Examining the Dark Side of Innovation: A Review of the Divergence in Regional Economic Opportunity within the United States

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Introduction

Innovation has resulted in tremendous growth and development around the world, as it is widely considered to be key to real economic growth and development. Researchers suggest that innovation must not be something that simply happens, but is a policy target for governments to drive mission-oriented and investment-driven innovative growth (Mazzucato, 2015). The national innovation system concept has also driven and supported the case that knowledge and innovation are what continue to drive real economic growth. The concept was formulated by economists who found that traditional neoclassical economics offered insufficient answers for the true determinants of growth and competitiveness.

National innovation systems often include the institutions, policies, actors, and processes that affect the creation of knowledge and the processes that influence the adoption of innovation (Chaminade et al., 2018). Economists have found that a nation's competitiveness is often a function of many non-price factors, some of which include capabilities, the nation's knowledge infrastructure and linkages between institutions. These concepts help nations formulate policy strategies to drive development and competitiveness on the basis of knowledge and learning.

However, the importance of innovation to economic theory precedes the national innovation system concept. Innovation theory and how it drives economic growth and development began with Joseph Schumpeter who coined the phrase "creative destruction," recognizing the role of innovation in disrupting existing systems and improving efficiency. The process of creative destruction is critical to economic growth and development, providing incentives on behalf of incumbents to consistently improve to maintain competitiveness, and inspiration for others to disrupt. Well-recognized business management theories are based upon this core idea, such as David Teece's Dynamic Capabilities framework, which focuses on behaviors and activities that help to prevent disruption and drive new innovation (Teece et al., 1997). These theories are often applied in the context of individual technologies, firms, or industries, where one is able to leapfrog or maintain an advantage in the marketplace through a new business model, technological advance, or pioneering a new market segment entirely. The opportunity to disrupt and shape the direction of markets, technology, and economic growth is core to the optimal functioning of economic markets and thus central to improvements in productivity, economic outcomes, and general welfare.

However, does all creative destruction lead to a fair share of the benefits and does creative destruction always lead to stronger innovative capabilities?

Although creative destruction and its underlying principles of competition are key to creating incentives that lead to improvements in efficiency and economic outcomes, it has historically not led to equitable shares in the gains of productivity. This is most evident when observing that the share of wealth and income gained has become increasingly asymmetric over recent decades, with the United States being a particularly good example. As of 2018, income inequality was found to be at record highs in the United States with the Gini Index measuring 0.485, nearly twice as high as Denmark's level of inequality, which was listed at 0.25 (CIA, 2020). Federal Reserve Chairman Jay Powell stated in February of 2019 that income inequality would be one of the biggest challenges of the next 10 years for the United States (Long, 2019). Wealth inequality was found to be even more asymmetric, with wealth inequality increasing over time. In 1989, the bottom 50% of families possessed 3% of the nations' net worth as the top 10% of the country possessed 67% of the nations net worth, while families in between possessed 30%. By 2016, the bottom 50% of households in the U.S. held $1.67 trillion or 1% of the net worth of the country, compared to $74.5 trillion or 77% held by the top 10% (Kent, Ricketts, & Boshara, 2020).

Despite being a historical leader in innovation on the world stage, the United States' greatest problems involve not only wealth and income inequality, but also in the realm of innovation. According to the Global Innovation Index, the United States has been declining in innovative ability and outcomes. Formed in 2007, the Global Innovation Index (GII) is an annual ranking of countries by their capacity for, and success in innovation. According to the index, the United States has neither been the most innovative, nor second most innovative nation since before the Great Recession in 2008. In the 12 years following the United States has ranked in the top 3 only once.

There are also other underlying issues that trouble the United States. In addition to declining innovative capacity and output, other worrying signs suggest that the overall health within the United States is in decline. Despite what have been strong economic indicators, life expectancy in the U.S. declined for three consecutive years between 2014 and 2017, something that had not occurred in the United States since 2018, during the Spanish Flu and World War 1 (Bernstein, 2018). For comparison, developed western nations in the EU have had increasing life expectancy over the period of 2014 to 2017.

The U.S. has been a world leader in innovation over the past century, accomplishing feats of technological change that has resulted in immense gains, particularly advancements in the worlds of bits, biomedical sciences, manufacturing, as well as continued technological innovation and automation. How has innovativeness supposedly declined? The United States has contributed some of the most impactful innovations in the modern world, how has life expectancy managed to decline for three years in a row for the first time in a century while the majority of the world witnessed increasing life expectancy?

Traditional innovation theory would suggest that economic profits are a reflection of innovative capability. Supporting frameworks, such as the SECI learning model for example, suggest that innovation and knowledge contribute to further growth in innovation and knowledge. Innovation leads to higher competitiveness and higher competitiveness leads to greater economic productivity, profit and welfare. In the United States however, innovative indicators that have been positively correlated with increased GDP have now declined and become negative in some instances. Is it possible that innovation and creative destruction has led to excessive disruption of the American economic system?

To address and understand this phenomenon, this project will seek to address the issue of the "dark side of innovation." In recent times, there has been an emphasis placed on the value of innovation and the role it plays in real growth. However, in measuring the value of knowledge, innovation, and the benefits of creative destruction to the progress of society, there must be an analysis of the negative externalities and effects of innovation. In particular, this paper will seek to understand the extent to which innovation and creative destruction have led to declining benefits on a national scale over time in the United States, and the factors through which this has occurred. This paper supports the argument that not only do the principles and outcomes of creative destruction apply to individual firms, industries, sectors, or markets, they influence future innovative capabilities. As mentioned, both qualitative and quantitative evidence support that idea that economic development is knowledge-driven, as knowledge creation and the resulting innovations reflect processes of interactive learning within systemic frameworks. In a country where income inequality, corporate profits and GDP are at record highs, examining the evolution of the economic landscape can build a better understanding of the relationship and effect innovation has had on the future of economic growth in the United States.

To more closely examine the shifts caused by innovation, economic geography and evolutionary economic geography can construct an understanding of regions that have been impacted by innovation. In addition, evolutionary economic geography presents a framework that highlights the role of innovation in the development and transformation of economies. Therefore, this project will aim to analyze the negative impacts of innovation and creative destruction through the lens of economic geography and industrial dynamics in order to better understand the mechanisms by which innovation can harm future productivity and economic development, with a particular focus on the economic geography of the United States.

This project will address the following research question:

Where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry? How has the evolution of knowledge, geography, and industry affected innovative capabilities? To what degree is innovation responsible for declining economic opportunities and outcomes?

Theory Section

In order to begin to develop an understanding to address the research question, it is vital to review relevant theory. This section will have a particular focus on addressing both the first and second parts of the three part research question:

Where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry? How has the evolution of knowledge, geography, and industry affected innovative capabilities? To what degree is innovation responsible for declining economic opportunities and outcomes?

This task involves not only aiming to address the question itself, but delving into theory in order to deeply comprehend the extent to which knowledge, geography, and industry evolve as a result of innovation.

For this reason, this section will cover a range of literature within the economic geography field, including evolutionary economic geography, with the aim to develop an understanding of how innovation influences the evolution of economic geography. Although the historical aspect inherent in evolutionary approaches is critical to understanding the evolution of geography and the American economic landscape, it is important to gain a clear understanding of the current situation. Michael Storper's paper titled, "*Separate Worlds? Explaining the current wave of regional economic polarization*" presents a useful introduction to the current economic landscape in the United States and a useful introduction to the effect that past innovation has had on the current economic landscape. Storper illustrates the divergence in opportunities and innovative capacity between the urban and rural areas of the United States by focusing on per capita incomes, labor mobility, and the spatial distribution of skills and educational outcomes. His work creates a useful contextual platform to dive deeper into causes of regional failure and success, as he presents strong evidence for diverging economic opportunities within the United States.

Storper's article captures statistics that illustrates the decline in American innovative capacity. Elements which have historically contributed to the idea of the 'American Dream', such as entrepreneurship, the ability to capture new opportunities, and upward class mobility have become increasingly peripheral to the typical American (Storper, 2018). Declining interregional migration and employment opportunities both reflect the disappearance of the 'American Dream.' Interregional migration has fallen to half of its century-long average from 1880 to 1980, and regions have become increasingly selective for skill level (Kaplan and Schulhofer-Wohl, 2012; Giannone, 2017)(Storper, 2018). Similarly, differences in the labor force participation rate between regions are at highs last seen during the Great Depression and intergenerational class mobility is increasingly polarized between regions (Chetty et al., 2014)(Storper, 2018).

Storper argues that the new divergent geography of employment and incomes corresponds with a dispersed geography of opportunity in the United States. For instance, the contrast between the growth in opportunities within metropolitan areas and the decline in opportunities elsewhere is stark. Metropolitan areas with greater than one million people in the United States created three-quarters of the net employment increase in the United States from 2010 to 2016 (Storper, 2018). In addition, “half of U.S. employment is located on 1.5 percent of its land area” (Storper et al., 2015, pg. 247).

