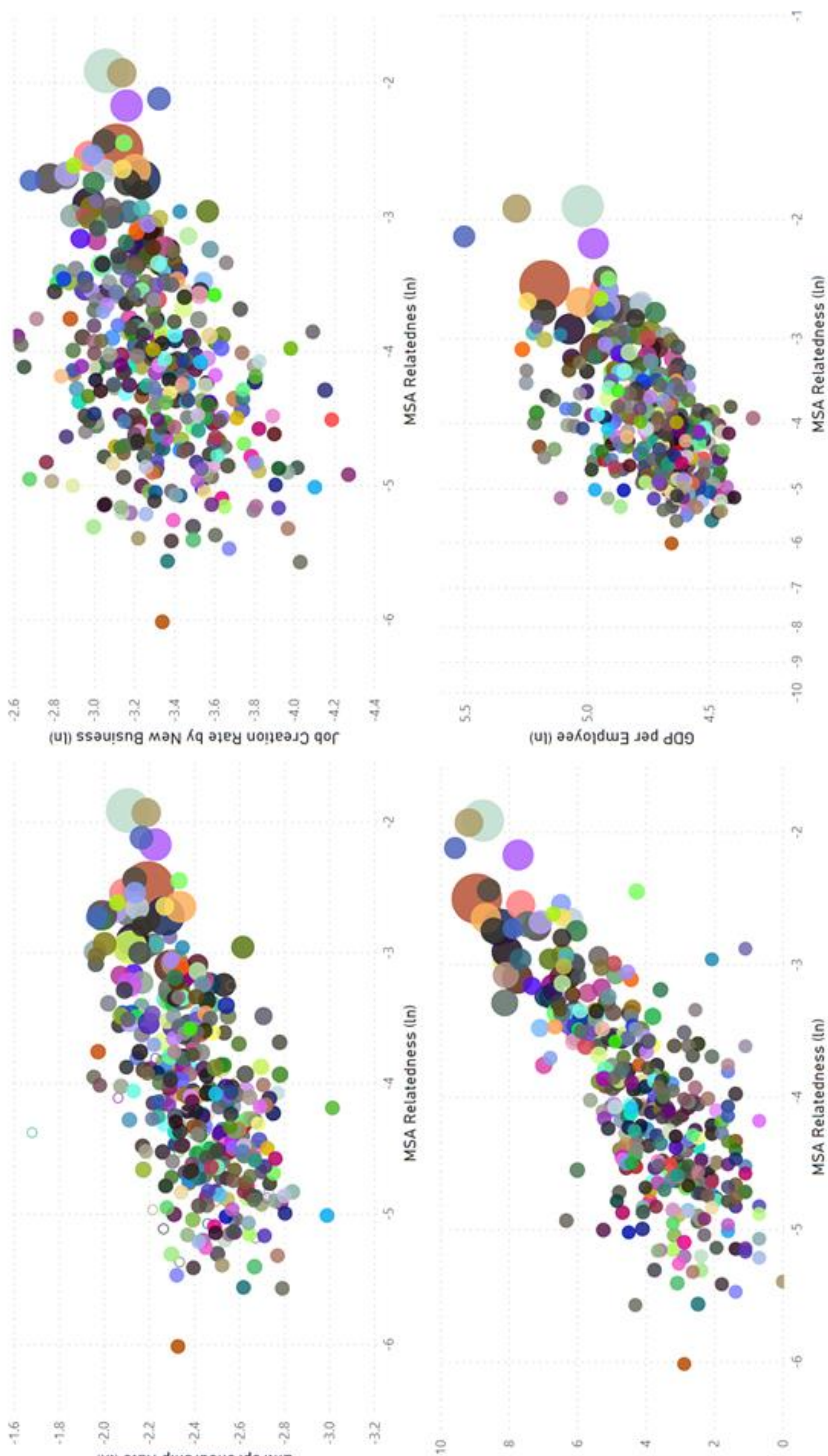


Figure 8 The Combinatorial Relationship Between Metropolitan Entrepreneurship and Related density Across Industry Specializations.
Note: Each node is a Metropolitan Statistical Area (MSA). Larger nodes indicate MSAs with larger employment. MSAs are individually color coded.

I also regressed RD on entrepreneurship rates, job creation rates by new businesses, number of patents per establishment, and GDP per employee for metropolitan areas while controlling for their size and wealth. I find strong positive and statistically significant coefficients. Nonetheless, as is evident in Figure 8, the largest MSAs in the nation tend towards a higher related density. This is an expected result given the co-determination of an ecosystem's size and the opportunities for growth it provides.

At a first glance, the data represented in Figure 8 support a Schumpeterian perspective on the relationship between localized combinatorial potential and realized economic outcome—in other words, the relationship between the available shared economic "Lego pieces" and economic outcomes seems to be positive, as expected.[15] One possible story suggested by Figure 8 is the following: Entrepreneurs take existing resources and recombine them to produce new economically useful resources which, in-turn, act as inputs in the generation of new entrepreneurial opportunity. This relationship—while self-reinforcing and iterative—remains constrained not only by the resources available to entrepreneurs but also the extent to which existing resources are available in adjacent economic spaces for recombination.[16] Consequently, where I find greater related density between economic knowledge and capabilities, I tend also to observe greater levels of entrepreneurial activity. In this way the structure of an entrepreneurial ecosystem reflects latent entrepreneurial opportunity.

[15] E.g. Weitzamn (1998); Auerswald (2017).
[16] Kauffman (2019).

I further extend the RD measure to the industry level. For policy relevance, it would be useful to know which industries are driving the recombinant potential of an MSA ecosystem as well as to know how the network density of an industry compares to the network density of the same industry in different MSA ecosystems.

For this purpose, I also estimate a *related density of industry (RDI)* constructed similarly as related density, but at the MSA-industry level and weight it by its MSA location quotient.

Equation 3 Industry-Specific Related Density

$$RDI_i^M = \frac{(Realized\ counts\ of\ high\ interdependencies)_{SSi}^M}{(Possible\ counts\ of\ high\ interdependencies)_{SSi}} \times LQ_i^M$$

An immediate advantage to RDI over the traditional use of location quotients, is that it penalizes MSAs that have a large location quotient in an industry, but do not have specializations in highly interdependent industries. RDI also provides a more nuanced view than *related density* as the inclusion of location quotient provides a measure of intensity of economic activity along the related density measure of the extent of integration of the economic activity into the ecosystem.

In the following section I produce Entrepreneurial ecosystem rankings for U.S. MSAs by their *related density*. I also produce MSA-Industry rankings and discuss their implications as useful policy and decision-making tools.

8. <u>Ranking Metropolitan Economic Ecosystems</u>

The Metropolitan Entrepreneurship Space refers to a metropolitan area's cluster of specialized industries that are also related in their agglomeration dynamics. These clusters play an essential role in the co-evolutionary dynamics of a metropolitan area's industry structure, and thus provide vital insight into a metropolitan area's growth trajectory, relevant for identifying opportunities for targeted policy making for entrepreneurship and economic development.

As discussed earlier, the *related density* of metropolitan areas correlates strongly and positively with entrepreneurship and innovation outcomes. This relationship provides the empirical basis for studying the networked structure of related density to identify sources of entrepreneurial opportunity in U.S. metropolitan areas. In fact, the data identify that an increase in the density of related industries by 1 percent for an ecosystem is associated with an increase of more than 1 percent in its entrepreneurship rate.

Whereas more empirical research on this topic is needed to develop a nuanced understanding of the co-evolution of industries in cities, I provide some interpretation of *related density* here in the following sections. First, in section 3.7.1, I present a ranking of metropolitan areas in the U.S. according to their *related density* for years 2013 to 2018. Next, in section 3.7.2., I present a ranking of metropolitan areas in the U.S. by select industries according to their *related density of industry* (RDI). In section 3.7.3., I also present two short anecdotes to hypothesize how MSAs grow, or decline, in their *related density* over time.

8.1. Metropolitan Rankings of Related Density

Table 3 below provides a ranking of the top ten U.S. Metropolitan Statistical Areas (MSAs) according to the related density of their entrepreneurial clusters. An entrepreneurial cluster refers a group of industries within the MSA for which the concentration of business activity in the MSA is more than the national average.

Compared across 388 MSAs in the U.S. for each of the years between 2013 and 2018, metropolitan areas with greater related density tend to exhibit higher entrepreneurship rates. Related density accordingly is a measure of how synchronous entrepreneurial activity is within an MSAs industry structure.

Table 3 MSA Entrepreneurial ecosystem Rankings by Related Density.

	National Rank					
Metropolitan Statistical Area	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**
Los Angeles-Long Beach-Anaheim, CA MSA	1	2	1	1	1	1
San Francisco-Oakland-Hayward, CA MSA	2	1	2	2	3	2
San Jose-Sunnyvale-Santa Clara, CA MSA	3	3	3	3	2	3
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	4	4	4	4	4	4
Fresno, CA MSA	5	5	6	6	7	7
San Diego-Carlsbad, CA MSA	6	6	5	5	6	5
Sacramento--Roseville--Arden-Arcade, CA MSA	7	9	8	8	5	6
Boulder, CO MSA	8	12	16	10	9	10
Bridgeport-Stamford-Norwalk, CT MSA	9	14	17	11	10	8
New York-Newark-Jersey City, NY-NJ-PA MSA	10	8	9	7	11	12

Six of the top ten MSA ecosystems by *related density* are in California. The top three places have changed back and forth over the years between the Los Angeles, San Francisco, and San Jose MSAs, while the Washington DC MSA has held firmly in the 4th

position. The Boulder, CO MSA and Bridgeport, CT MSAs have increased in the *related density* ranking in recent years, while the New York City MSA has fallen a couple places behind.

To get a better idea of the economic complementarities driving the MSA rankings, Figure 5 maps the metropolitan entrepreneurship spaces next to the U.S. industry space for the Los Angeles, CA MSA; the Washington, DC MSA; the New York City, NY MSA; and for the San Francisco, CA MSA.

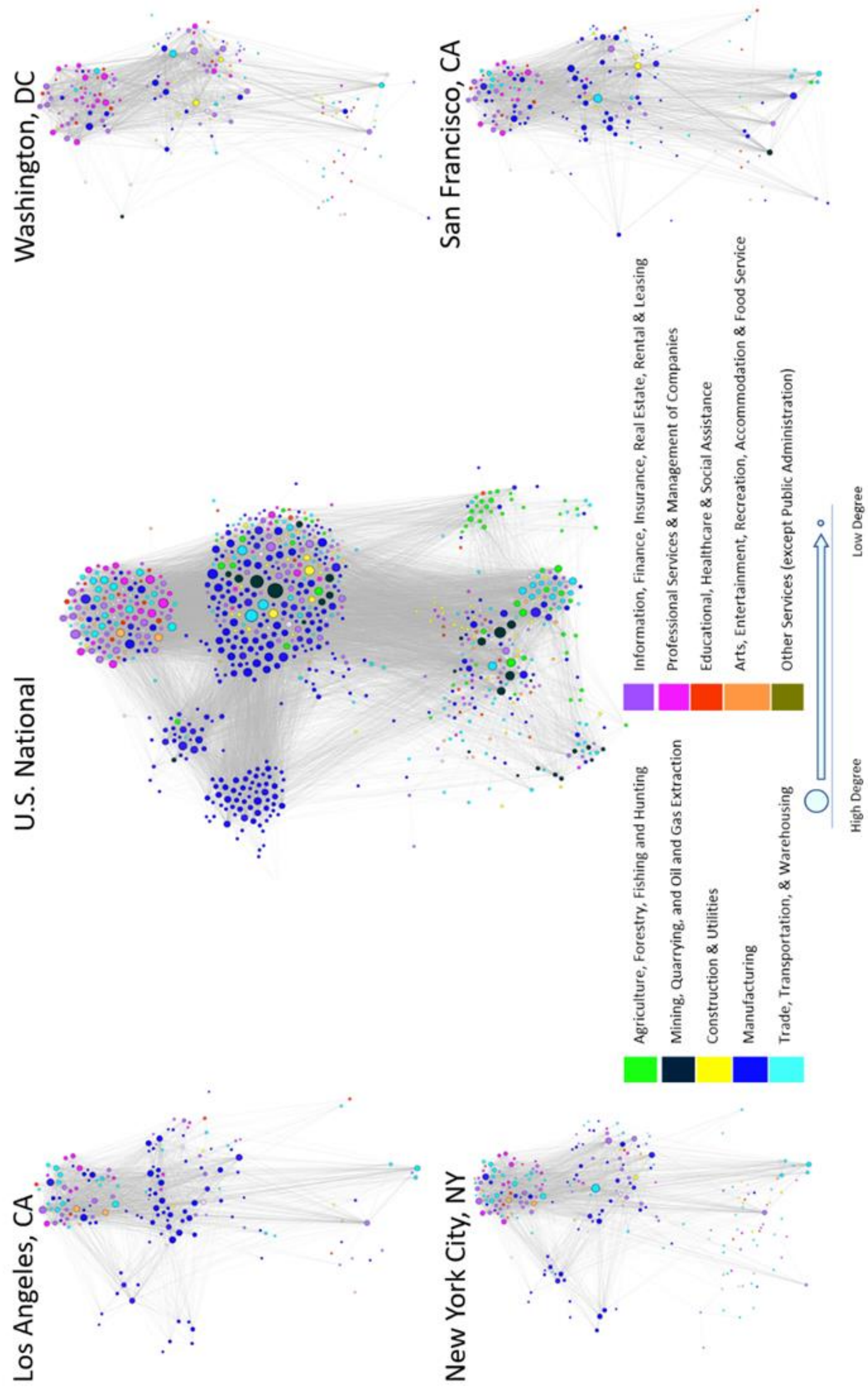


Figure 9 Metropolitan Entrepreneurship Spaces and the U.S. Industry Space.

Of the four metropolitan entrepreneurial ecosystems in Figure 9, Los Angeles, CA MSA and New York City, NY MSA represent more diverse entrepreneurial ecosystems, while San Francisco, CA MSA and the Washington, DC MSAs are more specialized.

The Los Angeles MSA has the greatest number of industries specialized in the largest central core of the U.S. industry space, a majority of which are in the manufacturing sector. As discussed previously in section 3.4, manufacturing industries play a vital role in the structure of the national industry space, additionally the most networked industries, albeit common industries, are concentrated in the large central core cluster. The Los Angeles, MSA ecosystem shows a density of specializations along both these features. Furthermore, this ecosystem is also specialized in the Advanced Services and Trade cluster. As a result, compared to other MSAs, the Los Angeles, MSA is well represented in most of the diverse clusters in the industry space and making it the closest in mimicking the national industry space because of its diverse specializations.

In comparison, the New York City, MSA ecosystem is also well represented in most of the large clusters of the industry space, however it lacks the same density of manufacturing specializations in the large core clusters where industries are most interdependent. The Washington, DC MSA ecosystem in contrast is more heavily concentrated in the Advanced services clusters, with its core of common specializations also in the Services sectors. As a result, the Washington, DC MSA ecosystem, while less diversely specialized than New York City, MSA, it is more densely related in its economic activities earning it a high rank among MSA ecosystems.

The San Francisco, MSA ecosystem is less diverse than Los Angeles, CA MSA or New York City, NY MSA, but more densely related. In particular, San Francisco, CA MSA ecosystem has manufacturing specializations the large common industries core cluster which drives up its related density, especially in comparison to the Washington, DC MSA ecosystem.