However, not all metropolitan areas have benefitted from the ‘re-urbanization’ of the United States. A study found that not only has economic outcomes diverged between metropolitan and non-metropolitan areas, they have also diverged between various metropolitan areas. Among cities in the United States, the variance of per capita personal income has risen 30% from 1980 to 2016 (Ganong and Shoag, 2017). This divergence in economic outcomes between urban areas has occurred regardless of skill, as the interregional variance in real income among workers with similar skills has increased (Kemeny and Storper, 2012).

Contextual details along with the empirical evidence presented by Storper highlight a shift from the post-WWII convergence of incomes and opportunities in the United States to an increasing divergence in incomes and opportunities, particularly between urban and rural areas. The cause of this shift, what many economic geographers call the “great inversion”, is due to the the “dual role of technological change in the form of the rise of new, spatially-concentrated sectors, and globalization, through a generalized revolution in trade costs” (Storper, 2018, pg. 262). Storper argues that rising regional disparities began in the 1970s with increasing levels of technological innovation (Storper, 2018). Supporting this timeframe, research done by Piketty and Saez in 2003 pointed out that income inequality among households has been rising since the 1970s (Piketty and Saez, 2003).

Factors contributing to the Divergence in Opportunity

Economic geographers have attributed increasing income inequality to factors like global trade-based integration, skill-biased technological changes and market-oriented institutional reform (Yamamoto, 2007). Globalization is considered one of the largest factors to the divergence of opportunity in the United States. The start of the rise in income inequality in the United States corresponded with a “critical shift in scales at which economic relations have been organized and governed from the early

1970s," as the global scale had replaced the nation state scale according to a review of the scalar literature on globalization (Yamamoto, 2007, pg. 81). Although transnational corporations remain heavily reliant on national policies and regulations within this global paradigm, urban regions have replaced the nation-state as the central player in global competition (Scott, 1988, 1998; Storper, 1992, 1997; Porter, 1998) (Yamamoto, 2007).

Within the United States, increasing income divergence between regions has been affected by both structural shifts in the real economy as well as in the financial sphere of the economy (Yamamoto, 2007). The heightened opportunity for firms to capitalize on comparative advantage through advances in technological innovation, transportation and communication have led to rising regional disparities typified by the rise of 'world cities' (Yamamoto, 2007; Storper, 2018). Technology, finance, and advanced service sectors within these large metropolitan areas continue to both stimulate and take advantage of agglomeration economies where firms within can select from a large pool of skilled workers in high-turnover labor markets (Storper, 2018).

The literature has provided context through empirical evidence demonstrating that technology and technology-led globalization are central to rising interregional inequality levels within nations. The heightened prominence of metropolitan areas on the global stage has coincided with a decline in opportunities within regions, as smaller cities and rural towns have become increasingly peripheral (Storper, 2018). However, technology and globalization are not the only factors responsible for economic decline outside of large metropolitan areas, it is also necessary for regions to adapt to the changing environment.

"The Wealth of Regions" - Causes of Regional Economic Development and Decline

The 1995 paper titled "*The Wealth of Regions*" by Michael Storper and Allen Scott constructs a framework that addresses the issue of market failure and declining economic growth within regions. Their framework is not only useful for organizing and conceptualizing causes of failure and areas of improvement, it is also useful for illustrating the actions that result in evolving economic opportunity and outcomes. "*The Wealth of Regions*" serves as a solid foundation for the continued theoretical examination of causes of economic geographical change and supports the need for a deeper understanding of the economic divergence in the United States.

Storper and Scott describe regions as a nexus of transactions and economic activity that can be applied to larger and smaller scopes, albeit with slightly different forms and contexts behind the transactions at each level. They argue that all economic and social processes are sustained by transactions - some of which include the exchange of information, goods and labor. For these economic and social processes to function properly, transactions require regular and sustained information exchange between individuals (Storper and Scott 1995). However, the authors note that transactions and economic processes can be underpinned by a “virtually infinite variety of market, non-market, and hybrid structures”, thus recognizing that economic processes are often contextual (Storper and Scott 1995, pg. 506).

In describing regional success and failures, Storper and Scott argue that space plays a key role, as economic processes both influence and are influenced by space. However, not all processes are influenced in the same way, as the type of transaction determines the influence geographic distance has: “The greater the substantive complexity, irregularity, uncertainty, unpredictability and uncodifiability of transactions, the greater their sensitivity to geographical distance” (Storper and Scott, 1995, pg. 506). Additionally, the more simple, codifiable, certain and regular a transaction is, the less it will be affected by geographical distance. Therefore, when complexity is reduced, transactions can occur via “routinized cognitive interactions or frameworks using standard transportation and telecommunications technology” (Storper and Scott, 1995, pg. 507). Transactions can range in scope from being highly local to occuring between regional, national, and international levels. However, even local regional communities will “typically have a mix of internal and external transactional relations shaping its form and locational characteristics" (Storper and Scott, 1995, pg. 507). Depending on the nature of economic activity, transactions within these regions can transcend the region itself; thus, the authors argue that regions are essential bases of industrial organization in the global economy and influence the spatial organization of the economy at multiple levels (Storper and Scott, 1995).

In detailing what determines the wealth of regions, the authors argue that transactions and failures in transactional efficiency are central. Regions often face transactional failure and are susceptible to crises as are individual cities, sectors and nations within the global economy (Storper and Scott, 1995). According to the authors, regions where the impact and frequency of transactional failure have been reduced through collective action and institution building have experienced higher levels of competitiveness (Storper and Scott, 1995). Institutions and industrial policy help to prevent decline in overall growth and productivity by guiding sensitive regional characteristics away from failure (Storper and Scott, 1995). In detailing these sensitive characteristics that regions often share, the authors present a framework of understanding why regions experience growth and decline. Thus, the authors' framework assists in building an understanding of how and why some areas of the United States have witnessed reduced economic prosperity.

Four Types of Transactional Failure

Storper and Scott point to four areas of transactional failure that frequently occur within regions. These failures occur within economic processes such as the inter-establishment of industrial relations and networks, the development and diffusion of technology and practical know-how, establishing efficient local labor markets, and the contribution to and of place-specific culture and order (Storper and Scott, 1995).

Breakdown of Relations and Networks

When there are breakdowns in information exchange, transactional failure can occur within industrial relations and networks, such as when a party holds privileged information (Storper and Scott, 1995). If there is a lack of formal and informal methods to reduce this form of transactional failure, a decline in trust can breakdown networks and relationships further as parties become more hesitant to share information (Storper and Scott, 1995). Storper and Scott argue that fostering effective interfirm networks and helpful relationships are important to the long-term dynamic competitive advantage of regions.

Breakdown of the Diffusion of Technology, Knowledge and Practical Know-How

Another source of declining regional competitiveness occurs when there is a systematic failure to develop improved technology and diffuse practical know-how (Storper and Scott, 1995). One of the reasons for this tendency involves firms systematically underinvesting in basic R&D relative to socially optimal levels (Storper and Scott, 1995). Even with patent protection, firms rarely realize the total economic gains of technological innovation and advances in knowledge as knowledge is a "leaky phenomenon" (Storper and Scott, 1995, p. 510). This market failure can be addressed by regional policy, such as subsidies and seed funding, to incentivize an increase in innovation (Storper and Scott, 1995). However, the authors also note that the development of technological know-how and practical knowledge is difficult as learning and technological innovation do not happen instantaneously - new ideas are created when there are “accumulated small-scale events in highly informal contexts” (Storper and Scott, 1995, pg. 511).

Nonetheless, regional innovation is often restricted by transactional failure when there are disconnects between socially desired levels of innovation, long-term commitment to a region and an individual firm’s incentives. To address, the authors argue that regional technology centers are another example of a public policy that may improve long run innovative output. Public-private sector collaboration and the enhancement of positive spillovers and learning effects can lead to improved regional knowledge and innovation - especially when there is a “transactional system that has a dense and trust-based collective structure” (Storper and Scott, 1995, pg. 511). Aligning incentives between firms and a region at large are key to optimizing formal and informal learning processes (Storper and Scott, 1995).

Breakdown of Efficient Labor Markets

Similarly to the logic that leads to suboptimal levels of innovation in a region, local labor markets also experience transactional failure. Within the labor force, firms tend to underinvest in training as they are uncertain that workers will stay within the firm (Storper and Scott, 1995). Employees also tend to limit developing their own skills as there is a probability that they will not be adequately rewarded (Storper and Scott, 1995). The authors argue that in areas with increasing levels of agglomeration, tendency towards this particular transactional failure is heightened as there are more alternative options within the labor market in large metropolitan areas (Storper and Scott, 1995). Due to these tendencies, Scott and Storper suggest that when training is not publicly subsidized, there will be an undersupply of relevant job skills harming firms’ efficiency, employees' abilities, and regional competitiveness.

Outside of the labor force, regions also experience inefficiency when matching individuals to jobs, as incomplete information exists for both job-seekers and employers (Storper and Scott, 1995). For this reason, the authors argue that publically funded agencies that operate as centers of information exchange can improve the efficiency of a labor market (Storper and Scott, 1995). When employers are unable to perform adequate hiring processes, particularly small-to-medium size firms, industry service centers are especially helpful in improving their capabilities (Storper and Scott, 1995). In regions with large ‘champion’ firms, centers can also be helpful in improving the labor market. Due to the tendency to ignore the needs of supplier firms, the authors argue that the competitiveness of the champion firm can be improved by strengthening the capabilities of the local industrial network (Storper and Scott, 1995).

Ultimately, public support is necessary for achieving suitable levels of worker education and skill development as labor training is a public good which is not produced efficiently by the market (Storper and Scott, 1995). By ensuring skills are at socially desirable levels, both SMEs and large firms can improve their long-term contribution to the regional economy. Otherwise, both private and social costs increase due to a larger misallocation of human capital, higher drop-out rates from the labor force, losses from training investments, and greater difficulty in realizing the full productivity potential of the labor force (Storper and Scott, 1995).

Breakdown in the Dynamic Capabilities of Regions

The remaining source of market failure and transactional inefficiency lies in "place-specific economic culture and order," according to Storper and Scott (pg. 512). When regional production systems and networks are formed, places often develop "informal rules and conventions that reflect its acquired industrial specialization and past historical experience" (Storper and Scott, 1995, pg. 512). Individuals within regions often share informal and formal institutions, norms, and culture which help to foster trust (Storper and Scott, 1995). As mentioned, trust is important for interfirm relationships and networks, but does not ensure success when there are larger structural shifts. In fact, the authors argue that shared tendencies, beliefs, and behaviors can reduce the ability of regions to adjust to external competitive pressure (Storper and Scott, 1995). This inability to change due to a build up of existing culture and routines is referred to as institutional sclerosis and requires collective action to shift the region towards improved innovative and developmental trajectories (Storper and Scott, 1995). The authors argue that dedicated regional development funds can help overcome tendencies towards institutional sclerosis as well as ensure that opportunities for economic development are captured (Storper and Scott, 1995).

Halting Regional Decline

However, regional policy alone is not enough to address tendencies toward regional decline. In order to efficiently address transactional failures, regional policy should coordinate with policy at other scales, such as the national level (Storper and Scott, 1995). The authors detail how the United States has failed to synthesize regional and national policy, as they argue that both industrial and regional policy has been comparatively weak in the United States relative to other advanced countries (Storper and Scott, 1995). Storper and Scott argue that the country's shift in focus to regional policy was “stimulated essentially by a retreat of the federal government from the economic development field” which “left a policy vacuum that many states and localities attempted to fill” (Storper and Scott, 1995, pg. 520).

In addition, the authors consider the few national approaches to support regions within the United States to be superficial compared to the policies that they advocate for, as industrial and regional policy often resulted in pay-as-you-go services with little strategy or coordination. An example of this lack of strategy includes incubators, which, despite being described as ‘strategic, systematic, and learning-oriented’, had “rarely any strategic, systematic, or learning orientation” (Storper and Scott, 1995, pg. 520). Despite the failure of incubators, the authors found that the absence of strategy and coordination is most evident when regions contribute increasing proportions of public resources to “locational tournaments” (Storper and Scott, 1995, pg. 520). These tournaments still remain relevant to policy discussions, as evidenced by the recent inter-city competition for the location of Amazon’s next headquarters (Selyukh, 2018).

In essence, *The Wealth of Regions* discusses both causes of regional decline and potential solutions to regional crises, which may be useful in helping to reduce the divergence of opportunity within the United States. However, to help reduce the future development of negative economic tendencies to avoid divergence in economic opportunities, it is important to understand how institutional sclerosis has developed within regions where economic opportunity and outcomes have declined.

Evolutionary Economic Geography and Understanding Regional Development

Evolutionary economic geography can assist in creating a deeper understanding of how tendencies towards failure develop and the mechanisms by which they are reinforced. In order to discover the mechanisms and patterns that lead to suboptimal regional performance, it is important to first understand the assumptions and views underpinning evolutionary economic geography.

Fundamentals of Evolutionary Economic Geography

Innovation and Routines

First of all, evolutionary economic geography is useful in that it applies evolutionary concepts to the context of economic geography to explain how and why economic activity evolves over time

(Boschma and Frenken, 2006). Much of evolutionary economic geography follows the Nelson and Winter framework of viewing organizations as competing on the basis of their routines which are subject to the evolutionary concepts of inheritance, variety, novelty and selection (Nelson and Winter, 1982). Due to this perspective, evolutionary thinking finds competition to be driven by "Schumpeterian innovation based on new products and technologies requiring new routines, rather than on production costs alone as assumed in neoclassical models" (Boschma and Frenken, 2006, pg. 278).

The effectiveness of an organization's routines, and thus the competitiveness of an organization, are often determined by both 'experience knowledge' as well as tacit knowledge (Boschma and Frenken, 2006). These routines are often difficult to codify, making it challenging to imitate the routines of successful firms and organizations (Teece et al., 1997). Within a group of organizations, routines tend to differ between them, which lead evolutionary theorists to dismiss both the neoclassical methodology of modelling organizations as homogeneous as well as the concept of a representative agent (Boschma and Frenken, 2006).

Bounded Rationality

Another critical assumption made by evolutionary economists is the concept of bounded rationality. Evolutionary thinking assumes that "economic agents are bounded rationals and base their decisions on routines and institutions," thereby dismissing the neoclassical assumption of the utility-maximizing agent (Boschma and Frenken, 2006, pg. 280). However, evolutionary economic theory does not argue that agents do not try to maximize their utility, but that they are unable to do so due to their bounded rationality. Instead, individuals often rely on routines at the micro-level and institutions at the macro-level when making decisions (Boschma and Frenken, 2006). With this more reasonable assumption in mind, evolutionary economics expects firms and organizations to behave similarly, relying on existing routines and institutions. It is found that firms and organizations prefer to innovate incrementally rather than adopt more radical innovations, as they are better able to exploit existing knowledge and routines within their organization (Boschma and Frenken, 2006).

Changing Distribution of Routines through Market Selection

The evolving routines of firms are not solely determined by endogenous incremental choices and decisions as firms and organizations within an economy must adapt to external competitive pressures.

Market selection can lead to a changing distribution of routines as market competition acts as a selection mechanism which causes fit routines to diffuse and unfit routines to exit (Boschma and Frenken, 2006).

Market selection also forces firms to address their diminishing competitive advantages by searching for new routines (Nelson and Winter, 1982). It is the combination of variety, novelty, and selection which lead evolutionary scholars to see the economy as a non-linear, out-of-equilibrium and open-ended process of economic growth and development (Hodgson, 1999). In fact, evolutionary economics argues that there is a temporary convergence towards equilibrium that is 'upset' by endogenously determined innovative firm behavior (Nelson and Winter, 1982)(Boschma and Frenken, 2006). The disruption of convergence by innovative firm routines is considered central to economic development as the search for disruptive innovation and supranatural profits is the main incentive within evolutionary theory (Boschma and Frenken, 2006). The convergence and erosion of profits due to price competition is viewed as a secondary dynamic to growth (Boschma and Frenken, 2006). Whether this pattern of economic development always leads to improved economic outcomes is precisely the question that this project aims to better understand.

Multi-Level Framework for Understanding Evolution

The authors also present a useful multi-level evolutionary framework for future theoretical and empirical research in economic geography that can assist in discovering how best to analyze the changing economic landscape within the United States (Boschma and Frenken, 2006).

Micro

On a micro-level, evolutionary economic geography places emphasis on processes of firm-level entry and exit, the role of innovation in these processes as well as the co-evolution of firms alongside institutions (Boschma and Frenken, 2006). Firm-level locational behavior is viewed through a historical perspective; firms often experience locational inertia as most start from home, or in the case of spinoffs, locate near the parent firm (Boschma and Frenken, 2006). Thus, an earlier decision often determines a firm's location (Boschma and Frenken, 2006). This tendency also supports the idea of firms and organizations being bounded rationals, as firms are "imperfectly informed about location" and "heterogenous in their capability to use information in a meaningful way" (Boschma and Frenken, 2006, pg. 293).

Meso

On a meso-level, evolutionary analysis involves the spatial evolution of sectors and networks (Boschma and Frenken, 2006). Entry and exit models provide a way to analyze the evolution of routines within a sector. The spatial evolution of an industry is described in terms of the location of firm entry and exit which both influence and are influenced by evolutionary mechanisms such as selection, variety, inheritance and novelty (Boschma and Frenken, 2006). Similarly, the evolution of networks is both dependent on, and contributes to, higher levels of knowledge creation and diffusion (Boschma and Frenken, 2006).

Macro

On a macro-level, evolutionary economic geography applies to the entire spatial system (Boschma and Frenken, 2006). Economic development of cities and regions can be seen as the aggregate of sectors and networks within a region. Regions and cities that are able to innovate to create new product life cycles and expand demand will be able to grow, while those that cannot will decline (Boschma and Frenken, 2006). Boschma and Frenken also argue that there is not an automatic mechanism that assures cities or regions can renew themselves (2006). Regions are expected to decline after periods of growth due to “vested interests, institutional rigidities and sunk costs associated with previous specializations,” echoing Storper and Allen’s concept of institutional sclerosis (Boschma and Frenken, 2006, pg. 295).