Entrepreneurial ecosystem rankings of *related density* provide policy relevant information on how the ecosystems track in terms of its entrepreneurial potential relative to their peers and over time. In this section I also laid some foundations for how the location of an ecosystem's industry specializations in the national industry space can affect entrepreneurial potential. In the following section I dive deeper into the concept of *related density* by provide rankings of MSA ecosystems for select industries.

8.2. Metropolitan Industry Rankings of Related Density

What is the best ecosystem to start a sound recording studio? Traditionally, to answers this question a regional economist will report back the MSA with the highest location quotient the "Sound recording studios" NAICS. However, as seen in Table 4, location quotients can be much larger for industries specialized in smaller ecosystems. For instance, Ithaca, NY has a higher location quotient than the Nashville, TN MSA, and similarly Asheville, NC MSA out-ranks Austin, TX MSA and Atlanta, MSA in terms of location quotient. However, when I rank ecosystems using the RDI measure, I see that although Austin, TX and Atlanta, GA have lower location quotients, they have more *related density* around sound recording studios and this rank higher. The same goes for

Ithaca, NY compared to Nashville, TN. Its also worth noting that although Ithaca, NY has a lower related density around “Sound recording industries” than Austin, TX, or Atlanta, GA, its significantly higher location quotient places it at a higher ranking than the larger metropolitan ecosystems.

Table 4 Top 5 MSA Ecosystems for Sound Recording Studios (NAICS 512240).

NAICS 512240: Sound recording studios		
MSA Name	**LQ**	**RDI Rank**
Nashville-Davidson--Murfreesboro--Franklin, TN MSA	7.02	1
Ithaca, NY MSA	7.42	2
Austin-Round Rock, TX MSA	2.84	3
Atlanta-Sandy Springs-Roswell, GA MSA	2.3	4
Asheville, NC MSA	3.17	5

Another practical policy application for the RDI is to identify which industries are providing an ecosystem its competitive advantage, and how do these industries rank relative to other MSA ecosystems. As an example, Table 5 provides the MSA-industry ranking for San Francisco, CA MSA.

Table 5 Top 5 Industries by Related Density for San Francisco-Oakland-Hayward, CA MSA Ecosystem.

San Francisco-Oakland-Hayward, CA MSA (Top 5 Industry Ranks)		
Industry Title	**LQ**	**MSA Rank**
Semiconductor machinery manufacturing	6.72	3
Other technical consulting services	2.09	3
Grantmaking foundations	2.39	5
Electronic computer manufacturing	3.29	5
Investment banking and securities dealing	2.18	6

Notably, San Francisco, CA MSA ecosystem does not rank first in any 6-digit NAICS category. San Jose, CA MSA and Austin, TX MSA outrank San Francisco, CA MSA both in terms of location quotient and related density. However, other MSAs such as Phoenix, AZ MSA (LQ = 7.25); Santa Maria, CA MSA (LQ = 8.21), have higher location quotients but do not have specializations in as many highly interdependent industries as San Francisco, CA MSA.

8.3. Related Density and Dominant Industries

To interpret the metric of related density, consider that the Los Angeles MSA has a *related density* of 13.5 percent. This tells U.S. that the Los Angeles MSA's entrepreneurial ecosystems comprises of 13.5 percent of the most highly interdependent industry pairs in the US. I can interpret this as indicating that 13.5 percent of the Los Angeles MSA's entrepreneurial cluster is strongly co-evolutionary, sharing interdependent and networked agglomeration dynamics. Of the 388 MSAs evaluated, the mean *related density* is 2.2 percent while the lowest is 0.2 percent for Altoona, PA MSA.

Given this wide dispersion of entrepreneurial agglomeration across U.S. MSAs, another policy relevant question is, how can an ecosystem increase its related density and thus its entrepreneurial opportunity?

Notably, dominant industries in a region foster related entrepreneurial opportunities by exerting a "gravitational attraction" that increases regional agglomerations centered around those industries. Economic developers have sought to attract large firms to their region to spur on this kind of impact and economic spillovers.

Similarly, if a large firm leaves an ecosystem, the rest of the economy diversifies toward new gravitational centers that can result in a decline in related agglomerations in the metropolitan area, as I conjecture was the case in low-ranked Altoona, PA.

In terms of entrepreneurial ecosystems, the examples of Hollywood in Los Angeles MSA and the Pennsylvania Railroad in Altoona MSA—the highest and lowest ranks on the related density spectrum, respectively—can help elucidate further the concept of *related density*. Diversity in these regional economic capabilities developed as a consequence of specialization in dominant industries—the film industry and freight rail, respectively:

- *Rank 1: Los Angeles, CA MSA.* The Los Angeles MSA's related density is apparent in the dominant role of Hollywood in the MSAs economy. For instance, of the top fifteen industry specializations of the MSA, four of industries are a direct consequence of the presence of Hollywood in the MSA: "Motion Picture and Video Industries; Sound Recording Industries", "Agents and Managers of Artists, Athletes, Entertainers, and other Public Figures", and "Independent Artists, Writers, and Performers". Another six specialized industries provide the products and services required for movie making such as "Textile and Apparel Manufacturing and Wholesales" and "Electric Lighting Manufacturing". The Los Angeles MSA shows the highest concentration of related entrepreneurial activity estimated in any of the U.S. metros assessed for 2018 in this paper.
- *Rank 388: Altoona, PA MSA.* Altoona MSA's industry structure is highly diversified with 85 6-digit NAICS industries that are specialized with LQ>1.

Altoona, PA MSA also ranks the first nationally for “Stationary product manufacturing” and has very high LQ > 10 in twelve different industries, showing a high number of diverse specializations. Yet, most of these industry specializations are unrelated, such as “Heavy duty truck manufacturing” and “Cookie and cracker manufacturing”. I conjecture this diversity in specializations came about because, historically, Altoona, PA MSA’s industry structure had evolved to take advantage of Altoona’s locational advantage a freight-rail transportation hub centered around the Pennsylvania Railroad. However, the importance of the rail industry to Altoona, PA declined, with the MSA no longer specialized in any rail related activity. The region diversified into varied clusters of economic activities that gradually lost their linkage to one another through freight rail. The top 3 industries by RDI for Altoona, PA are “Stationery product manufacturing”, “Libraries and archives”, and “Measuring, dispensing, and other pumping equipment manufacturing”.

To summarize this section of the paper, I mapped the U.S. Industry Space to reveal the underlying structure of economic interdependence in national entrepreneurial ecosystem. I also examined these structures for the sub-level ecosystems of MSAs to find they have diverse and broad sets of industry specializations, but how these are related to one another is correlated with the ecosystems entrepreneurial and innovation output. In the debate on whether metropolitan areas should specialize or diversify their economic capabilities, I argue that policy makers should work to improve the *related density* in their ecosystems' production capabilities. Such organization of an MSA's economic capabilities allows for greater recombinant potential in its ecosystem, facilitating innovation and entrepreneurship. I also operationalize the measures I develop by incorporating them into an MSA entrepreneurial ecosystem ranking, and further detailed a process to generate an MSA-industry ranking for a deeper dive into understanding the sources and scope for an entrepreneurial ecosystems recombinant entrepreneurial opportunity.

In the following section 4 I provide a framework that allows for a higher-level organization of an entrepreneurial ecosystem's industry space that classifies production activities into Supply Chain Traded; B2C Traded; Supply Chain Local; and, B2C Local industries, developed from Delgado and Mills (2019).

9. Levels of Organization Within Economic Ecosystems

I borrow concepts on the supply chain economy presented in Delgado and Mills (2019) to develop a bottom-up methodology for classifying regional economic capabilities that captures the structure and evolution of interdependence between industries in a region. I subsequently argue that this methodology allows for a high-level and policy-relevant view of any entrepreneurial ecosystems (regardless of scale) that can offer guidance to policymakers seeking to enable entrepreneurial ecosystems.

9.1. Economic Ecosystem Levels and the Supply Chain Economy

As noted above, Delgado and Mills (2019) [D&M] distinguish a region's industry mix between industries that sell primarily to consumers (B2C), and supply chain (SC) industries that sell to other businesses or government. D&M also combine their categorization with the Porter (2003) categorization of Traded and Local industries, as also with Manufacturing and Services, to find that suppliers in an economy are the drivers of innovation, job, and wage growth.

In this paper, I replicate D&M industry categories for primarily Supply Chain and B2C clusters using data from the Bureau of Economic Analysis Input-Output national accounts data for the year 2012 and similarly combine these categories with the traded and local industries classification[17] to produce four categories of industry clusters: SC Traded; B2C Traded; SC Local; B2C Local.

Re-framing this classification, I map the levels of an economic ecosystem to the four industry classifications as shown in Figure 10.

[17] U.S. Cluster Mapping Project (2018).

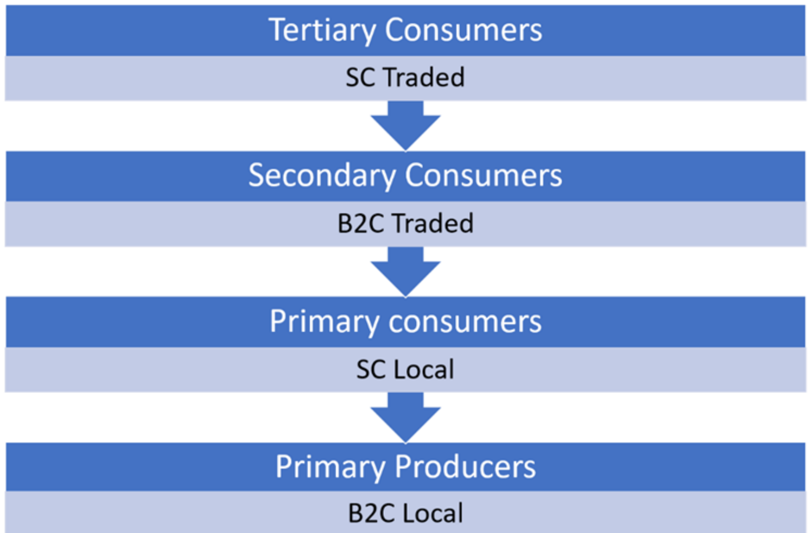


Figure 10 Economic Ecosystem Levels of Organization and the Supply Chain Economy.

In the economic ecosystems model presented here, supply chain exchanges of goods and services relate one level to another as well as connect internal productive activities to different economic ecosystems external to the region. For instance, when considering the economic ecosystem as a closed system, the provision of local services is essential for firms in the traded services, be it legal and professional services, or building maintenance services, or local eateries and gas stations, these are essential for the everyday functioning of the traded economic activity that primarily attracts external resources internal to the ecosystems through sales of manufactured good, tourism services, or other traded activities serving markets beyond the boundaries of the economic ecosystem.

This classification also proves useful when evaluating interactions across different economic ecosystems, for instance when evaluating an international supply chain that extends across different countries and thus different localized economic ecosystems with their own political, social, and technical regimes.

Importantly, this classification is applied to elucidate the regulation of economic resources in the economic ecosystems. The decision to place Traded clusters at the top hierarchy was motivated by their larger controlling effect on the net energy resources of the ecosystem and parallels the intuition presented by Feldman, Guy, and Iammarino (2019) that local monopoly firms tend to dominate the innovation and growth trajectories of regional economies. Furthermore, a look at the employment and wage structure of the economic ecosystem levels for the U.S. national economy provides insight into this classification (Figure 11).

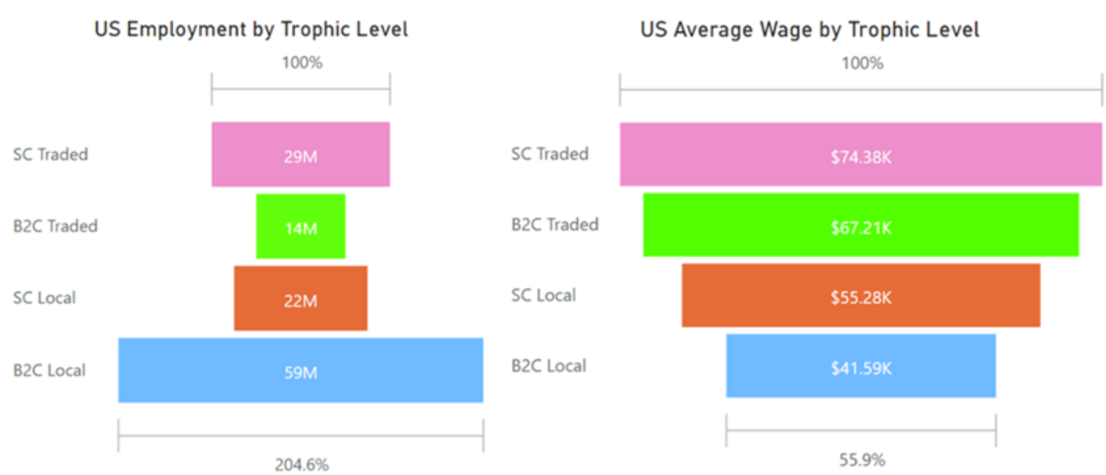


Figure 11 Employment and Wages in the U.S. Economic Ecosystem Levels.

The majority of employment as well as the lowest average annual wages in the U.S. national ecosystem are concentrated in the B2C Local level, i.e. mostly service industries where businesses are primarily selling final products direct for personal consumption. Examples of low-wage B2C Local industries include “Limited-service restaurants” ($16,408), “Fitness and recreational sports centers” ($17,196), and “Children’s and infant’s clothing stores” ($17,399). Examples of high-wage B2C Local industries include “Natural gas distribution” ($112,151), “Electric power distribution” ($109,519), and “HMO medical centers” ($105,381).

Industries in the SC Local level report the next lowest average annual wages and the second smallest concentration of employment. Examples of industries in this category include “Janitorial services” ($23,731), “Private mail centers” ($27,050), and “Security guards and patrol services” ($28,168). Examples of high-wage industries in this economic ecosystem level include “Offices of lawyers” ($102,509), “Television broadcasting” ($98,561), and “Offices of certified public accountants” ($90,583).

The B2C Traded level comprises of businesses in industries that sell their products or services directly to final consumers both within and outside of their economic ecosystem. Most of these industries leverage the ecosystem’s unique comparative advantages and are as such concentrated in tourism, finance, energy generation, and certain types of farming. Examples of low-wage B2C Traded industries (with average wages) include “Amusement arcades” ($16,594), “Bed and breakfast inns” ($21,483), and “Apple orchards” ($26,763). Examples of high-wage B2C Traded industries include: “Portfolio management” ($288,246), “Sports teams and clubs” ($228,958), “Nuclear electric power generation” ($141,663).

The SC Traded category employs the second most workers in the U.S. economic ecosystem and also pays out the highest annual average wages of any of the economic ecosystem levels. Businesses at this economic ecosystem level are concentrated in knowledge and resource-intensive industries and thus rely on any competitive advantages afford by the ecosystem. Examples of low-wage industries in this economic ecosystem level include “Tobacco farming” ($28,039), “Other airport operations” ($31,782), and “Crop harvesting, primarily by machine” ($34,676). Examples of high-wage industries in the SC Traded economic ecosystem level include “Investment banking and securities dealing” ($272,248), “Research and development in biotechnology, except nanotechnology” ($178,548), and “Semiconductors and related device manufacturing” ($164,117).

Recasting industries into economic ecosystem levels provides a high-level view of the economy, specifically, which activities are driving growth and innovation in the ecosystem. As discussed above, the U.S. national ecosystem is polarized with employment concentrated in the top-most SC Traded economic ecosystem level that is most associated with innovation and entrepreneurial growth, but also in the bottom most B2C Local economic ecosystem level that provides the foundation of the ecosystem. Specifically, the B2C Local industries include local activities most associated with supporting and improving the quality of life of resident individuals and businesses.

D&M provide evidence in support of using a supply chain industry classification for understanding the industrial mix of a regional economy. However, their classification does not fully capture the extent of industry interdependencies within any economic ecosystem. For this purpose, the following section 5, I introduce our interdependence measure alongside the supply chain classification to provide a more dynamic view of competitive advantage within economic ecosystem, at any scale of local geography.

10. Structure of Economic Ecosystems

My motivation behind integrating the supply chain economy (Delgado & Mills, 2019) with an economic ecosystems perspective is to lay the foundation for identifying the controlling processes that drive the complex relationships within an economic ecosystem. The economic ecosystem levels represented in figure 11 are an initial step in the effort, however a significant limitation is that it provides little policy relevant information on how these structures vary across different economic ecosystems, the unique "signature" of any economic ecosystem, and on quantitative measures of how they relate to one another for any given economic ecosystem.

To bridge this gap, I next extend the empirical quantification of economic interdependence to elucidate the linkages within and across economic ecosystem levels for any economic ecosystem of any size within the national economy.

For instance, simply applying D&M's classification to any MSA economy will allow a policy maker to interpret what proportion of local production activity is concentrated in Supply Chain or B2C industries, as well as in Traded or Local industries. However, as discussed in Section 3, economic ecosystems with greater realized *related density* in their industry mix are associated with better entrepreneurial and innovation outcomes. Thus, two entrepreneurial ecosystems, even if both specialize in the same type of manufacturing, will still have qualitatively different economic output dependent on the presence, or absence of related economic activity in the ecosystem.

Accordingly, here I present a method for capturing the *related density* present within and across an ecosystem's economic ecosystem levels. Similar to the methods in Section 3, I operationalize this concept of the *related density* of economic ecosystem levels as the percent of realized high interdependencies in the economic ecosystem interactions of a metropolitan industry space relative to total available high interdependencies of that economic ecosystem interactions in the national industry space.

10.1. The U.S. Economic Ecosystem Structure with Interdependencies

Figure 12 shows a graphical representation of the interactions in the U.S. national economic ecosystem levels of organization. The right panel shows the U.S. industry space with individual industries color coded according to the D&M's classification discussed in Section 4. The left panel graphs the high-level economic ecosystem structure aggregating the within interdependencies for each level, represented by the size of the node, and the size of the edges showing the between interdependencies.

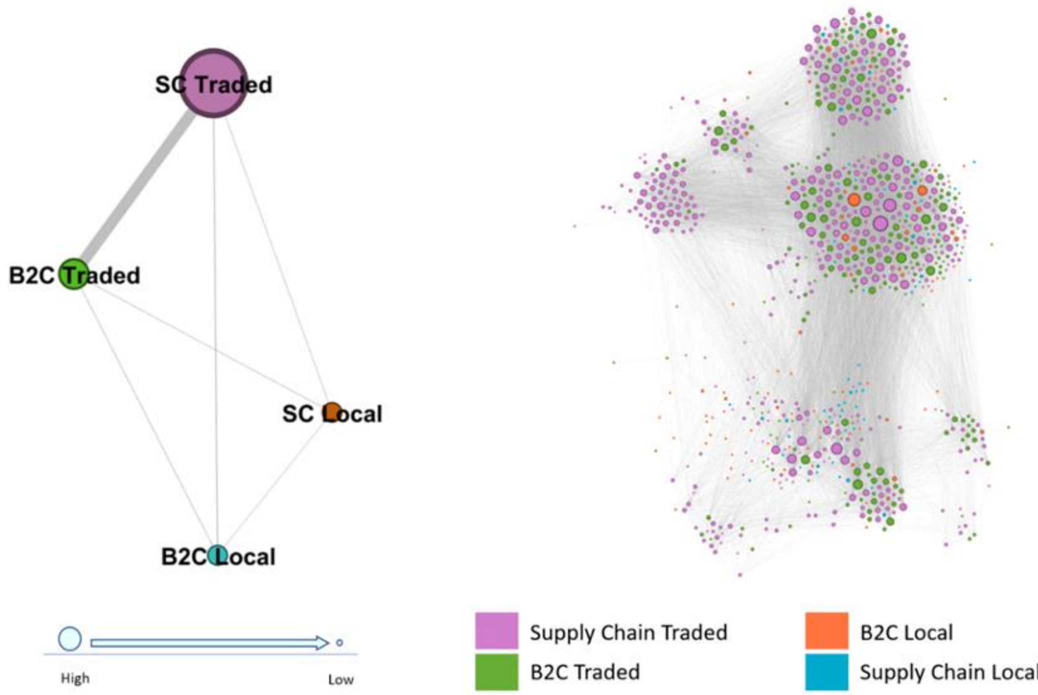


Figure 12 U.S. National entrepreneurial ecosystems Structure with Interdependencies.
Note: Left panel node sizes reflect count of high interdependencies within each entrepreneurial ecosystems level. Right panel node sized reflect the degree of each node. Graphs generated using Gephi 0.9.2 and OpenOrd Clustering Algorithm.

Notably, the highest number of within interdependencies are concentrated in the SC Traded economic ecosystem tier, followed by B2C Traded tier, B2C Local tier, and SC Local tier. SC Traded industries nationally also have the largest total number of high interdependencies to other economic ecosystem levels, most concentrating between the SC Traded and B2C Traded tiers. B2C Traded industries similarly have the second highest counts of between interdependencies. These findings parallel our expectation that Traded industries, particularly the supply chain type, have the largest agglomeration effects within any entrepreneurial ecosystem and thus contribute most to ecosystem capabilities that drive entrepreneurship and innovation.

In the local serving category, the SC Local industries have fewer interdependencies than the B2C industries, both in terms of within and between interactions. Most employment and establishments are concentrated in the B2C Local economic ecosystem level as these dominate final products and services to consumers that helps manage their day-to-day living covering a broad range of demand from consumers. On the other hand, SC Local industries, serving a small range of business and government customers service a smaller range of products and services.

10.2. Regional Economic Ecosystem Structure with Interdependencies

A salient feature of mapping the economic ecosystem structure is that it is scale agnostic, making it possible to study the complex economic relationships of any size economic ecosystem as a sub-space of the national ecosystem. For instance, Figure 13 below provides the economic ecosystem structure of the San Francisco–Oakland–Hayward, CA metropolitan statistical area (MSA).

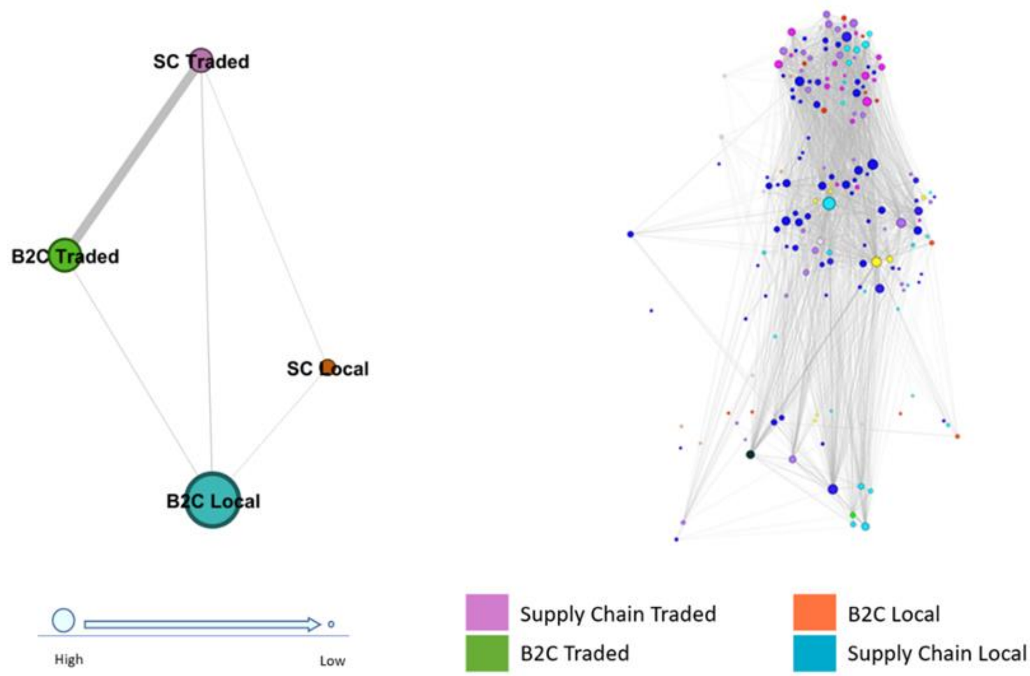


Figure 13 San Francisco, CA MSA Economic Ecosystem Structure with Interdependencies.
Note: Left panel node sizes reflect the proportion of high interdependencies for each entrepreneurial ecosystems level, relative to that of the national entrepreneurial ecosystems level. Right panel node sized reflect the degree of each node. Graphs generated using Gephi 0.9.2 and OpenOrd Clustering Algorithm.

Graphing the sub-spaces of the national ecosystems reveals hidden information about the unique character of the economic ecosystem. For instance, as seen in figure 13 above, in the San Francisco, CA MSA ecosystem, the SC Traded economic ecosystem level only reflects 3.5 percent of the total positive within SC Traded interdependencies as the U.S. national ecosystem and accounts for 441 thousand regional jobs. On the other hand, the B2C Traded economic ecosystem level covers the smallest number of regional jobs of any economic ecosystem level, 122 thousand as of 2018, but accounts for the largest share of interdependencies in the ecosystem at 9.1 percent. A policy interpretation of these data suggests that even if the SC Traded economic ecosystem level pays the highest wages and has the largest interdependencies nationally, in San Francisco incentivizing entrepreneurship in the B2C Traded economic ecosystem level is likely to have a larger ecosystem-wide effect on the region's resources and output as that level is relatively underdeveloped relative to its potential.

In the following section I elaborate more on, and generalize, the policy implications of using an entrepreneurial ecosystem's economic ecosystem structure to inform entrepreneurship policy with a more example of regional ecosystems.

11. Conclusion

In this chapter I mapped the structure of economic ecosystems both nationally and regionally by focusing on economic complementarities that drive agglomerations and input-output patterns of exchange between firms and industries in regional economies as drivers of the evolution of an economic ecosystem. I recommended that mapping the relative strength of those networked relationships provides a way of identifying those industries (or adjacent industry spaces) that act as critical nodes in the economic ecosystem—and thus represent high-value targets for entrepreneurship policy.

In the next chapter 4, I combine the theoretical foundations and policy framework of economic ecosystems discussed in chapter 2 with the methodology developed here to provide an example of this economic ecosystem approach in practice.

CHAPTER 4. AN ASSESSMENT OF THE ENTREPRENEURIAL ECOSYSTEM OF VENTURA COUNTY, CA

This chapter provides an example of an entrepreneurial ecosystems policy framework applied at the county-level for Ventura County in California. The theory and perspectives developed in this dissertation are applied in this chapter to identify the strengths, weaknesses, and opportunities of Ventura County's economy with a view to foster the regional development of a high-functioning entrepreneurial ecosystem. The research agenda was developed in cooperation with the Economic Development Collaborative of Ventura County, and engaged directly with several stakeholders[18] and policy organizations vested in fostering the region's entrepreneurial ecosystem.

In keeping with the theoretical developments of chapter 2 and the methodology elaborated on in chapter 3, the core idea forwarded in this chapter is to better align Ventura County's entrepreneurship and innovation efforts with its regional economic ecosystem. Accordingly, a series of target industries is suggested for entrepreneurship policy intervention based on their capacity for generating technological spillovers broadly in the economy, and spur entrepreneurship that is rooted in the county.

[18] A complete list of the stakeholders and participants in the research is provided in the Appendix.

1. Introduction

The research in this chapter concentrates on identifying entrepreneurial opportunity in Ventura County's regional economic ecosystem, and explicating the regional institutional systems enable innovation and entrepreneurship in the region.

Too often, when economic development officials start talking about strategies to develop regional entrepreneurship, the discussion turns immediately to hackathons, accelerators, and the activities of university technology transfer offices. Yet, most entrepreneurship is not digital, most entrepreneurial learning does not take place in accelerator programs, and most entrepreneurial dynamism does not come from the licensing of technology from universities. Entrepreneurship is embedded in regional capabilities and entrepreneurial ecosystems are a tangible part of the day-to-day reality of economic life—that is, within the larger domain of economic development activity—deeply embedded within every dimension of regional economies. Every new restaurant, every corporate spin-off, every startup dream nurtured in a community college classroom or retirement seminar is part of the entrepreneurial ecosystem.

The capacities of people in the region to do real work are like the DNA of the ecosystem. As I have noted earlier, the ability of economic actors and agents in a region to combine and re-combine those productive capacities into new goods and services—including ones that are new to the region or new to a neighborhood, even if not new to the world—is the essence of the entrepreneurial process.

In this chapter, I draw upon the concepts and tools introduced in the first two chapters of the dissertation to present an assessment of the entrepreneurial ecosystems of

Ventura County, California. In so doing, I undertake to capture the real entrepreneurial activity along various dimensions, both structural and institutional.

In section 2, I introduce an index of entrepreneurial ecosystem performance based on regional entrepreneurship outcomes. While the ecosystem indicators selected here have a strong basis in the literature, their specific selection was also guided by the policy expertise and experience of the regional economic developers. The selection of these metrics was guided by a need for easily grasped set of performance indicators for each of California's 58 counties, allowing comparisons between and among them.

In Section 3, I draw on the entrepreneurial ecosystems strategy literature to identify the domains of policy action and relate these to the indicators assessed above. The purpose of this section is to display Ventura County's strengths and weaknesses in a graphic format, organized around the several "domains" of an entrepreneurial ecosystem: Policy/Leadership, Finance, Culture, Supports, Human Capital and Markets.

This step crucially helps various stakeholders and practitioners involved position themselves in relation the policy objectives and goals of fostering Ventura County's entrepreneurial ecosystem (Isenberg D. , 2014). Managing entrepreneurial ecosystems is a complex task involving many programs, organizations, and individuals interacting along various dimensions. Providing a domain space for policy action enables a convergence of policy conversations and the formulation of strategic initiatives and alignment of resources across different entities mandated with managing the region's entrepreneurial ecosystem.

In Section 4, I identify pathways of entrepreneurial activity that extend naturally from the county's strongest, and most distinct, current capacities. This method is a direct application of the methods for mapping the structure of economic ecosystems discussed in chapter 3. For the purposes of Ventura County's assessment, the interdependence measures were estimated at the county-level using all US counties with available data in 2018 in the Quarterly Census of Employment and Wages.

In Section 5, I extract competitive and related industry clusters that most share the promise of entrepreneurial growth in the region. The selection of the clusters was based on an empirical assessment of the most related industries in Ventura County's economic ecosystem. However, the definitions and boundaries of relatedness for each of the related industry clusters was informed through conversations with regional economic developers, as they are aware of informal processes and constraints in Ventura County's entrepreneurial ecosystem that are not easily explicated through a quantitative assessment of the data.