Evolutionary economic geography is a potential synthesizer of more reasonable economic assumptions which can explain the divergence of economic outcomes within regions in the United States. Evolutionary economic geography formulates an understanding of how knowledge leads to differential growth between regions by focusing on how novel behavior can become successful routines in the form of new products, new firm entry, and improved innovativeness. Thus, evolutionary theory presents a potential blueprint for understanding how to drive regional success. Building off of this, Frenken and Boschma present regional economic evolution as dependent on firm-level differences in routines, conceptualizing economic evolution as dependent on firm-level changes and growth.

Industrial Dynamics and Urban Growth as a Branching Process

Frenken and Boschma in a second paper titled, *"A theoretical framework for evolutionary economic geography: industrial dynamics and urban growth as a branching process,"* define evolutionary economic geography as aiming to explain the spatial evolution of cities, regions and nations through the entry, growth, exit and relocation of firms (2007). As mentioned, evolutionary economic geography deals with the uneven distribution of economic activity across space in addition to the historical processes which have led to the current trajectories of economic activity, as "the explanation to why something exists intimately rests on how it became what it is" (Dosi, 1997, 1531)(Frenken and Boschma, 2007, pg. 636). Economic geography is thus inseparable from economic growth processes, as spatial patterns emerge from economic processes that have occurred prior (Frenken and Boschma, 2007).

In their paper, the authors expand on their multi-level framework that measures economic evolution through analyzing firm-level entry and exit, where urban growth is seen to be dependent on industrial dynamics (Boschma and Frenken, 2006)(Frenken and Boschma, 2007). They proposed that this is "an evolutionary branching process of product innovation" where a product innovation presents a growth opportunity for both existing and new firms (Frenken and Boschma, 2007, pg. 645). By creating firm-level growth opportunities, product innovations also lead to growth opportunities for cities and regions (Boschma and Frenken, 2006; Frenken and Boschma, 2007). Measuring growth through increased product innovation is possible as innovation can lead to new product divisions within existing or new firms. The authors argue that both firm size and city size distributions are the direct result of this single evolutionary process (Frenken and Boschma, 2007). This argument also synthesizes with the evolutionary theory of the firm where growth is seen as a progressive process of diversification (Frenken and Boschma, 2007). Penrose had argued that since the turnover of a single product is "ultimately bounded by the minimum efficient scale and consumer demand for a specific product, further growth requires a firm to diversify in other products" (Penrose, 1959)(Frenken and Boschma, 2007, pg. 637).

The evolution of the economic landscape is also dependent on the diversification of routines. Evolutionary economic geography views a changing economic landscape as representative of the shifting distribution of routines within a firm, city or region. Key to the diffusion of new routines within a region or economy is the process of routine replication (Frenken and Boschma, 2007). The inheritance and replication of new routines are considered spatially influenced due to their often difficult-to-codify tacit nature (Boschma and Frenken, 2006). When routines become dominant in certain regions, the evolution of the routines occur locally. This is expected as most spinoffs are located near their parent firm, new divisions are often created inside existing firms and most employees change jobs within the same labor market area (Rigby and Essletzbichler, 1997; Essletzbichler and Rgiby, 2005; Boschma and Wenting, 2007)(Frenken and Boschma, 2007).

Outside of local contexts, systematic replication of routines in different geographies and in new branches is considered key to many firms' competitiveness, particularly in advanced service sectors (Boschma and Frenken, 2006). Firms strategize to replicate routines in different geographic contexts; for example, successful multinational corporations are able to efficiently transfer knowledge and routines across borders (Boschma and Frenken, 2006). However, the typical process of routine replication and the diffusion of knowledge across space is usually considered to be partial and imperfect (Frenken and Boschma, 2007).

Not all innovations are equally likely to lead to growth opportunities. Frenken and Boschma argue that as the radicalness of a potential innovation increases, the probability of it leading to internal firm growth decreases (2007). Radical innovations are more likely to lead to labor mobility and spinoffs than incremental innovations are (Frenken and Boschma, 2007). Thus, with increased radicality, the less likely it is that an innovation will benefit from the existing routines and institutions within the parent city or region (Frenken and Boschma, 2007). The authors argue that this tendency to disincentivize radicalness is one explanation for why firms, cities, and regions experience negative lock-in: "the inability to incorporate radical innovations leads firms and cities to accept only incremental innovations, the scope for which are depleted by saturating market demand" (Anderson and Tushman, 1990; Grabher, 1993; Hassink, 2005; Wezel and Van Witteloostuijn, 2006)(Boschma and Frenken, 2006, pg. 644).

The authors' framework of analyzing the process of economic development as an evolutionary branching of product innovations combines several arguments made within the evolutionary economic literature. For this reason, their argument presents an appropriate platform to begin to analyze the divergence in opportunities within the United States. Identifying divergence as a process of firm level diversification of routines can aid in understanding the dark side of innovation.

Key Takeaways

Research presented by economic geographers has pointed to a divergence in economic opportunities across the American economic landscape, particularly between metropolitan and non-metropolitan areas. Large macro-level structural shifts, such as technological advancement and globalization, have been influential in affecting firm-level routines and behaviors as the global scale has replaced the nation-state scale, thus leading to a decline in employment in regions where firms have exited. Following this discussion of factors that have contributed to widespread regional decline across the United States, there is a discussion of the role regions play in their own decline and development.

Regions consist of a variety of transactions, and it is transactional failure within networks, knowledge creation and diffusion, labor markets, and capabilities that also can contribute to declining economic and innovative output. Addressing these types of transactional failure requires coordination between regional and national policy to coordinate and incentivize socially optimal levels of innovative activity, knowledge creation, and economic output. Furthermore, evolutionary economic geography describes the mechanisms by which transactional failures can develop over time, due to the bounded rationality of firms and the influence of market selection on knowledge and routines. Changes in routines and the growth of knowledge are vital to understanding the drivers of divergence in economic opportunities and outcomes between regions. Thus, firms are considered integral to innovation and the evolution of regions, as changes in firm-level routines are fundamental to regional economic growth.

A framework based upon the evolutionary role of firms describes regional economic evolution as the result of a branching process of product innovations. This process is based upon Penrose's evolutionary growth theory of the firm, which contends that firms must improve or introduce new products in order to grow and evolve, as price competition from competitors as well as market saturation will limit profits over time. Due to their bounded rationality, firms are likelier to introduce incremental rather than radical innovations to exploit already existing routines. Incremental innovations are also likely to lead to internal firm growth in terms of employment as well as for the region the firm operates in. However, with increased radicality, firms become less likely to be able to exploit the innovation due to its existing routines, resulting in greater chances of labor mobility and the entrance of spinoff firms. This also impacts regions, as radical innovations are less likely to succeed in regions with established routines and networks. Therefore, radical innovations and new firm entry are more likely to occur outside of regions with established routines. Ultimately, it is the introduction of new variety in products and routines that present growth opportunities for regions.

In summation, the theory section presents valuable information regarding the extent to which innovation has influenced the evolution of knowledge and geography. Moving forward, this section contributes to the construction of a framework that will help discern the extent to which innovative capabilities have declined as a result of past innovations. The analysis will build upon the understandings developed in the theory section by leveraging ideas from the branching process of product innovations hypothesis, strengthening the understanding of how knowledge, geography, and industry have been impacted by past innovations.

Methodology

The analysis will leverage existing data to test and better understand regional economic evolution through changes in firm-level innovation. This understanding is based upon the framework provided by Frenken and Boschma, who purport that innovation ability within firms are central to regional growth rates, as product innovations of varying degrees of radicalness present growth opportunities in the form of internal firm growth or new firm entry, either internally or externally to the firm and its region. In order to understand and test this hypothesis, data concerning macro level changes in firms that involve the number and size of firms within regions is required.

The analysis will be conducted through an examination of data from the U.S. Census Bureau's Business Dynamics Statistics database (BDS). This data includes annual measures of business dynamics such as employment growth and decline, firm and establishment-level entry and exit, as well as yearly firm and establishment totals between 1977 and 2014. The data also provides more specific information as well, such as employment added by new and established firms, or employment lost due to firm exit. Furthermore, the data is also aggregated and categorized by firm and establishment characteristics, examples being size and industry. Therefore, the data is able to be leveraged within the branching process of product innovations hypothesis.

Data that was particularly useful for examining the hypothesis include gross employment numbers, numbers of jobs created and destroyed, the number and size of firms, as well as the number and size of establishments. The data distinguishes firms from establishments, as establishments include any place where business is conducted, while firms can have 1 or more establishments. Thus, a firm is also considered an establishment. Additionally, the data is separated into various categories, such as geography, size, and sector. Importantly to the analysis, whether a firm or establishment is considered metropolitan or not is assigned at the county level, as metropolitan statistical areas are defined as areas with 50,000 or more inhabitants. As of March 2020, there are 384 metropolitan statistical areas in the United States (U.S. Census Bureau, 2020).

This data will be analyzed to examine both ideas presented within the hypothesis, as well as to better understand how the regional evolution of the economic landscape over time. Therefore, the analysis will take an approach considered to be "appreciative theorizing" where inductive reasoning is leveraged through the use of existing knowledge and frameworks surrounding evolutionary economic geography while empirical evidence is leveraged to examine the depth of understanding or misunderstanding. Empirical methods leveraged in the project primarily involve bivariate regressions.

Due to the comparative, and fundamentally simple, nature of the hypotheses that are addressed in the analysis, simple regressions sufficed for inferencing the differences and changes in innovative output over time within metropolitan and non-metropolitan areas, as well as in various sectors. In a future study, this is an area for further development and improvement.

Additionally, knowledge and information from the MIKE program that includes existing frameworks through which the data and evolutionary economic geography theory will be analyzed is utilized. These ideas are foundational for the analysis and deployment of central concepts found in the evolutionary economic geography literature as they lay the groundwork for understanding firm, industry and institutional change through ideas such as firm-level dynamic capabilities, technological change, disruptive innovation, among others.

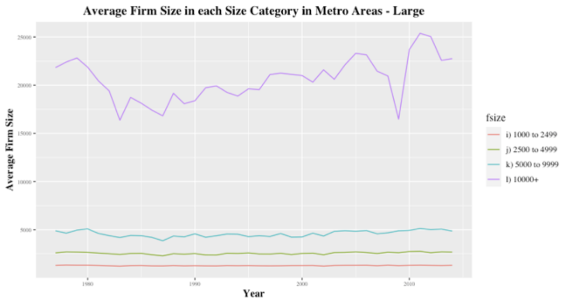
Therefore, given the inductive foundations of the research, the data analysis will build a stronger understanding of the extent to which ideas presented by economic geographers and innovation scholars are pertinent to the economic divergence of the United States and where additional room for research can be made. However, before detailing the structure of the analysis, the nature of the data as well as questions regarding the data are addressed.

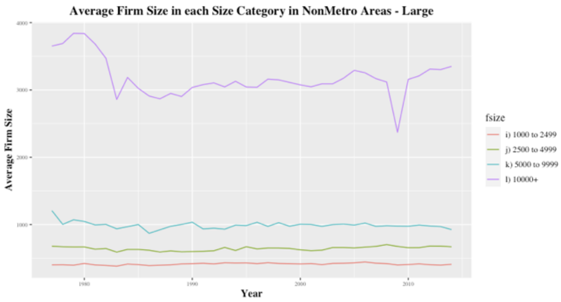
Questions Concerning BDS Data

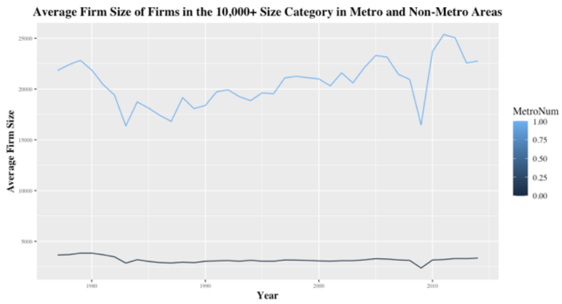
Although the U.S. Census Bureau's Business Dynamics Statistics provide a large amount of useful information to develop stronger understandings of the United States' evolving economic landscape, there are a few questions that remain. One of the biggest issues with the data involves the average firm size of firms in metropolitan and non-metropolitan areas.

Here is a graph of the average firm size of firms in the 10,000+ size category, in both Metropolitan and Non-Metropolitan Areas. Interestingly, the average firm size for Non-Metro firms in the largest "fsize" categories are far below what the minimum value should be to be included in the category. The average firm size of firms in nonmetropolitan areas is much lower than it should be as the average firm size varies between 2,500 to 4,000, when it should be above 10,000.

In metropolitan areas, the data is not as egregiously flawed, but there are still multiple instances of an average firm size in a category being below what it should be. For instance, the average firm size for firms in the 5000 - 9999 employee category hovers around or below 5000 over the time series, when it should likely range between 6000-8000.







To better understand why the average firm size of the largest firms is so low, I contacted the U.S. Census Bureau regarding the BDS data. Jim Lawrence, a member of the BDS's economy-wide statistics division, responded to my concerns, stating,

"*... geography and industry are defined at the establishment level. So when you're counting up firms say at the metro versus non-metro tables, the firm count in metro areas represents the number of firms that had at least one estab in a metro area, and the firm count in non-metro areas represents the number of firms that had at least one estab in a non-metro area. So the same firm can show up in both the metro and non-metro tables.*"

With respect to firm size, the data collected by the U.S. Census Bureau has been organized in a way that misrepresents the truth surrounding the number of large firms and the amount of jobs they have within the economy. Particularly in non-metropolitan areas, the data over represents the number of firms who are large employers, as they are often unqualified to be considered a large employer in that area. For example, a firm that employs more than 10,000+ people nationally, but employs 2,000 people in non-metropolitan areas, is still considered a 10,000+ size employer in non-metropolitan areas.

This misrepresentation of the number of larger firms, particularly in non-metropolitan areas, could be solved by organizing the raw data in a way that constructs the data from area employment, instead of categorizing firms who report 10,000+ employees automatically as a 10,000+ size firm, regardless of how many they actually employ in those areas. As an example, if Nike employs 2,000 people in Non-Metro areas and 12,000 people in Metropolitan areas, Nike would be considered a 1,000 to 2,499 size firm in non-metropolitan areas and a 10,000+ size firm in metropolitan areas, and a 10,000+ size firm economy-wide as well.

In this regard, researchers and policymakers can be misled into believing that there are more large employers in Non-Metro areas than in actuality. On face value, the data therefore inaccurately portrays, and arguably downplays, the growing role and economic power that consolidating corporations have attained within the American economic landscape, particularly in rural America.

Average Firm Size of Industry Data

Another unusual portion of the data is concerning the number of firms. Totals for the entire economy regarding the number of firms in certain size categories do not match the sum of each industry's firm totals in those same size categories. For example, data regarding the entire US economy reported a total of 727 firms that employ 10,000+ people in 1977. In the same year, the combined sum of each sector's number of firms within this 10,000+ category is 2359 firms. For additional evidence, when adding the total number of employed by these 2359 firms, they precisely match the total employed by the 727 firms, so it is not an issue of accidentally categorizing specific firms differently. Concerning all firms irrespective of size, the number of total firms in the nation-wide dataset is quite close to the total of firms in the industry-size dataset, within 1%. Therefore, it doesn't seem to be the case of double counting, as seen in the Metro vs. Non-Metro breakdown where the same firm could appear in both datasets.

Concerned, I reached out to Jim Lawrence again with the following:

"*In 2014, across the economy, there are 1370 firms that employ 10,000 or more people, but when adding up the number of 10,000+ size firms in each industry in 2014, there are 3260 firms. The overall number of firms economy wide in 2014 using the bds_f_sz_release.csv datatable is 5,060,326, while the overall number of firms in 2014 in the bds_f_szsic_release.csv datatable is 4,987,000, so it doesn't seem to be an issue of double counting. Why is this the case?*"

Jim Lawrence responded once more:

"*While geography and industry are assigned at the establishment level, firm size and firm age are assigned at the firm level, and refers to the entire firm, not just the part that operates within a given geography or industry.*
Hope that helps."

Finding this response unsatisfactory, I followed up with a rebuttal on the topic:

"*Your explanation does explain the higher totals of firms in the industrial 10,000+ size range vs economy-wide 10,000+ size range, as a firm can have establishments in multiple industries or sectors. However, shouldn't there then be more firms in the industry firm sizes dataset than in the economy firm sizes dataset overall as well? The total amount of firms economy wide is greater than the total amount of firms in the industry datatable as mentioned in the previous email*."

This issue remains unresolved, as the Census Bureau has not yet responded to my rebuttal. The full email correspondence is available in the index at the end of the paper.

The issue of mismatched average firm sizes in various size categories is prevalent in various sectors as well. Time series graphs which illustrate the average firm sizes of the largest firms within the nine sectors, as well as economy-wide, are locate in the appendix.

Implications for the Analysis

The classification of data within the BDS's dataset has implications within the sections of the analysis that pertain to the changes within certain size categories. Additionally, it can be argued that the integrity of new firm entry in non-metropolitan areas is put into question, as the entry of a new firm could be the result of the expansion of an existing firm in metropolitan areas. Furthermore, questions linger regarding other questionable and potentially misguiding errors within the data.

Foundations of the Analysis

Nonetheless, the analysis of the divergence of the United States will be based upon findings made in the literature review/theory section. Within the theory section, it is noted that there is an opportunity to leverage Boschma and Frenken's framework of viewing regional development through the lens of an evolutionary branching process. As mentioned, this process follows the evolutionary perspective of regional growth being based upon the bounded rationality of existing firms, as existing routines dominate the locational decisions made by individuals and firms. The following will reiterate how firm-level changes in behavior influence and to some extent, determine the rate of regional economic evolution. The bounded rationality of firms leads Boschma and Frenken to view the growth of regions as a branching process of product innovations, as firms must innovate or introduce new product lines in order to grow, as specified by Penrose (1959). Product innovations can lead to internal firm growth, new firm entry, or new industries, which often lead to regional economic evolution. Increased levels of product innovation often leads to higher levels of new firm entry and firm growth.