Finally, Section 6 provides my concluding remarks on for aligning a region's entrepreneurship policy with its economic ecosystem. The research in this chapter is focused on Ventura County's entrepreneurial ecosystem, yet, the chapter and approach has been structured to make the policy framework outlined in chapter 2 a generalizable policy tool for entrepreneurial ecosystems policy.

2. Assessing Ventura County's Performance

2.1 Entrepreneurial Ecosystem Indicators

As of 2018, Ventura County ranks 9th among California's 58 counties for its entrepreneurial ecosystem performance. Ventura County's relatively strong rank at 9th, and ahead of Santa Barbara County at 12th (by criteria described in detail below) is counter to popular perception. Rather than recognizing Ventura County's competitive strengths, I more commonly heard in the development of this report that Ventura County does not host a vibrant or competitive entrepreneurial ecosystem. The data tells a more nuanced story. While it is encouraging to see the county's relative strong overall standing, the purpose of the methodology and ranking is not for credit or blame, rather it is to provide an analytical framework that may inform what actions the region's leadership might consider to nurture the entrepreneurial ecosystem and thereby improve the county's economic competitiveness. What becomes apparent in the several indicator summaries following is that Ventura County is characterized by a diversity of strengths and weaknesses; recognizing and understanding those provides meaningful guidance for priorities in policy and practice moving forward.

To assess Ventura County's performance in some considerable detail relative to California's 58 counties, I adapted a toolkit developed in 2015 by the Kauffman Foundation for measuring entrepreneurial ecosystems to make county level entrepreneurship assessments. Upon that basis, I ranked the vibrancy and performance of each California county, specifically along four entrepreneurship indicators:

- entrepreneurial density,

• startup connectivity,

• resource fluidity, and

• economic diversity.

Each of these four indicators is informed by several sub-measures, described in more detail in the following summaries. I also in the following summaries compare the indicator rankings of Ventura County with those of Santa Cruz, Santa Barbara, and Orange counties, as these counties provide a reasonably diverse set of comparatives in the geography and culture of coastal California. A full list of indicators and standing by county is provided in Appendix I.

Figure 14 provides a radar chart showing the overall comparative entrepreneurial ecosystem indicator rankings of:

• Orange County, rank 4;

• Ventura County, rank 9;

• Santa Cruz County, rank 11;

• Santa Barbara County, rank 12.

In Figure 14, the top vertex shows the overall county rank, and the remaining four vertices show the individual indicator ranks for each of the counties. Higher ranks— for example Orange County ranked number 4 overall, near the top of Figure 14—are represented away from the center.

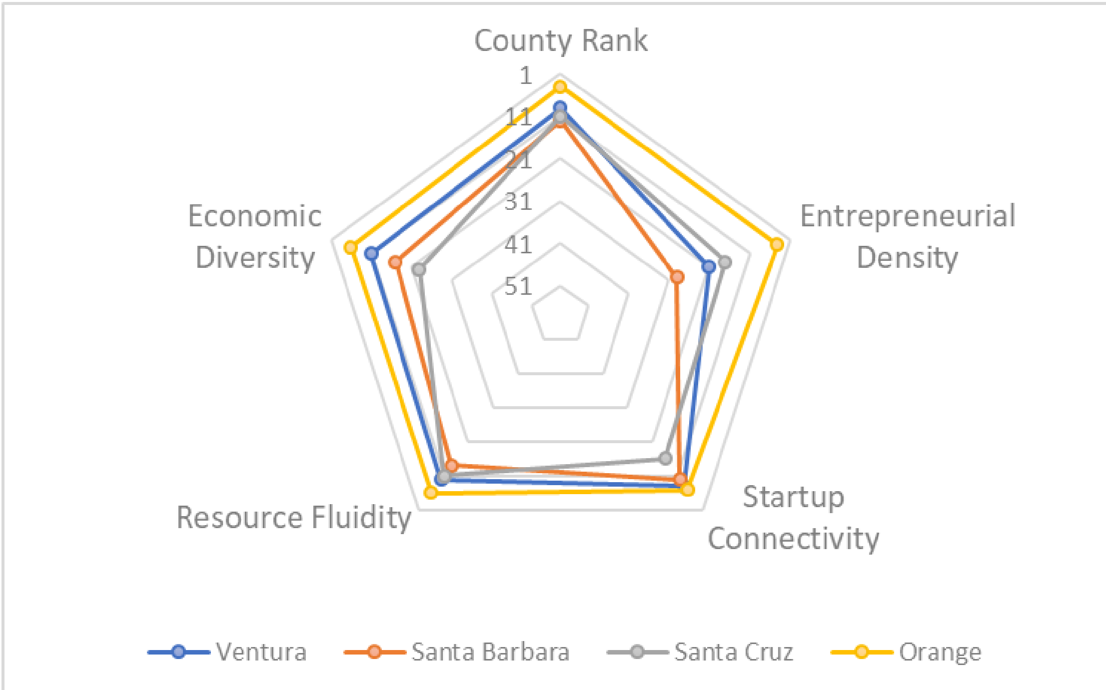


Figure 14 Entrepreneurial Ecosystem Indicator Rankings for Select Counties in CA, 2020.

Ventura County performs best in terms of its startup connectivity, ranking 8th in the state. The county's ecosystem also ranks very high, 10th and 11th, respectively, in terms of the resource fluidity and economic diversity indicators. Less competitively, however, the County's entrepreneurial ecosystem significantly underperforms in generating entrepreneurial density—defined as the concentration of entrepreneurial activity in the region in terms of new business activity—ranking 21st in the state. The following provides detail on the several economic measures that comprise the indicators, along with a summary of Ventura County's relative standing.

2.1.1 Entrepreneurial Density:

Entrepreneurial density measures the concentration of entrepreneurial activity in the region, in terms of new business activity and its potential for growth and successful exit. Here I measure: • The concentration of new business activity registered on the Crunchbase database in the past year because I want to capture the density of entrepreneurial new firms actively advertising a desire for growth by engaging with investor networks. • The number of initial public offerings (IPOs) issued since 2015 to companies headquartered in the county, to reflect the potential for successful growth and exit. • The rate of incorporated self-employment activity in the workforce to reflect the entrepreneurialism of residents, and the professional support available to local startups.

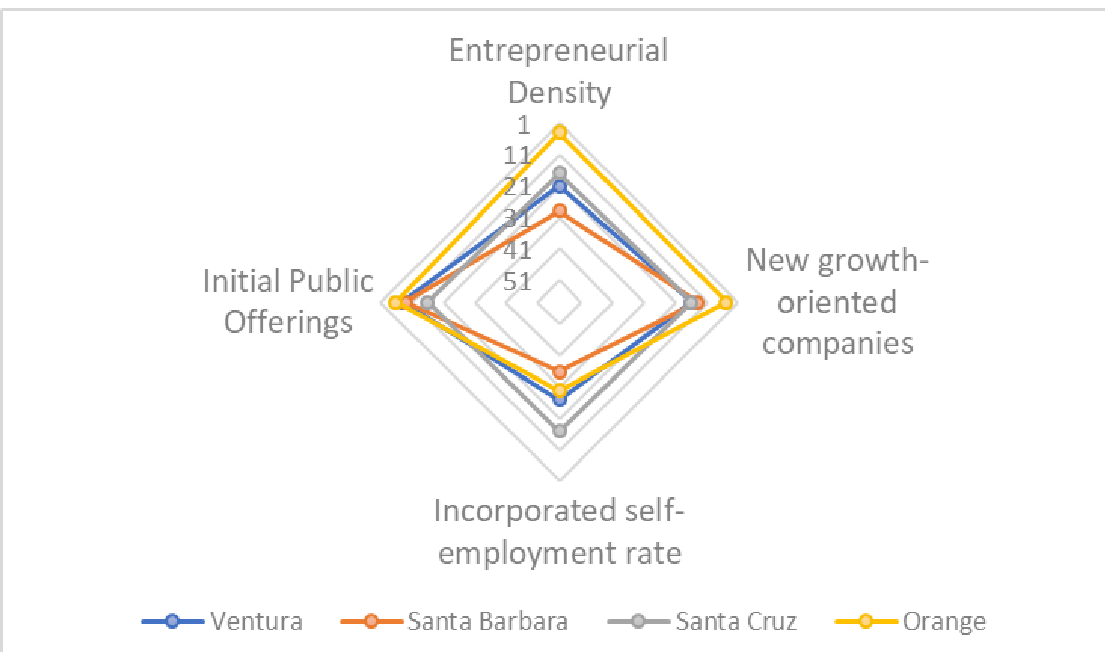


Figure 15 Entrepreneurial Density Indicator Rankings for Select Counties in CA, 2020.

Ventura County underperforms significantly in the entrepreneurial density indicator, ranking 21st overall. The county's ranking lags especially because of a low incorporated self-employment rate of 3.8 percent, 27th out of the state's 58 counties. Ventura County also ranks a relatively low 16th for the number of growth-oriented companies, but a relatively high 8th rank for the number of IPOs issued in the county since 2015. See Figure 2.

2.1.2 Startup Connectivity:

Startup Connectivity Ecosystem connectivity measures the presence of institutional and individual agents that facilitate the formation, growth and success of local startups. In this indicator I assess: • The number of startup events hosted in the county. • The number of entrepreneurship programs in local higher education institutions. •The density of individual angel investors reported active in the county. Ventura County ranks 8th in the state for its entrepreneurial startup connectivity. The county outperforms both Santa Barbara (10th) and Santa Cruz (16th) on this indicator but still lags Orange County (7th). For this indicator, Ventura County also ranks 8th both for the number of startup events and entrepreneurship programs hosted in the county. However, Ventura County underperforms in the number of angel investors actively investing in local businesses, ranking 13th in California, with Crunchbase reporting 37 active individual angel investors in the County. Ventura County's strongest suits in this indicator are in hosting start-up events and entrepreneurship programs, with 15 startup events and 13 entrepreneurship programs listed on Crunchbase in the past year.

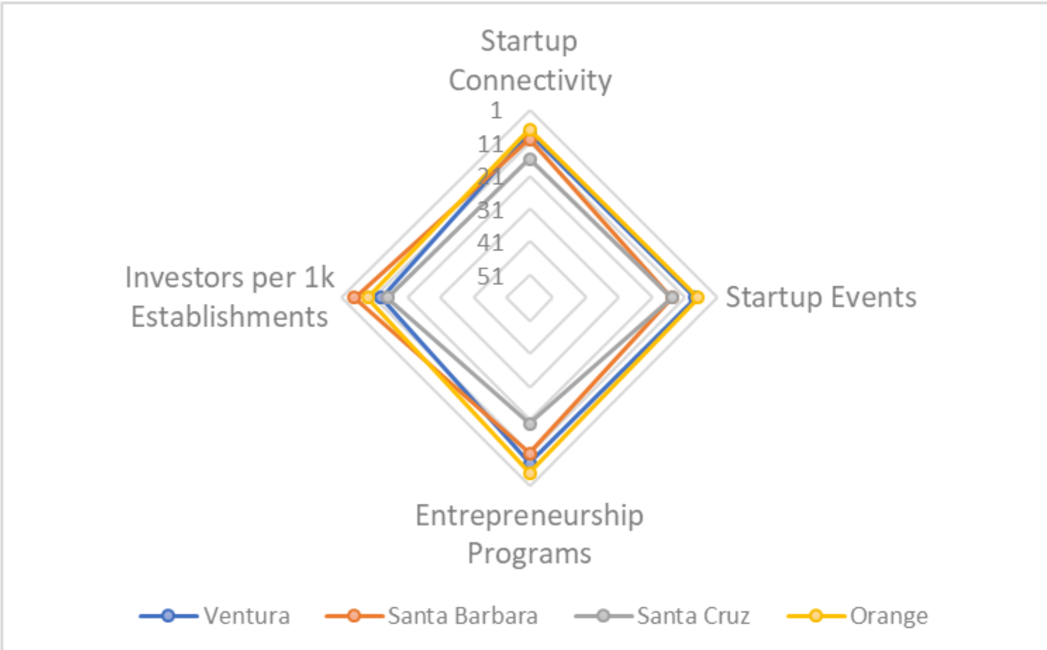


Figure 16 Startup Connectivity Indicator Rankings for Select Counties in CA, 2020.

2.1.3 Resource Fluidity:

Resource Fluidity Ecosystem resource fluidity is a measure of how effectively the entrepreneurial ecosystem is in using existing resources to create new opportunity. This indicator includes: • The rate at which the county adds net new business establishments to its economy, as this captures the expansion of economic activity in the region. • The incidence of high-growth firms to reflect the potential for new economic activity to be transformative for the ecosystem. • The number of successful second stage rounds funded to companies headquartered in the county to capture the ecosystem assets that enable the high growth activities. Ventura County ranks 10th in the state for its ecosystem fluidity, outranking both Santa Cruz (11th) and Santa Barbara (14th) on this indicator but lagging Orange County (6th). Ventura County added 351 net new establishments to its economy in 2015, growing at a rate of 1.7 percent, placing it 12th in the state, and has 17 companies listed on the Inc. 500 list as of 2018, providing the County with a rank of 8th for high growth firms. Investors closed 48 second-stage deals with companies in Ventura County in the last 3 years, giving it a relatively low dealmaker's rank of 15th in California.

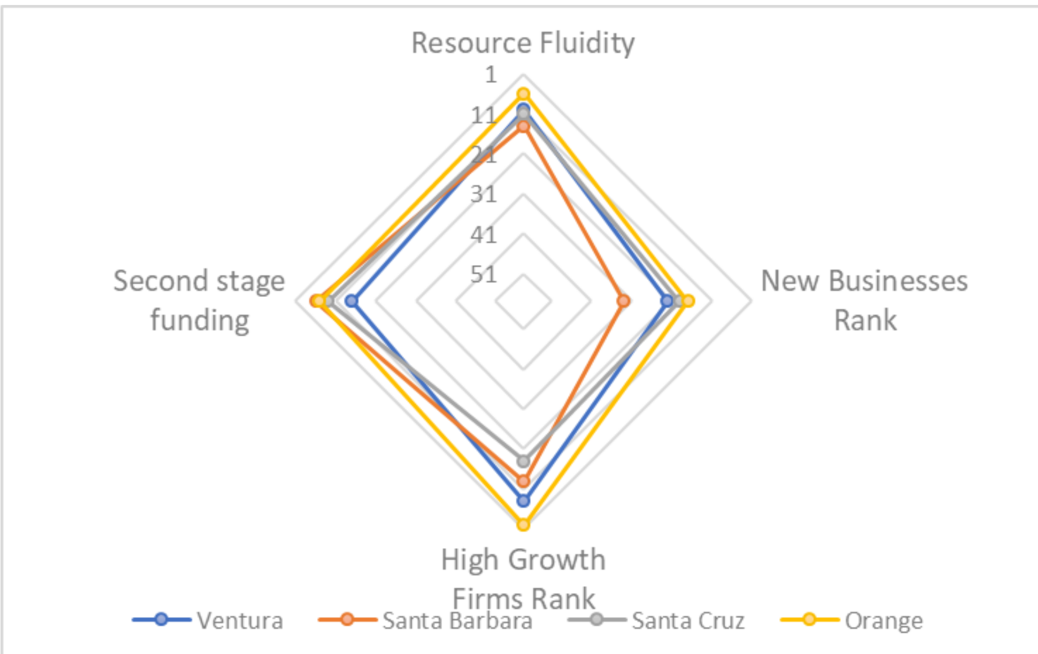


Figure 17 Resource Fluidity Indicator Rankings for Select Counties in CA, 2020.