However, there is a caveat - Frenken and Boschma hypothesize that innovations with greater levels of radicalness have greater likelihoods of firm entry outside of the parent city and lower levels of internal firm growth (Frenken and Boschma, 2006). This is due to the combination of incremental innovation contributing to higher levels of internal firm growth and city size, as well as regional areas experiencing 'negative lock-in' or institutional sclerosis, as both regions and firms prefer to exploit existing routines rather than foster radical innovation (Boschma and Frenken, 2006, pg. 644). Due to this, Frenken and Boschma argue both firm size and city size distributions are positively correlated with the evolutionary process of incremental product innovations, while increased radicalness would limit, or negatively affect, firm and city size growth. The analysis of this project will test multiple hypotheses based upon this framework.

Structure of the Analysis & Hypotheses to be Tested

Incremental Innovation

The first section of the analysis will deal with incremental innovation. According to the branching process hypothesis, due to greater population growth in metropolitan areas, firms in those areas have experienced higher levels of internal firm growth as a result of higher levels of incremental innovation compared to non-metropolitan areas. Given the aggregated data, there is no possibility to examine and tie incremental innovation to individual firms. Therefore, the analysis will compare average firm size, and the growth in average firm size, within metropolitan and non-metropolitan areas. Although average firm size when firms are classified into different size categories remains dubious, average firm size of firms within aggregated regions appear relatively reasonable and valid.
The following is the hypothesis to be tested using average firm size as the representative for internal firm growth, and thus incremental innovation:

1. Internal firm growth has been greater in metropolitan areas than in non-metropolitan areas.

However, discerning whether or not regional economic growth has increased due incremental innovation is difficult due to the aggregated nature of the metric, average firm size. As the metric involves both aggregate employment and aggregate firms within regions, it is imprecise. Average firm size may have increased over time due to either growth in the employment or by the exit of firms, thereby blurring the analysis as radical innovation may lead to the exit of firms. To address this, an analysis is performed that compares the relationship between average firm size growth and firm exit rates using a simple regression in both metropolitan and non-metropolitan areas.
Following the examination of the effect of firm exit on average firm size growth in metropolitan and non-metropolitan regions, there is a closer look at the employment side of the average firm size metric. This analysis utilized information regarding the number and size of firms within different size categories to better understand internal firm growth and increased incremental innovation in both regions. As mentioned prior, firm size analyses are impacted by the way in which the BDS organizes and categorizes firms, resulting in a higher representation of firms in the 10,000+ size category in non-metropolitan areas than there are in reality.

Radical Innovation

Radical Innovation is the focus of the second section of the analysis. Radical innovation and the manifestation of it within the data is based upon Frenken and Boschma's branching process hypothesis. Due to firms' preference to exploit existing routines, as well as the innovative 'lock-in' within regions, radical innovation that does arise is more likely to succeed outside of established regions, leading to new firm entry and regional growth. If radical occurs within established regions however, it is likely to lead to declining firm size and city size distributions, as labor mobility and the creation of spinoff firms is more likely. Thus, measuring radical innovation will involve new firm entry statistics within the data.

Three hypotheses are developed to test this logic and examine levels of innovation across the United States. First, since non-metropolitan areas are external to the 'lock-in' within large established metropolitan areas, non-metropolitan areas should have experienced higher levels of radical innovation. Second, given the growth in firm and city size distributions, there has been declining levels of radical innovation within metropolitan areas due to increasingly greater levels of 'lock-in'. Lastly, there have been increasingly lower levels of radical innovation nationwide as there has been a decline in spontaneous industrial clustering and regional growth outside of large established metropolitan regions.

These three hypotheses are interlinked as each hypothesis involves linking radical innovation to new firm entry, and are as follows:

1. New firm entry is greater in non-metropolitan areas than in metropolitan areas.
2. Metropolitan areas have experienced a decline in new firm entry.
3. New firm entry has declined across the United States.

Sectoral Analysis

The third section of the analysis concerns radical and incremental innovation within sectors across the United States. In contrast with the rest of the analysis section, the aim of this section is to build additional context surrounding the first research question:

Where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry?

This section will leverage the methods used in the preceding two sections, to understand which industries have had increasing or decreasing incremental and radical innovation through observing firm-level changes in size, entry and exit. In comparison with the prior two sections of the analysis, this section does not delve as far into detail, but provides evidence of the extent to which innovation has influenced the evolution of industry. Additionally, comparisons of economic and innovative growth and decay between sectors strengthens the understanding of where the evolution of knowledge and geography has impacted economic and innovative opportunities.

Research Aim

The analysis will take a historical perspective to understand whether heightened competitiveness and growth in one area leads to the ability to grow and innovate later on, leveraging ideas listed in the aforementioned review of evolutionary economic geography. As mentioned, both quantitative and qualitative evidence point to a divergence in opportunities within the United States and to a concentration of production, income and wealth in certain geographical regions. Evolutionary ideas can help to better understand the tendencies which have led to this re-allocation of resources and can potentially improve the understanding of innovation's role in driving this shift. The ultimate goal of the project is to understand whether and to what effect general innovative growth over the years has led to the divergence in economic opportunities in areas around the United States.

By reviewing the changes in number, size, and locations of firms, firm entries, and firm exits, this analysis treats the general innovative trends such as globalization, digitization, and automation as endogenous and central to changes in the American economic landscape. Therefore, this analysis does not seek to discern the specific costs or benefits of certain innovations, but seeks to improve a general understanding of the effect of past innovation on future economic opportunities and growth in various regions of the United States. The scope of the analysis is also broad, as the data covers economy-wide, metropolitan, and non-metropolitan areas.

In effect, the broad scope of the project allows for a holistic understanding of the extent to which past innovation has influenced the evolution of knowledge, geography, and industry, the ways in which the evolution of knowledge, geography, and industry has influenced economic and innovative opportunities, as well as the degree to which innovation is responsible for declining economic opportunities and outcomes across the United States.

Analysis

Introduction to the Divergence in Economic Growth

In data provided by the United States Census Bureau, there is categorical information regarding the number of firms and establishments per year in both metropolitan and non-metropolitan areas within the United States starting in 1977 and ending in 2013. As mentioned prior, whether a county is considered metropolitan or not is based on having a population of 50,000 people or more.

According to the U.S Census Bureau's Business Dynamic Statistics, the number of firms and establishments in metropolitan areas in 1977 totaled 2,714,411 and 3,320,642, respectively. By 2013, the number of firms increased to 4,257,132 while establishments increased to 5,649,889, an increase of 57% in firms, and 70% in establishments. In non-metropolitan areas, the number of firms and establishments was listed as 725,713 and 833,100 in 1977. By 2013, totals increased to 832,971 firms and 1,053,644 establishments, a ~15% increase in the number of firms, and a ~26% increase in the number of establishments. From these headline numbers we can see that the growth in the number of firms and establishments in metropolitan areas dwarfs non-metropolitan areas both in absolute and relative terms as seen in the graphs below (Metro and MetroNum are dummy variables established to discern from non-metropolitan areas in the data, where 1 is equal to metropolitan areas, and 0 is equal to non-metropolitan areas).

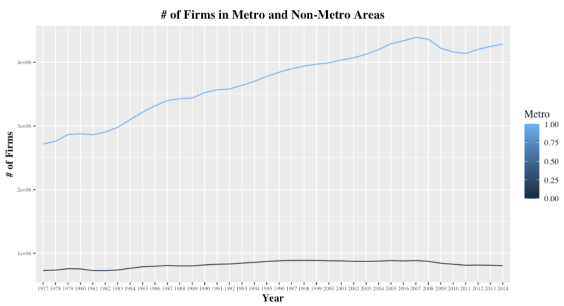


Figure 1

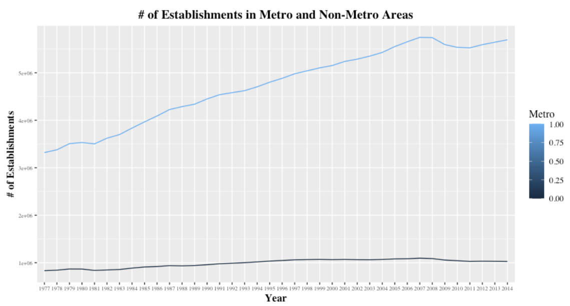


Figure 2

The difference in the number of employed within metropolitan and non-metropolitan areas is also large. Metropolitan areas saw an employment increase of ~84%, as the workforce increased from ~56 million to just under ~103 million in 36 years. In non-metropolitan areas, employment numbers increased by ~42%, from ~10 million to ~14 million. As a share of national employment, metropolitan areas expanded from ~85% to ~88% while non-metro areas declined from ~15% to ~12%.

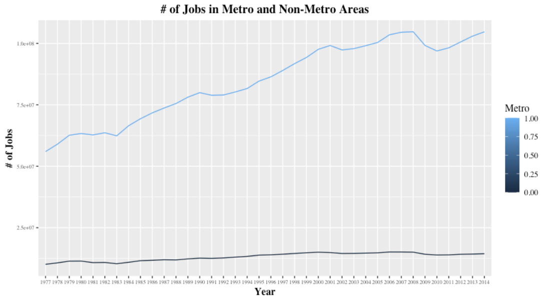


Figure 3

Employment and population size seem to be highly correlated with one another given the growth in population within large metropolitan areas. It is clear that metropolitan areas have experienced much higher growth regarding overall employment and business creation, which corroborates with existing research.