2.1.4 Economic Diversity:

Economic diversity captures the variety of available resources in the ecosystem for the generation of new ideas and business ventures. I measure diversity along two dimensions – people and processes. This indicator includes:

• **People.** The share of foreign-born residents in the county as a reflection not only of a higher propensity for entrepreneurship, but also to capture the presence of cross-country and cultural networks that facilitate the introduction of new ideas and resources into the entrepreneurial ecosystem.

• **Processes.** The diversity of inter-related economic production processes at work in the county. This estimated measure provides an idea of how well- aligned different industrial activities are to one another, such that entrepreneurs can more effectively 'bricolage' existing knowledge and resources for innovation.

The appendix of this dissertation provides a detailed assessment of Ventura County's economic 'substrate'. Ventura County ranks a low 17th in California for the diversity of its entrepreneurial ecosystem. The county ranks 16th for its foreign-born share of population and 12th in terms of its economic diversification index.

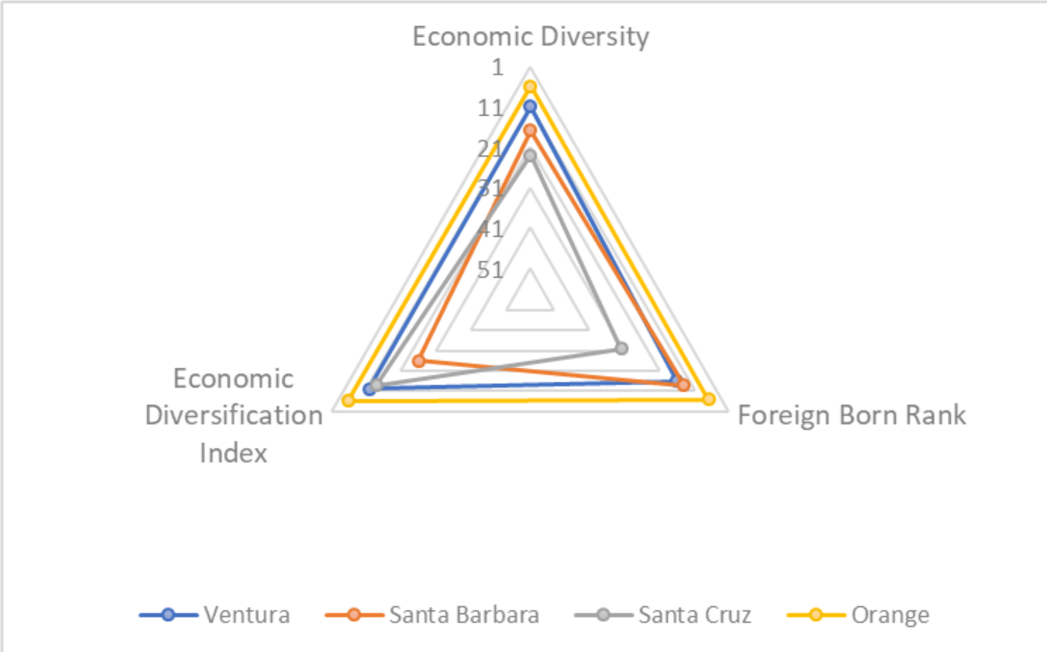


Figure 18 Economic Diversity Indicator Rankings for Select Counties in CA, 2020.

Ventura County boasts a strong diversity of economic activity that ranges across the agriculture, advanced manufacturing, biotechnology, defense related technologies, professional services, and the entertainment and tourism sectors. However, many of the county's industry specializations do not share substantial interdependencies, resulting in potential loss of economic efficiencies that can bolster entrepreneurial growth. For instance, the policies that engage technical exchange across different industry specializations are likely to have high entrepreneurial payoffs for the County. More detail is provided on the economic 'substrate' and industrial diversity of Ventura County in the next sections.

2.2 Interpreting the Rankings for Ventura County and California

As displayed in Appendix I, five counties in California tend to significantly outperform all the other counties in the state in the ecosystem indicators. These counties are Los Angeles, San Francisco, Santa Clara, San Mateo, and San Diego.

This effect is partially due to the size of the counties (but not only, as San Mateo is not among the state's largest counties) but also to the wide distribution of economic, demographic and geographic characteristics of counties in California. An implication of this fact is that breaking into the ranks of the top five counties in California is significantly more difficult than entering the top 10.

Yet, even considering the skewed competitiveness of entrepreneurialism by county in California, my examination of the summaries at what informs Ventura County's overall ranking reveals that the county underperforms in several important measures relative to its peers. The county has a strong mix of the pre-requisites for a robust entrepreneurial ecosystem—a diverse economy, entrepreneurial culture, capacity to deepen entrepreneurial and investor networks—but the ecosystem requires attention relative to its capacity to increase entrepreneurial density.

The following section provides more insight into Ventura County's relative strengths and weaknesses, as well as guidance on priorities for improving the region's competitiveness.

3. The Policy Structure of Ventura County's Entrepreneurial Ecosystem

To better understand the policy structure, strengths and weaknesses of Ventura County's entrepreneurial ecosystem, I mapped the indicators measured above to Daniel Isenberg's 2011 domains of entrepreneurial ecosystems, highlighted in color below, in Figure 6.

Figure 6 provides a visual representation for where policy and practice may be concentrated to improve entrepreneurial outcomes.

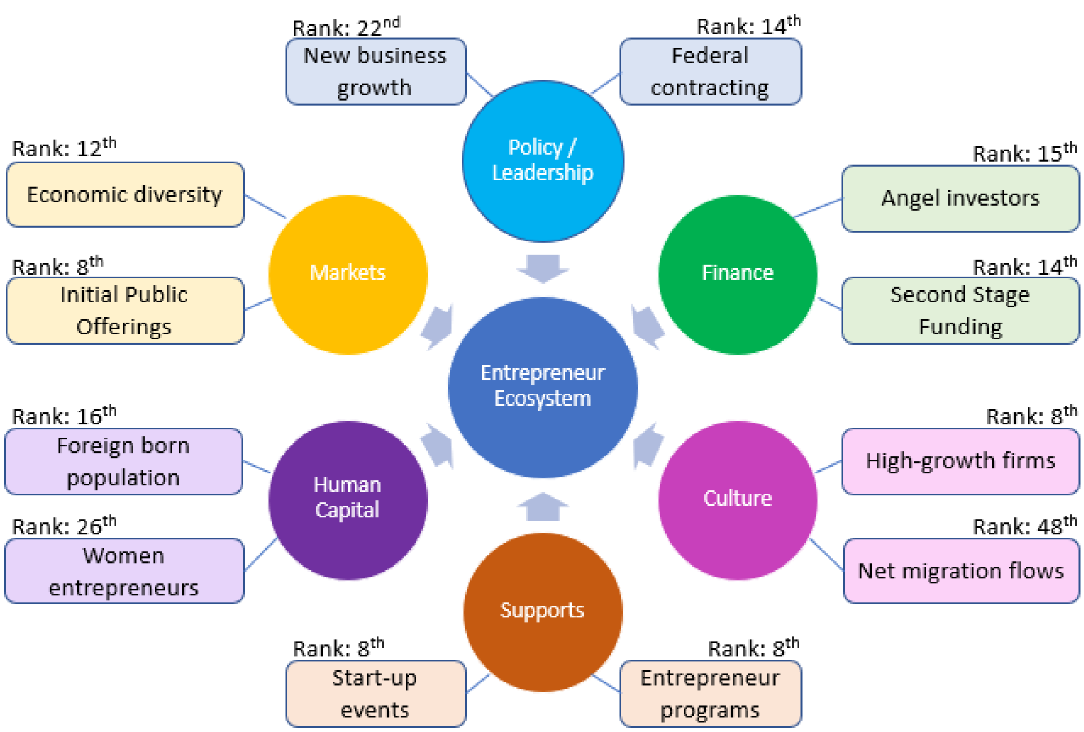


Figure 19 The Domains of Ventura County's Entrepreneurial Ecosystem. Adapted from Isenberg (2011).

For a sample of how this chart may help guide our regional formation of policy and practice, I note the Finance domain, which displays that Ventura County ranks 14th and 15th, respectively, in angel investors and second stage funding. This validates what is commonly believed, that Ventura County's entrepreneurial ecosystem is weak in terms of access to equity investment. While Ventura County's ranking in the Finance domain isn't dire, it does suggest opportunity for improvement.

Related to the Policy/Leadership domain, I see that Ventura County ranks 22nd in new business growth. This is a more difficult indicator to influence—that is, there is no single policy action or practice that alone will move the needle—though the data clearly suggests that the county's startup environment needs attention. Two additional measures—the amount of federal contracting dollars awarded to businesses and the net migration rate—are included in Figure 6 but were not included in the rankings. While I did not include these two measures in the core evaluation structure—mostly out of a desire to keep to a manageable set of variables—these additional measures help highlight important entrepreneurial ecosystem issues. The federal contracting data, attached to the blue Policy/Leadership domain, is a bit of a mixed message.

On the upside, Ventura County attracted $2.8 billion in federal contracting dollars by place of performance, which represents extraordinary opportunity for accelerating growth through public/private partnerships. But on the downside, Ventura County's levels remain far shy of San Diego and Los Angeles counties, which attracted about $31 billion each, and, worse, currently there is little in strategic programming to optimize the value of the local federal investment.

The net migration flow data, attached to the pink Culture domain, reveals a profound weakness, that Ventura County ranks near the bottom quintile in California.

That is, the county has been losing domestic migrants over recent years, even while it has gained in foreign migrants. This net outflow in domestic migration justifies an increasing anxiety among local policy leaders about the county's future, that Ventura County's population is getting older and the high cost of living makes Ventura County less attractive than other parts of the state. As a balance to that concern, I do note with some encouragement the orange colored Supports domain, which shows that Ventura County is stronger than generally believed for startup events and entrepreneur programs. As positive as that is, it is also motivation to concentrate ever more effort in this area, nurturing an emerging strength of the region's entrepreneurship ecosystem.

4. Mapping Ventura County's Related Industry Space

Ventura County's entrepreneurial ecosystem is very diverse with 111 four-digit NAICS industries showing a regional concentration of business activity greater than the national average, suggesting broad sectoral specialization. Focusing on the most specialized business activity in the county and their related industries, I identified six entrepreneurial clusters in Ventura County.

1. Agriculture
2. Advanced Manufacturing
3. Biotechnology
4. Defense Related
5. Information and Communication Technologies (ICT)

6. Entertainment, Tourism and Professional Services

"Related industries" are those that share a high degree of interdependence with each other. This interdependence may result from shared supply-chains, common labor pools, or requiring similar infrastructure. In short, related industries tend to share overlapping economic agglomerations that bolster entrepreneurial output.

4.1 Ventura County's Entrepreneurial Ecosystem Tiers

Figure 7 shows the entrepreneurial ecosystem of Ventura County segmented into three tiers according to the level of specialization of each industry. Only those industries present in one of the six entrepreneurial clusters of Ventura County are represented in the figure, and each tier's core characteristics are listed alongside.

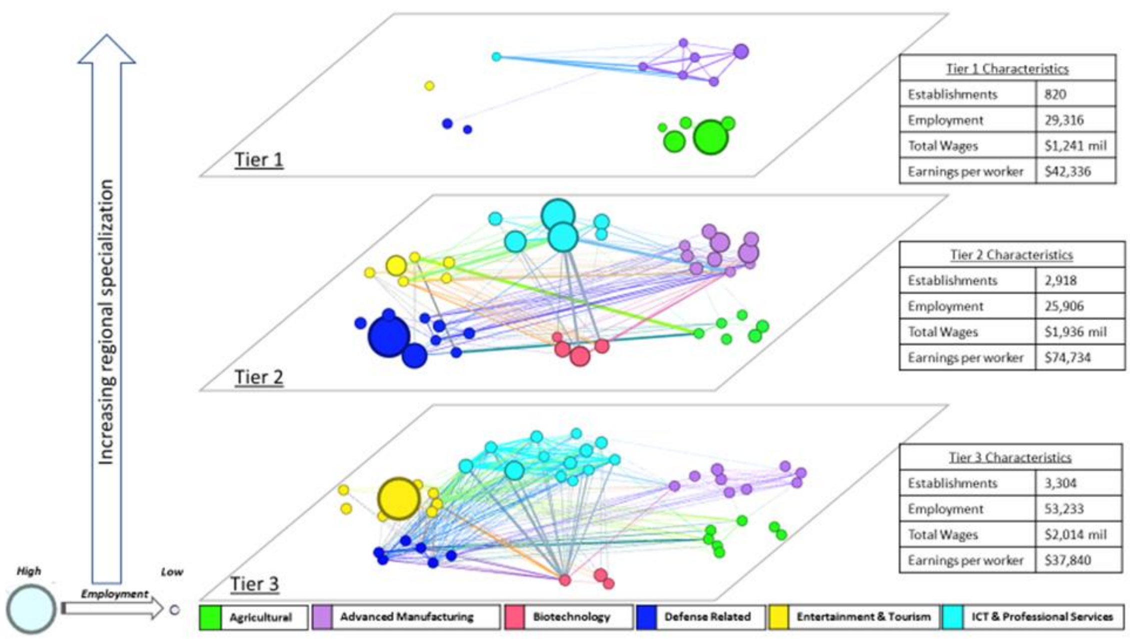


Figure 20 Map of Ventura County's Economic Substrate.

Tier 1 industries are at least twice as concentrated as the national average, revealing that businesses in these industries gain high competitive advantages from locating in Ventura County. Tier 1 businesses tend to be the oldest on average (median age 14 years) than other industries in the region, making them well-established and entrenched in the region's economy. Tier 1 businesses had cumulative sales of $3,121 million in 2014, which amounted to $112,277 in sales per worker, highest in the county's economy.

Tier 2 industries bare some competitive advantage in the regional economy being more concentrated than the national average, but less than Tier 1 industries. Businesses in this cluster have a greater turnover than Tier 1 industries and are also younger with a median age of 6 years. Nonetheless, in Ventura County business in this Tier pay the highest median wages to their employees at approximately $75,000 annually and bring in the most sales at $6,735 million in 2014, amounting to $109,853 sales per worker.

Tier 3 industries show no competitive advantages to being in Ventura County, and may even face regulatory or resource disadvantages that impede their growth. Businesses in these industries have a lower concentration than the national average and some, such as "restaurants and other eating places" are primarily local serving and lower paying. The median earnings per worker in this tier are the lowest at $37,840 with the tier's total sales in 2014 at $4,247 million, or about $71,882 sales per worker.

4.2 Ventura County's Ranking for Density of Related Industries

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Table 6 Ventura and Santa Barbara County Related Density Ranking.

2016 Rank	CA Counties Emp > 100 k	All California Counties	U.S. Counties 100k < Emp < 300k
Ventura County	#12 / 22	#25 / 58	#33 / 163
Santa Barbara County	#16 / 22	#31 / 58	#45 / 163

A primary hurdle to comparing the economic performance of regions is accounting for the differences in their industrial compositions and their degree of industrial diversification. To address this concern, I adjust for each county's industrial mix in terms of its "Related Density", i.e. the density of shared economic agglomerations within each entrepreneurial ecosystem.