Incremental Innovation

The first hypothesis supports the argument that metropolitan areas have experienced higher levels of incremental innovation than non-metropolitan areas, as metropolitan areas have had greater levels of population growth according to existing economic geographers, and the above empirical evidence. The hypothesis to be addressed is as follows:

1. Internal firm growth has been greater in metropolitan areas than in non-metropolitan areas.

To recap, evolutionary growth within firms and regions are dependent on the branching process of product innovations, which can result in higher internal firm growth, new spinoff firms and increased firm entry. Innovation is ultimately responsible for growth, as a firm's revenue within a product line can become capped by either saturated market demand or greater price competition by new competitors. Both instances require the development of new or improved products to maintain or increase profits. New, improved, or additional product lines often require new labor and often lead to greater employment and larger firm sizes. Therefore, innovation consequently leads to higher levels of employment and an increase in regional population as suggested by the branching process hypothesis. For further support, Storper and Scott argued that regions' growth or decline is dependent on their innovative success or failure (1995).

To confirm whether incremental innovation has been greater in metropolitan areas as hypothesized, it is important to examine internal firm growth explicitly. As mentioned, this hypothesis was formulated due to the firm's propensity to innovate incrementally rather than radically so to better exploit existing routines and innovations, thus adding employment to a firm and its region.

Analyzing Average Firm Size Growth

Through finding the average firm size in both metropolitan and non-metropolitan areas, the difference in internal firm growth can be found. Average firm size is calculated by dividing the total amount of employment in a region by the total amount of firms in a region.

In terms of average firm size, non-metropolitan firms have had higher growth. In metropolitan areas, the average firm grew from 20.6 to 24.2 employees, an increase of ~17% while non-metropolitan firms increased ~24%, from 13.9 to 17.2 employees. Non-metropolitan establishments also experienced greater growth. Employment per establishment increased more in non-metropolitan areas as well. The average size of an establishment increased ~8% from 16.9 to 18.2 in metropolitan areas, while the average non-metropolitan establishment increased their workforce by ~12%, from 12.1 to 13.6.

From this perspective, it appears that incremental innovation has been greater in non-metropolitan areas, given that firms have added more employees. A linear regression examining the influence of the dummy variable Metro on the change in average firm size over time found firms in metro areas to have about 2.9% less growth than non-metro firms. With a p-value of 0.03, this is considered statistically significant. (For additional information, see regression 1 in the appendix). With this in mind, we can reject the hypothesis that firms in metropolitan areas have had larger amounts of internal firm growth. However, there should be a further examination of Frenken and Boschma's branching process of innovation hypotheses with respect to distinguishing incremental and radical innovation.

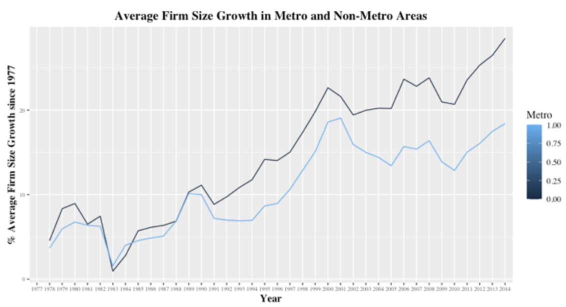


Figure 4

Considerations regarding Average Firm Size

Leveraging average firm size and average firm size growth as a metric is an imprecise method of measuring incremental innovation, as the 2 variables in play, employment and firms are affected by incremental and radical innovation. As mentioned, incremental innovation can lead to hiring additional employees but attributing the variable of average firm size as an approximate measure of incremental innovation blurs the analysis, as average firm size in areas can be affected by higher levels of firm exits. In the case of rural firms adding more employees than metropolitan firms on average, is this due to employment increases or failing firms exiting? This is not to discredit the role of incremental innovation in strengthening firm-level competition causing firms to exit. However, it remains an area for further examination within both the metropolitan and non-metropolitan datasets. To better understand this, it is important to examine and compare the relationship between firm exit and average firm size in rural and urban areas.

Analyzing Firm Exits' Effect on Average Firm Size Growth

By using a simple regression analysis, with average firm size growth as the dependent variable and number of firms exiting (as a percentage of all firms) as the independent variable, we can discern the influence of firm exits on average firm size growth in both metropolitan and non-metropolitan areas. This analysis does not aim to be definitive, but will be used to compare the effect of firm exits on average firm size growth between metropolitan and non-metropolitan areas.

In non-metropolitan areas, the growth in average firm size and firm exit are negatively correlated, with each percent increase in firm exit corresponding to a ~4.3 percentage decrease in average firm size growth. These two variables are negatively correlated in metropolitan areas as well, with each percentage increase in firm exit correlating with a ~2.6 percentage decrease in average firm size growth. The correlation between the two variables differ somewhat significantly between metropolitan and non-metropolitan areas as well. In non-metropolitan areas, firm exits show greater correlation with average firm size growth than in metro areas, as evidenced by the multiple R-squared value of .319 in non-metro vs .128 in metro areas. This suggests that firm exits are more explanatory for average firm size growth in non-metropolitan areas compared to metropolitan areas (For additional information, see regressions 5 and 6 in the appendix).

However, these numbers do not imply causality. The inverse relationship does not imply that for every increase in firm exit there is a decline in average firm size growth, but is reflective of the relationship between the variables. In the datasets, higher levels of firm exit coincided with lower average firm size during earlier years in the BDS dataset. Over time, firm exits as a percentage of total firms declined in both metro and non-metro areas, while average firm size increased, resulting in the negative relationship. The aim of this analysis is not to imply causality but to further understand the relationship between the two factors involved in the average firm size metric. Thus, the regression analysis suggests that firm exits have had a stronger correlation with average firm size growth in non-metropolitan areas than metropolitan areas. As illustrated below, firm exits have had a stronger effect on the growth in the number of firms in non-metropolitan areas, as net firm entry has plateaued relative to metropolitan areas, resulting in greater average firm size growth, controlling for employment.

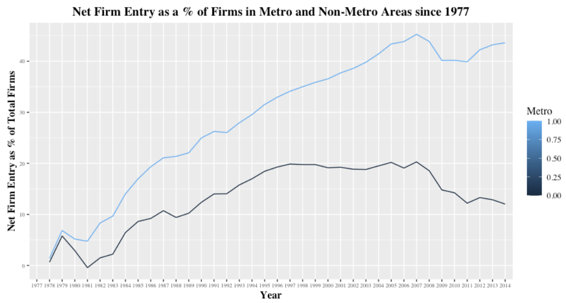


Figure 5.

Analyzing Employment Changes in Depth

To better understand changes within the numerator of the average firm size metric, analyzing firm size distributions can provide greater contextual detail to the growth in employment within firms, and thus present stronger evidence for the role of incremental innovation within both metropolitan and non-metropolitan areas. The U.S. Census Bureau's BDS data provides categorical information regarding firms with sizes ranging from 1 to 4, 5 to 9, 10 to 19, 20 to 49, 50 to 99, 100 to 249, 250 to 499, 500 to 999, 1000 to 2499, 2500 to 4999, 5000 to 9999, and 10,000+ employees.

In regards to absolute figures, employment has doubled in metropolitan areas among firms in the 10,000+ size category, whereas growth in non-metropolitan areas has been slightly less. As a percentage of all employment in their respective areas, the % of employment by the largest firms has increased in metropolitan areas. In non-metropolitan areas, the number of employees as a percentage of total employment has been relatively stagnant, but has been increasing since 2004.

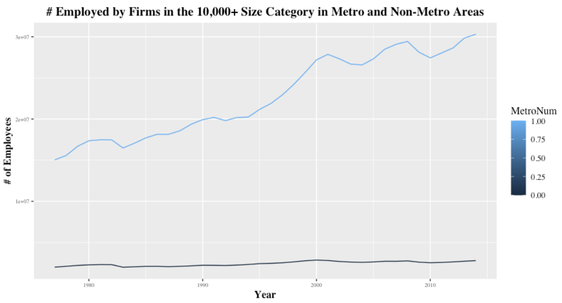


Figure 6

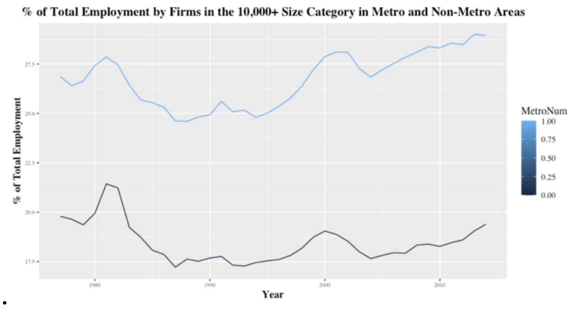


Figure 7

The number of firms within this category has risen as well, both in absolute terms and as percentage of total firms in their respective areas.