This method reveals that compared to other U.S. counties with employment over 100,000, both Ventura and Santa Barbara counties perform near average in terms of their net new establishment creation rates (Fig A1). However, they significantly underperform in their rate of new job creation (Fig A2) as well as total wage growth (Fig A3). This suggests that the entrepreneurial ecosystems of both Ventura and Santa Barbara Counties are under-leveraging their economic assets for creating new and higher-paying jobs for the types of new business the region generates compared to other counties in the nation with similar levels of industrial agglomerations.

I evaluate how well unobserved ecosystem features including regional policy in Ventura and Santa Barbara counties is aiding, or hampering, entrepreneurial performance relative to other counties by generating a ranking that accounts for the county's related density, its employment size, and its wage structure, and reveals a measure of a county's entrepreneurial output relative to its expected performance given its economic structure and assets. The results of the ranking are robust to different measures of county-level entrepreneurial output including; net establishments growth and the rate of new business registrations.

The rankings show that Ventura and Santa Barbara both lag other mid to large size counties in California, as well as counties of similar size nationally. Table 1 below summarizes the county rankings, with the complete lists provided in the Appendix.

The ranking indicates both counties to be below average in their ecosystem performance.

5. Regional Entrepreneurial Clusters

5.1 Advanced Manufacturing

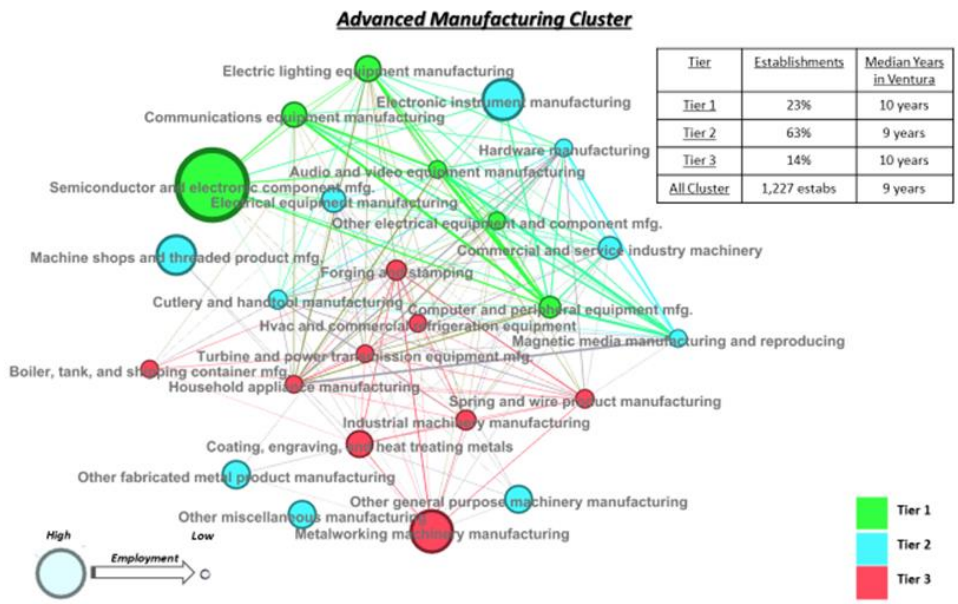


Figure 21 Ecosystem Map of Ventura County's Advanced Manufacturing Cluster.

The Advanced Manufacturing cluster in Ventura County is well-established, with the median business having started or located into the county around 9 years ago. Most of the cluster's activity is concentrated in Tiers 1 and 2, indicating that most of the county's businesses in this cluster are gaining some degree of local competitive advantage. The largest employment share in Advanced Manufacturing in Ventura County either works for businesses in "semiconductor and electronic components manufacturing" (Tier 1), "electronic instrument manufacturing" (Tier 2) or "metalworking machinery manufacturing" (Tier 3).

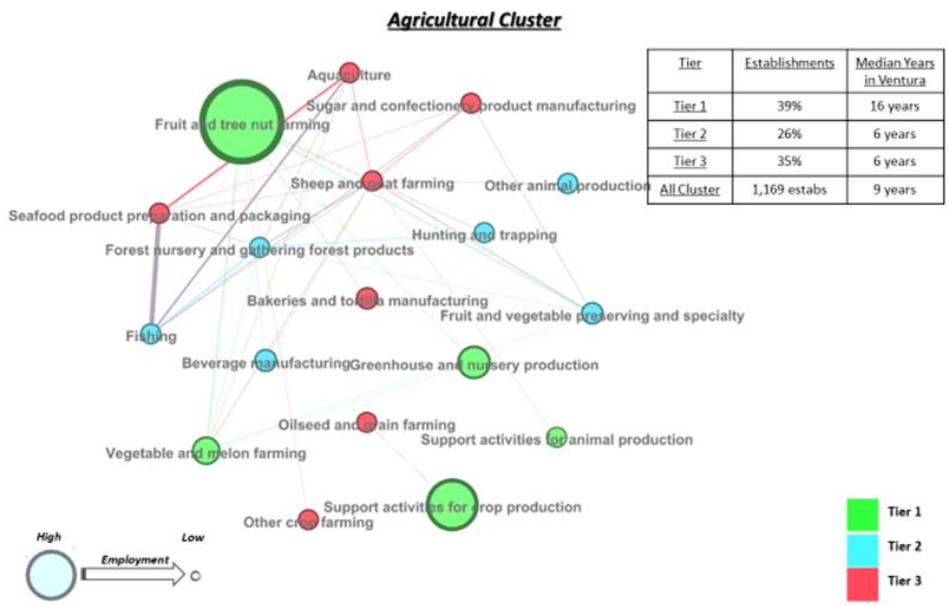
Table 7 Ventura County Advanced Manufacturing Related Cluster Metrics.

Employment, level	27,569 employees
Total Annual Sales	$3,880 million
Tier 1 - Establishments under 5 years (%)	22% (62 establishments)
Tier 2 - Establishments under 5 years (%)	30% (229 establishments)
Tier 3 - Establishments under 5 years (%)	20% (35 establishments)
Cluster Establishments under 5 years (%)	27% (326 establishments)

The 5 largest employers in this cluster in 2014 were; "Power-One, Inc."; "Technicolor Thomson Group"; "Xmultiple Technologies, Inc"; "Kavlico Corporation"; and, "Northrop Grumman Corporation".

The 5 fastest growing companies relative to their peers in sales in 2014 were; "Power-One, Inc."; "Scosche Industries, Inc."; "Zebra Technologies Corporation"; "Miller Electric Mfg. Co."; and, "Pacific Scientific Company".

5.2 Agriculture



Tier	Establishments	Median Years in Ventura
Tier 1	39%	16 years
Tier 2	26%	6 years
Tier 3	35%	6 years
All Cluster	1,169 estabs	9 years

Figure 22 Ecosystem Map of Ventura County's Agriculture Cluster.

The Agricultural cluster in Ventura County, broadly defined to include aquaculture and food-related activities, is well-established with the median business having started or located into the county around 9 years ago, and 16 years for Tier 1 industries in the cluster. The cluster's activity is almost evenly distributed across all three tiers, but most young businesses less than 5 years of age are in Tier 2 or Tier 3. The largest employment share in the Agricultural cluster in Ventura County either work for businesses in "fruit and tree nut farming" (Tier 1), "support activities for animal production" (Tier 1), or "vegetable and melon farming" (Tier 1).

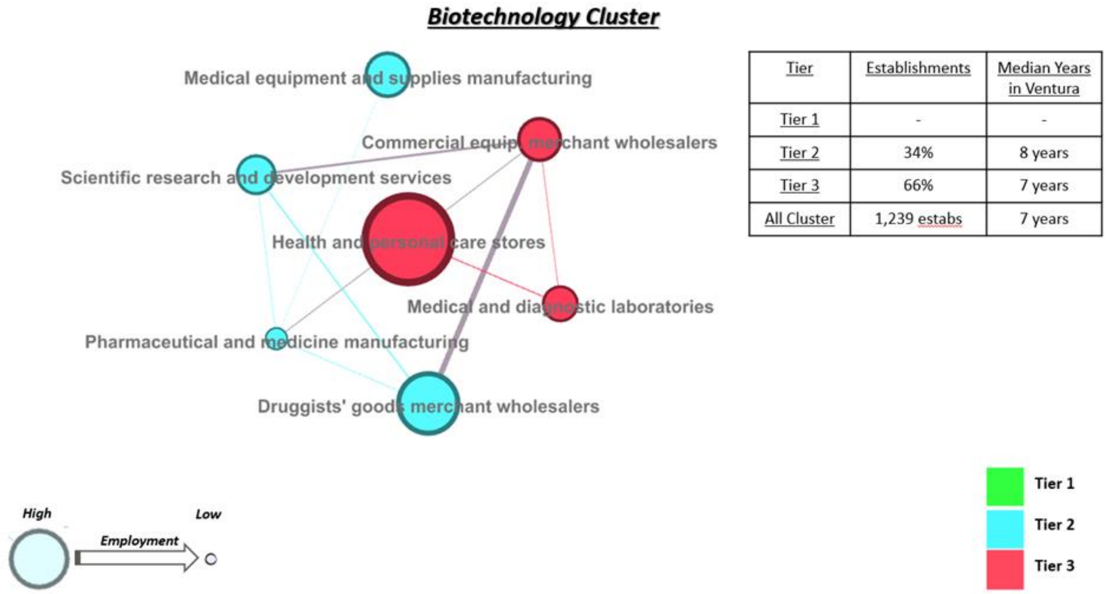
Table 8 Ventura County Agriculture Related Cluster Metrics.

Employment, level	12,297 employees
Total Annual Sales	$862 million
Tier 1 - Establishments under 5 years (%)	16% (72 establishments)
Tier 2 - Establishments under 5 years (%)	49% (150 establishments)
Tier 3 - Establishments under 5 years (%)	46% (188 establishments)
Cluster Establishments under 5 years (%)	35% (410 establishments)

The 5 largest employers in this cluster in 2014 were; “Boething Treeland Farms, Inc.”; “Pleasant Valley Flowers, Inc.”; “California Mushroom Farm, Inc.”; “Conroy Farms, Inc.”; and, “Boskovich Farms, Inc.”

The 5 fastest growing companies relative to their peers in sales in 2014 were; “California Mushroom Farm, Inc.”; “San Miguel Produce, Inc.”; “Red Blossom Sales, Inc.”; “DW Berry Farms, LLC.”; and, “Marin Labor Services.”

5.3 Biotechnology



Tier	Establishments	Median Years in Ventura
Tier 1	-	-
Tier 2	34%	8 years
Tier 3	66%	7 years
All Cluster	1,239 estabs	7 years

Figure 23 Ecosystem Map of Ventura County's Biotechnology Cluster.

The Biotechnology cluster in Ventura County is young and emergent with no industries specializing in Tier 1 and other activities distributed across Tier 2 and Tier 3. The region's biotech activity has historically developed around a handful of large companies, including Amgen, however this activity has not converted into significant spillover through sustained regional spinoffs to foster a thriving and entrepreneurial biotech cluster. New ventures in this space tend to follow venture capital and relocate outside of Ventura County (though there is some emergent activity for local equity investment). Additionally, the low presence of "medical and diagnostic laboratories" (Tier 3) in the county hampers the growth of new biotech venture startups that require wet-lab spaces to innovate and grow. The Biotech cluster shows potential for growth and can be defined still to be in a nascent stage regionally—identifying as an important growth opportunity for the region. The largest employment share in the Biotechnology cluster in Ventura County either work for businesses in “health and personal care stores” (Tier 3) “druggists’ goods and merchant wholesalers” (Tier 2), or “commercial equipment merchant wholesalers” (Tier 3).

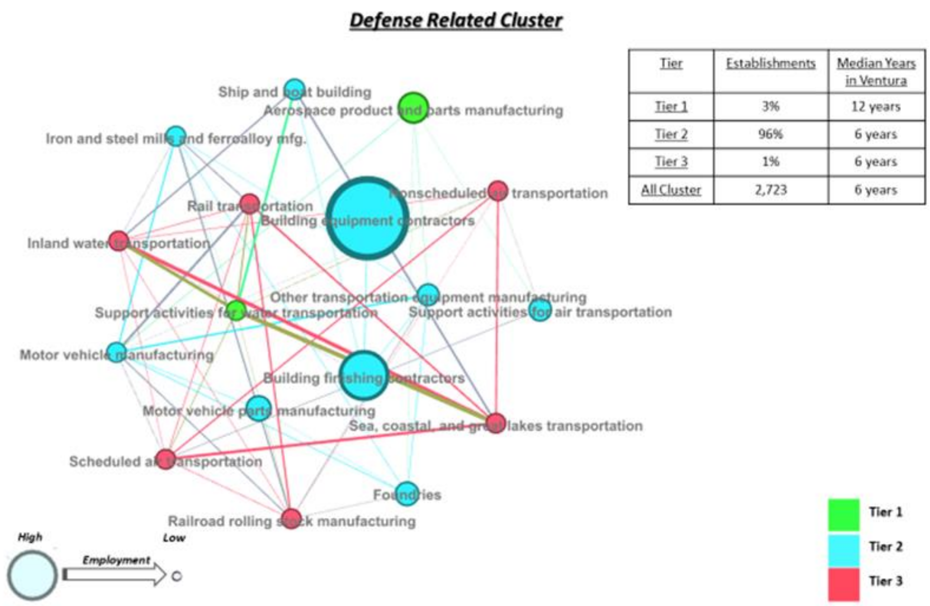
Table 9 Ventura County Biotechnology Related Cluster Metrics.

Employment, level	15,355 employees
Total Annual Sales	$2,348 million
Tier 1 - Establishments under 5 years (%)	-
Tier 2 - Establishments under 5 years (%)	31% (134 establishments)
Tier 3 - Establishments under 5 years (%)	34% (276 establishments)
Cluster Establishments under 5 years (%)	33% (410 establishments)

The 5 largest employers in this cluster in 2014 were; “Amgen, Inc.”; “Baxter Healthcare Corporation”; “Baxter Bioscience”; “Data Exchange Corporation”; and, “Seminis, Inc.”

The 5 fastest growing companies relative to their peers in sales in 2014 were; “Amgen, Inc.”; “Baxter Bioscience”; “Rolling Oaks Pharmacy, Inc.”; “Pharmaceutic Lith Label, Inc.”; and, “New Albertsons, Inc.”

5.4 Defense-related



Tier	Establishments	Median Years in Ventura
Tier 1	3%	12 years
Tier 2	96%	6 years
Tier 3	1%	6 years
All Cluster	2,723	6 years

Figure 24 Ecosystem Map of Ventura County's Defense-rated Cluster.

The Defense-related cluster in Ventura County, narrowly defined to include maritime and aerospace activities, is an older regional cluster with the median business having started or located into the county around 6 years ago and 12 years for Tier 1 industries in the cluster. The cluster's activity is almost entirely concentrated in Tier 2 industries (96% of establishments), and young firms appear in Tiers 2 and 3 industries of the cluster at nearly the same rate. This suggests the cluster to have dominant established companies in the Tier 1 space industries that dissuade new entrepreneurial entry. The largest employment share in the Defense-related cluster in Ventura County either work for businesses in "building equipment contractors" (Tier 2), "building finishing contractors" (Tier 2), or "aerospace products and parts manufacturing" (Tier 1).

Table 10 Ventura County Defense-related Related Cluster Metrics.

Employment, level	13,689 employees
Total Annual Sales	$1,454 million
Tier 1 - Establishments under 5 years (%)	17% (13 establishments)
Tier 2 - Establishments under 5 years (%)	43% (1,131 establishments)
Tier 3 - Establishments under 5 years (%)	46% (11 establishments)
Cluster Establishments under 5 years (%)	42% (1,155 establishments)

The 5 largest employers in this cluster in 2014 were; "Taft Electric Company"; "Meggitt America, Inc."; "CPP-Port Hueneme"; "PAC Foundries, Inc."; and, "PTI Technologies, Inc."

The 5 fastest growing companies relative to their peers in sales in 2014 were; "PTI Technologies, Inc."; "American Airlines, Inc."; "Thiessen Products, Inc."; "Tidewater Marine Western, Inc."; and, "SDG Enterprises."

5.5 Entertainment and Tourism

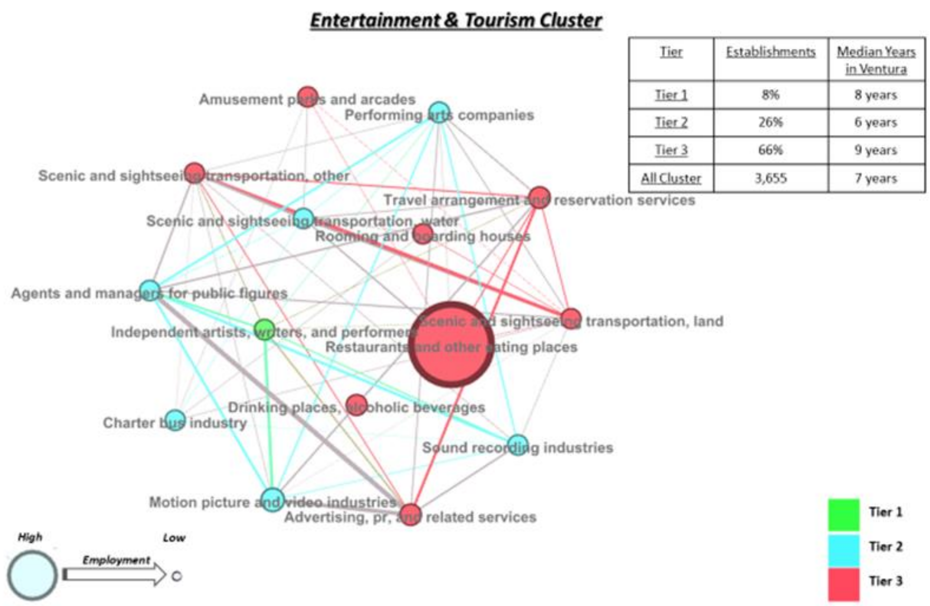


Figure 25 Ecosystem Map of Ventura County's Entertainment and Tourism Cluster.

The Entertainment and Tourism cluster in Ventura County is underdeveloped with potential for future growth. Most businesses in the cluster are between 6 and 9 years of age, making it a relatively young cluster in the county. The cluster's activity is mostly concentrated in Tier 3 industries (66% of establishments) and in mostly local serving industries such as "restaurants and other eating places." Young firms are mostly evenly distributed across the three tiers suggesting there is no specific entrepreneurial entry advantage to businesses in one tier over another. The largest employment share in the Entertainment and Tourism cluster in Ventura County either work for businesses in “restaurants and other eating places” (Tier 3) “motion picture and video industries” (Tier 2), or “advertising and related services” (Tier 2).

Table 11 Ventura County Entertainment and Tourism Related Cluster Metrics.

Employment, level	35,282 employees
Total Annual Sales	$1,690 million
Tier 1 - Establishments under 5 years (%)	37% (108 establishments)
Tier 2 - Establishments under 5 years (%)	42% (396 establishments)
Tier 3 - Establishments under 5 years (%)	34% (817 establishments)
Cluster Establishments under 5 years (%)	36% (1,321 establishments)

The 5 largest employers in this cluster in 2014 were; “Technicolor Thomson Group”; “Technicolor HM Entertainment Services, Inc.”; “Hishmeh Enterprises, Inc.”; “Pleasant Holidays, Inc.”; and, “Cheesecake Factory Restaurant, Inc.”

The 5 fastest growing companies relative to their peers in sales in 2014 were; “Pleasant Holidays, Inc.”; “Westlake Davvar Corporation International”; “Debard, Inc.”; “Phillips, Ltd.”; and, “Chilis, Inc.”

5.6 Information Communication Technologies (ICT) and Professional Services

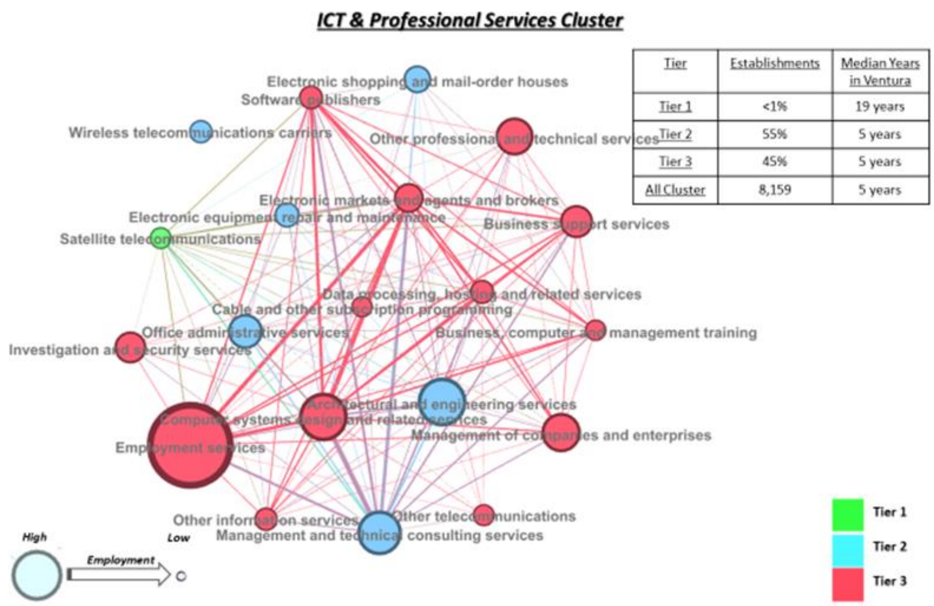


Figure 26 Ecosystem Map of Ventura County's Information and Communication Technologies and Professional Services Cluster.

The ICT and Professional Services cluster in Ventura County has emerged largely as a support cluster for other regional economic activities. This is evident in the fact that less than 1% of establishments in this cluster are present among Tier 1 industries, all concentrated in "satellite telecommunications." Most businesses in the cluster are young, around 5 years of age, yet those in "satellite telecommunications" have been in Ventura County for a median 19 years. Most of the cluster's business activity concentrates in Tier 2 industries (55% of establishments). Young firms are evenly distributed across the Tiers 2 and 3, suggesting possible barriers to entrepreneurial entry in Tier 1. The largest employment share in the ICT and Professional Services cluster in Ventura County either work for businesses in “employment services” (Tier 3), “computer systems design and related services” (Tier 3), or “architectural and engineering services” (Tier 2).

Table 12 Ventura County Information and Communication Technologies and Professional Services Related Cluster Metrics.

Employment, level	43,948 employees
Total Annual Sales	$3,868 million
Tier 1 - Establishments under 5 years	-
Tier 2 - Establishments under 5 years	47% (2,100 establishments)
Tier 3 - Establishments under 5 years	51% (1,871 establishments)
Cluster Establishments under 5 years	49% (3,971 establishments)

The 5 largest employers in this cluster in 2014 were; “Engility Corporation”; “Xavient Infor Systems, Inc.”; “Central Purchasing, Inc.”; “Hearst Communications, Inc.”; and, “JDA Software, Inc.”

The 5 fastest growing companies relative to their peers in sales in 2014 were; “Engility Corporation”; “Encore Repair Services, Inc.”; “Home Depot USA, Inc.”; “Dial Security”; and, “C D Lyon Construction, Inc.”

6. <u>Conclusion</u>

If one word can capture both the strengths and weaknesses of the Ventura County economy, it is “maturity”. For a regional economy, maturity is obviously a positive characteristic. It suggests that the region possesses highly evolved capacities that are unlikely to exist in other places—the economic equivalent of the presence of a snow leopard or white rhinoceros in a biological ecosystem. The possession of such rare capacities makes the mature economy the envy of less-mature economies. However, "maturity" can also imply stasis —the possibility of a hard reality that substantive evolution has come to an end, terminating at a developmental plateau. Nurturing an entrepreneurial ecosystem in a place like Ventura County is really about making the most of the upsides of regional economic maturity, while avoiding its downsides.

This chapter has provided an example of how the strategic practices of entrepreneurial ecosystems can be combined with the evolutionary research approaches of entrepreneurial ecosystems. The purpose has been to demonstrate how developments in the entrepreneurial ecosystem theory can directly contribute towards improving our understanding of economic development while building on approaches and standard practices of today. Importantly, this chapter, through example has emphasized the uniqueness of geography, the scale-free, and multi-dimensional nature of economic interdependencies as essential concerns for economic development.

The essence of an entrepreneurial ecosystem is its people and the culture of trust and collaboration that allows them to interact successfully. The ecosystem allows for the fast flow of talent, information, and resources so that entrepreneurs can quickly find what they need at each stage of growth. As a result, the whole is greater than the sum of its parts. A thriving ecosystem includes these elements:

- Entrepreneurs who aspire to start and grow new businesses and the people who support entrepreneurs.
- Talent that can help companies grow.
- People and institutions with knowledge and resources to help entrepreneurs.

- Individuals and institutions that champion entrepreneurs and the ecosystem.
- Onramps (or access points) to the ecosystem so that anyone and everyone can participate.
- Intersections that facilitate the interaction of people, ideas and resources.
- Stories that people tell about themselves and their ecosystem.

Culture that is rich in social capital – collaboration, cooperation, trust, reciprocity and a focus on the common good.[19]

If entrepreneurship is about gap-filling (Shane & Venkataraman, 2000), opportunity identification, and recombination (Auerswald P. E., 2015), the entrepreneurial ecosystem must be a reflection of not only the people, processes, and systems that enable the realization of novel economic opportunity, but also the sources of that opportunity embedded in a region's history and its capabilities. This dissertation, and this chapter in specific, has provided a novel synthesis of the sources and realization of entrepreneurial opportunity in the context of policy evaluation and implementation.

[19] From the Kauffman Foundation, The Entrepreneurial Ecosystem Playbook 3.0 (Ewing Marion Kauffman Foundation, 2020)

CHAPTER 5. A FUTURE RESEARCH AGENDA FOR ENTREPRENEURIAL ECOSYSTEMS RESEARCH

I began this dissertation with the question, are entrepreneurial ecosystems designed or evolved? In answer, I argued that entrepreneurial ecosystems are evolved artifacts of human design. They are a result of human ingenuity but they follow natural processes of economic growth that Schumpeter (1934) proposed early on as the foundations of development. The question of design vs evolved also helps differentiate the entrepreneurial ecosystems approach from its antecedent theories in systems of innovation, or the innovation systems literature, that did not necessarily ascribe to a complex view of entrepreneurial systems. In drawing upon the biological analogy, the entrepreneurial ecosystems approach has pushed entrepreneurship theory and practice into a realm of new computational models and heterodox approaches to explaining the sources and processes of economic novelty.

The entrepreneurial ecosystems approach is here to stay. The core premise of placing entrepreneurial action within the context of its environment has materially shifted entrepreneurship policy conversations from static assessments of entrepreneurial output, to considerations of entrepreneurial processes. In the entrepreneurial ecosystems perspective, entrepreneurship is not studied simply along individualistic dimensions of the aspiration, motivations, and characteristics of individual entrepreneurs, nor only with the aim of building the right institutional frameworks for supporting entrepreneurship, but instead the entrepreneurial ecosystems approach emphasizes a meso-systems level of economic analysis that focuses on interactions, dynamism, and processes of growth (Lambooy, 1990).

Scholars within this perspective have largely abandoned neo-classical assumptions of static equilibrium and embraced traditionally heterodox views on bounded rationality and multiple equilibria. Alongside the relaxation of basic assumptions, the entrepreneurial ecosystems approach has also been drawn towards more computationally heavy empirical assessments built on network theory, complexity theory, and are often modeled through simulations. This meso-level thinking brings entrepreneurship studies in line with emergent empirical methods in the social sciences developing specifically from complexity theory.

The advent of these theoretical and empirical developments, such as those proposed in this dissertation, have opened new avenues to explore and explain complex economic phenomenon and address critical questions on the nature and practice of entrepreneurial ecosystems. For instance, Alvedalen and Boschma (2017, p. 898) list five critical areas for entrepreneurial ecosystems scholarship that need advance;

(1) A clear analytical framework to explicate what is cause and effect in an entrepreneurial ecosystem.

(2) Clarification on how proposed elements are connected in an entrepreneurial ecosystem, and which interactions matter most.

(3) Clarification on which institutions and spatial scale have an impact on the structure and performance of entrepreneurial ecosystems.

(4) An empirical framework for elucidating the comparative and multi-scalar perspective of entrepreneurial ecosystems.

(5) Explicit modeling of the how entrepreneurial ecosystems evolve over time.

The research in this dissertation has addressed some of these challenges while others remain in the domain of future research. Specifically, I have proposed a framework to identify the sources and opportunities for entrepreneurial growth in regions. This framework doesn't disentangle causal mechanisms behind growth but helps identify specific areas with an economy for closer investigation. Importantly, by embedding an entrepreneurial ecosystem within its regional economic ecosystem the framework provides a link between the visible entrepreneurial activity in a region and its local capabilities.

Furthermore, by distinguishing between institutional systems where entrepreneurial interactions exist, and the regional industrial structure where entrepreneurial capabilities reside, the framework enables policy makers to empirically identify niches of entrepreneurial opportunity and develop targeted policies based on the strengths and weaknesses of any niche. Short of an analytical framework for explicating cause and effect, the proposed methodology identifies spaces of entrepreneurial interactions where evolutionary and institutional processes interact and are ripe for empirical research.

The second limitation stated by Alvedalen and Boschma (2017) is related to the consideration of how a region's economic history has contributed to its current entrepreneurial state and its future potential. Entrepreneurial ecosystems are complex forms of organization whose history is represented by multiple potential pathways of development, although only one of which manifests to reality. Identifying which elements of an ecosystem are driving entrepreneurial processes, as well as which interactions matter most should be related to the pathways of economic development under consideration and are likely to be different across regional industry clusters as well as over time. For instance, entrepreneurial ecosystems policies for regional diversification need to identify the industry branches where entrepreneurial action is most likely to re-shape the regional structure in the desired direction of economic growth, and should be evaluated under the consideration of regional leadership and resources available for the policy action. Thus, the determination of an entrepreneurial ecosystem's connected elements and their relevant interactions is a consideration based of the desired outcomes of the entrepreneurial ecosystem policy and the available resources to the policy makers.

The third limitation harks back to the problem of identifying the boundaries of an entrepreneurial ecosystem. To this point, I have argued that an entrepreneurial ecosystems is embedded in its regional economic ecosystem, and that similar to ecology, no two economic ecosystems are identical, that they are multi-scalar, and often overlap, or share transition zones with one another. An entrepreneurial ecosystem's boundaries then should be defined according to its economic ecosystem, at least in the geographic dimension. Furthermore, the teleological argument stands prominent in defining the proper scope and boundaries of an ecosystem, and just as political boundaries have been defined according to the scope of policy action, so should entrepreneurial ecosystem boundaries be defined according to the scope of the policy makers reach.

In this dissertation I have provided a method for mapping entrepreneurship spaces based on network theory and developed upon the principle of relatedness (Hidalgo, et al., 2018). The goal has been to provide a means of empirically identifying the sources of entrepreneurial opportunity in a regional industry mix. In chapter 3, I developed the methodology for metropolitan statistical areas and in chapter 4 I extended the methodology to the county-level of assessment. Important features of my approach include its applicability across different scales of an economy, but also allow for a comparability of relatedness across different ecosystems, as well as over time. Most salient feature of this advance is it ability to identify ecosystem niches and assess entrepreneurship outcome indicators specific to the industry niches in concern, thus allowing for comparative assessments based on individual ecosystem components and processes.

In this dissertation I have suggested that the entrepreneurial ecosystems perspective is maturing as a field under the re-convergence of both the evolutionary and institutionalist economics views. This re-convergence is ushering in non-conventional and heterodox computational approaches to the study of entrepreneurship. Alongside conversations in entrepreneurial ecosystems are fast moving into the realm of dynamic equilibria and simulation models.

Although much work remains on identifying the causal mechanisms in entrepreneurial ecosystems that bring about systemic change in their economic ecosystems, my research in this dissertation has laid the initial foundations for a future research agenda. I have outlined the theoretical precepts for entrepreneurial ecosystems and presented a network methodology for mapping the resources available for recombinant entrepreneurship.

APPENDIX

Figure A1: Map of Ventura County's Economic Substrate, with industry labels

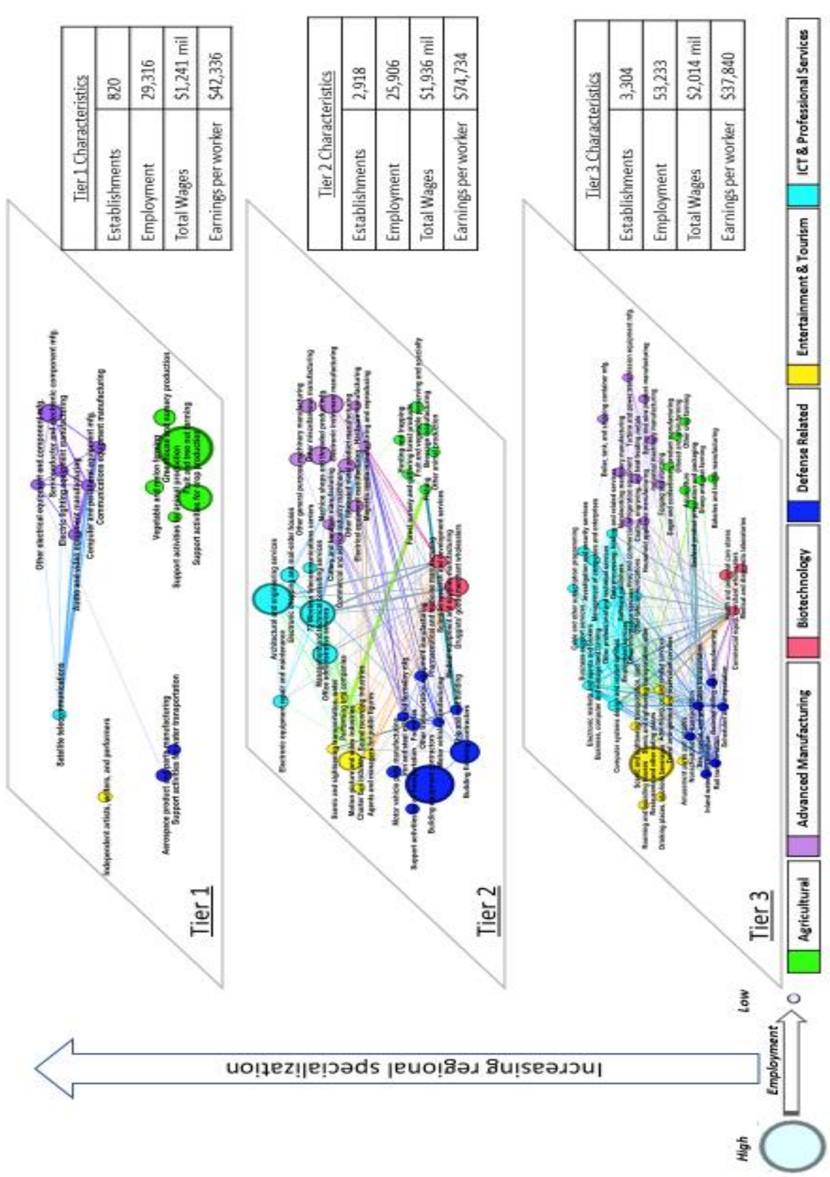


Figure A2: Net Establishments Growth Rate Ventura & Santa Barbara Counties

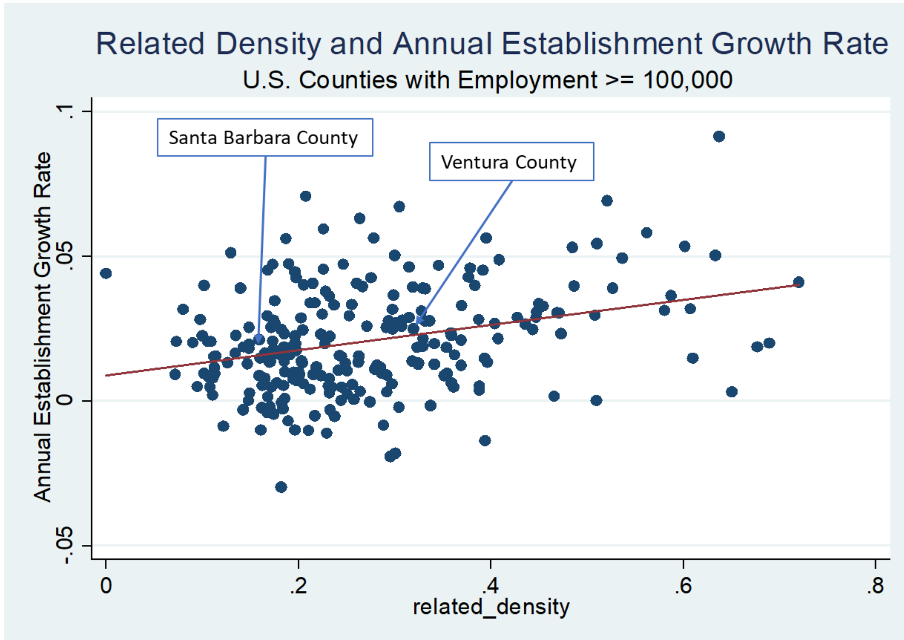


Figure A3: Employment Growth Rate Ventura & Santa Barbara Counties

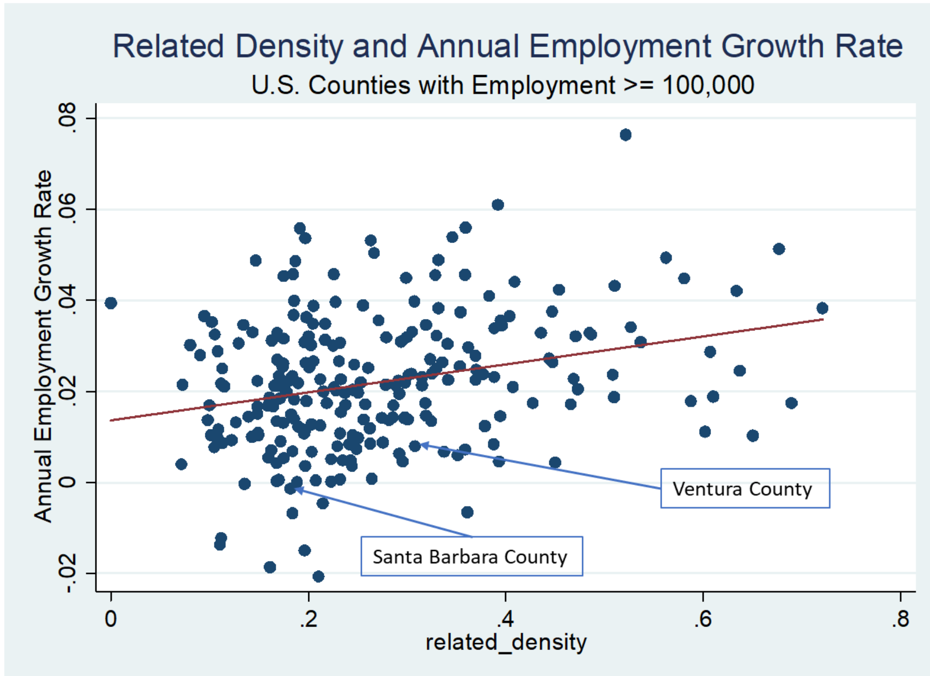


Figure A4: Total Wage Growth Rate Ventura & Santa Barbara Counties

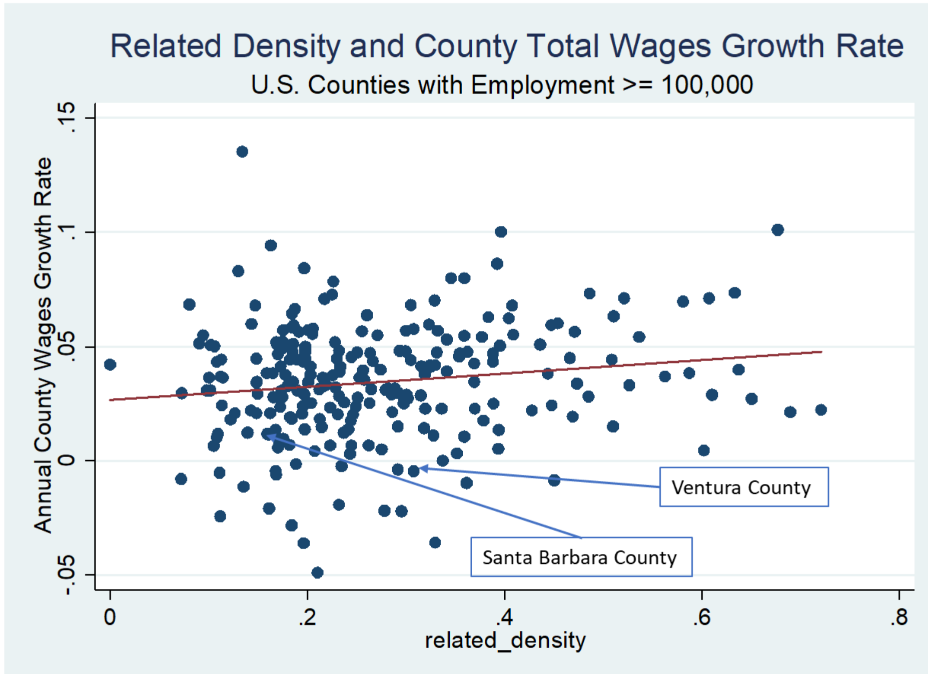
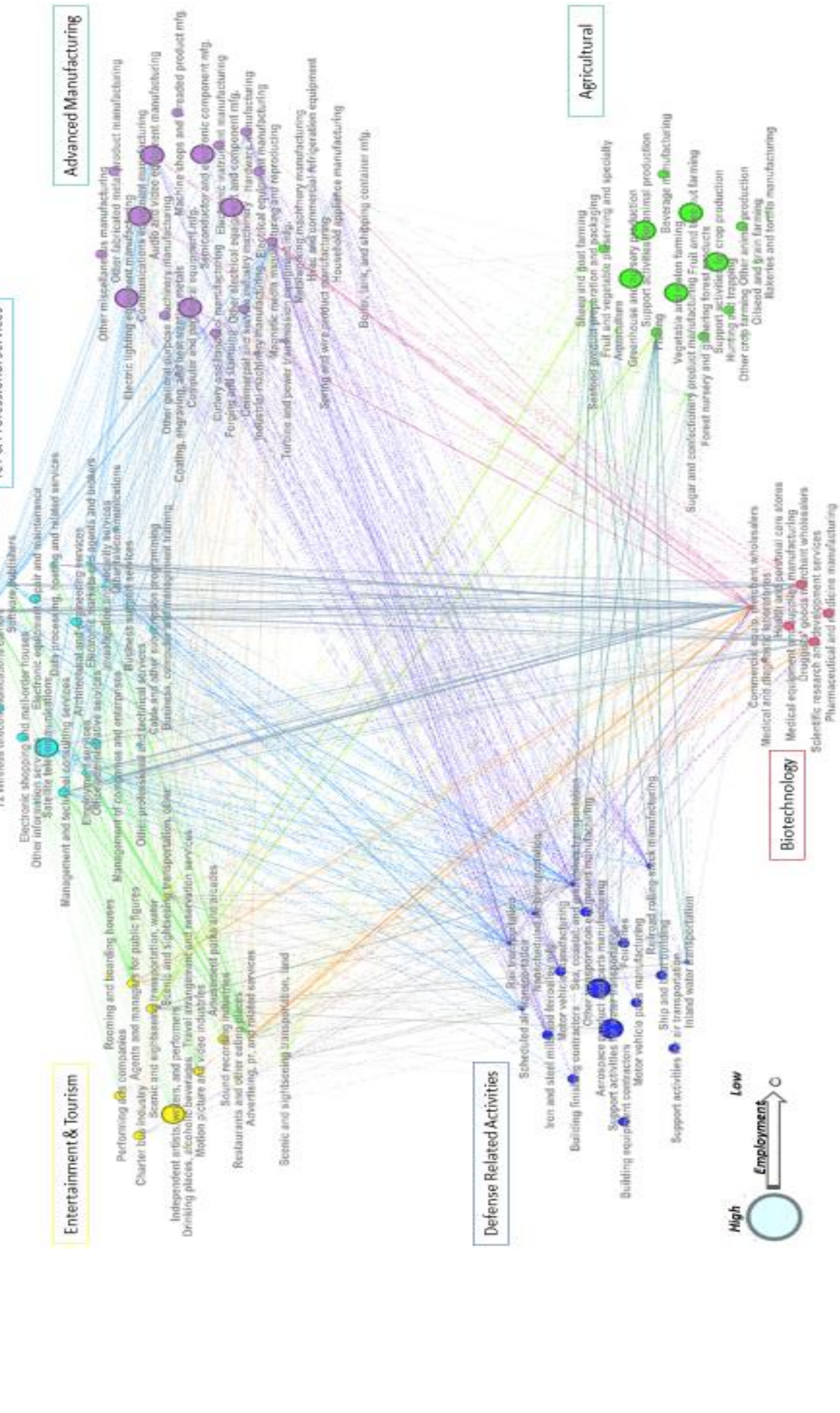


Figure A5: Ventura County's Cross-Cluster Relatedness



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