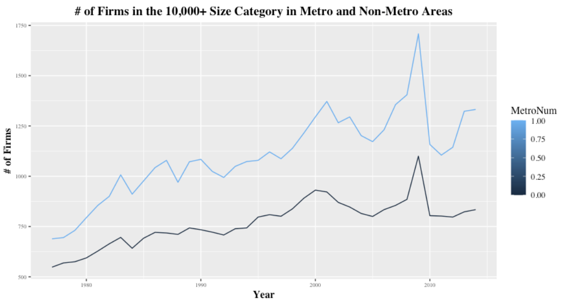


Figure 8

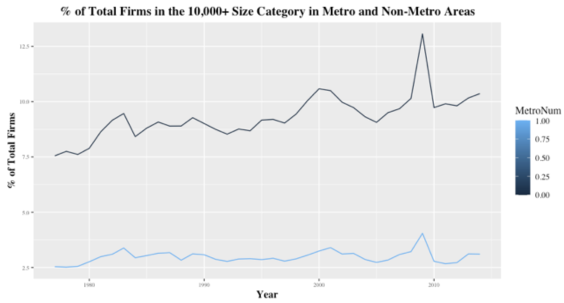


Figure 9.

For additional evidence of the increasing prominence of expanding large firms and incremental innovation, the increase in the number of establishments created by the largest firms in both metropolitan and non-metropolitan areas is telling, as establishments per firm have nearly doubled in both areas. Additionally, the average firm size of the largest firms, particularly in metropolitan areas, has been increasing since the mid-1980s. Since then, the growth in average firm size among firms in the 10,000+ category has outpaced the growth in average firm size of all firms within metropolitan areas.

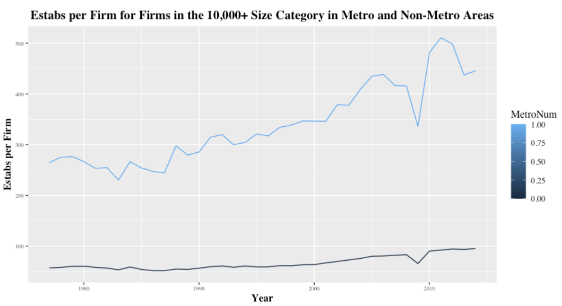


Figure 10

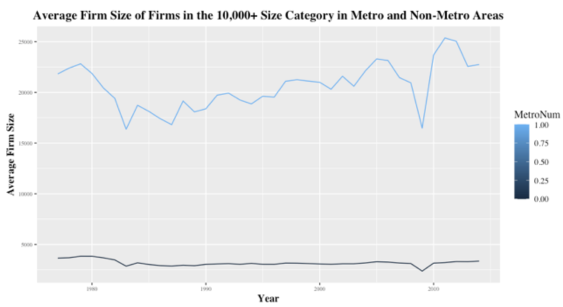


Figure 11

This data helps to understand that incremental innovation within both metropolitan and non-metropolitan areas has been positive, if not more prominent amongst the largest firms. Although there has been an increase in employment amongst the largest firms in non-metropolitan areas as well, the categorization of firms in the 10,000+ size categories artificially inflates the number of firms within this category, resulting in a deflation in the average firm size of non-metropolitan firms with 10,000+ size firms. The methodological choice to classify firms as 10,000+ size employers even though they may employ far less than 10,000 people has also inflated the large firms in non-metropolitan areas as a percentage of total firms, as seen in figure 9.

Intermission

The preceding section of the analysis contributed to a greater understanding of the economic divergence between metropolitan and non-metropolitan areas, while strengthening arguments and claims made in the Theory Section. Hypotheses concerning incremental innovation have strengthened the understanding that firm-level behavior and incentives drive the development of economic regions in the United States, with specific focus on internal firm and regional growth.

Whether firms in metropolitan or non-metropolitan areas have experienced greater incremental innovation is nuanced depending on the data and arguments posed. Firms within non-metropolitan areas have seen greater amounts of incremental innovation on average, which is reflected in the greater growth in average firm size. However, there also has been a greater influence of firm exits on increasing average firm size growth. The smaller growth in net firm entry as a % of total firms in non-metropolitan areas compared to metropolitan areas has played a consequential role in the seemingly larger internal firm growth in non-metropolitan areas as evidenced by figure 5. Despite this, it would be disingenuous to disregard the role of incremental innovation in influencing and contributing to increasing firm exits. The innovative ability of established firms to expand operations, increase employment, and build new establishments can be highly influential in this regard, as evidenced by the doubling in the number of establishments per firm within the 10,000+ size category in non-metropolitan areas.

While the primary focus has been on testing the branching process hypothesis concerning incremental innovation and growth, the second portion of the analysis will examine how radical innovation has driven, and been influenced by, the divergence of the American economic landscape. Thus, radical innovation will be concerned with strengthening the understanding of the extent to which past innovation has influenced current innovative opportunities and capabilities. There will be an examination of new firm entry, which is considered to be the main metric of radical innovation according to the branching process hypothesis.

Thus far, the focus on radical innovation has pertained to the metrics used to measure incremental innovation in metropolitan and non-metropolitan areas. This included comparing internal firm growth through measuring average firm size and the growth in average firm size over time. Since the data deals with aggregates, finding the average firm size - and the change in average firm size over time - required dividing total employment by the total number of firms. Both radical and incremental innovations are able to impact the number and size of firms within industries, thus blurring the analysis of incremental innovation in metropolitan and non-metropolitan areas.

The second section of the analysis will focus on analyzing metrics of radical innovation which are mentioned in Frenken and Boschma's branching process hypothesis. In particular, this involves the rate of new firm entry as radical innovation is considered to lead to new spinoffs and new firm entry. The authors argued that the more radical the innovation, the less likely the innovation could succeed in geographic regions with already established firms, industries and institutions, as their routines would be difficult to disrupt and change. Therefore, radical innovations often lead to new industrial clusters and the development of economic regions elsewhere.

Based on Frenken and Boschma's hypothesis, non-metropolitan areas should have experienced greater levels of new firm entry than established metropolitan areas due to lower levels of 'lock-in'. Likewise, urban areas should have experienced a decline in radical innovations and new firm entries due to regional 'lock-in' and a focus on incremental innovation. Furthermore, the large migration of people to large "megacities" such as New York, San Francisco, and Los Angeles, despite those areas' hypothesized lack of radical innovation, points to a lack of radical innovation in the United States as a whole.

Radical Innovation

This section will address the following three interlinked hypotheses, as suggested by Frenken and Boschma's branching process framework:

1. New firm entry is greater in non-metropolitan areas than in metropolitan areas.
2. Metropolitan areas have experienced a decline in new firm entry.
3. New firm entry has declined across the United States.

With regard to the research question, this section will contribute to an understanding of how past innovation has influenced differences in innovative capabilities between geographies, with specific concern for radical innovation. Additionally, this section will test how knowledge and geography affects the innovative capabilities of regions with respect to 'lock-in'.

Below are two graphs which reflect absolute levels of new firm entry in metropolitan and non-metropolitan areas:

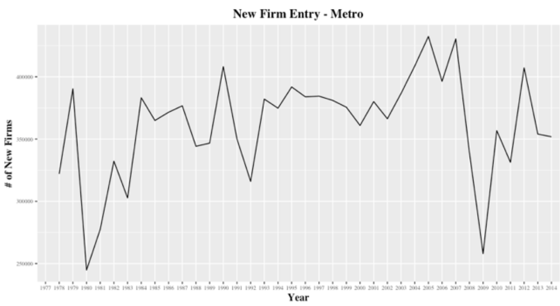


Figure 12

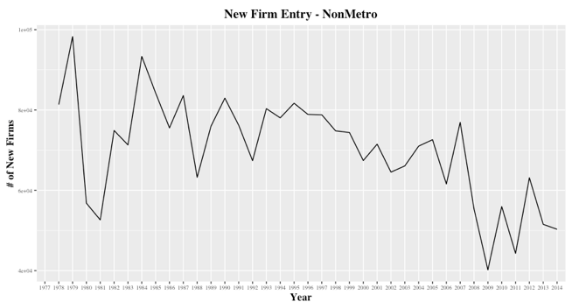


Figure 13

Absolute levels of firm entry have been declining more in non-metropolitan areas than in metropolitan areas. However, to better grasp whether or not radical innovation itself is greater in metropolitan areas, it is important to measure new firm entry as a percentage of total firms in each area, as well as as a percentage of total employment in each area.

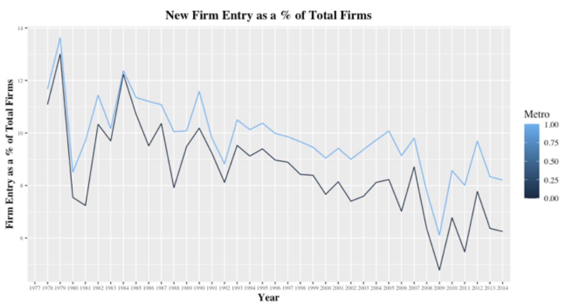


Figure 14

As a percentage of the number of total firms in non-metropolitan areas, new firm entry rates remain lower than in metropolitan areas. Therefore, radical innovation appears to be greater in metropolitan areas according to this metric. For additional information, regression #10 in the appendix shows the correlation between new firm entry as a percentage of total firms and the dummy variable metro.

However, as a percentage of total employment in each area, non-metropolitan areas have higher rates of firm entry than metropolitan areas throughout the time series. When accounting for employment, the argument that new firm entry is higher in areas with less lock-in has validity. Also related to the rise of incremental innovation in non-metropolitan areas, radical innovation has been declining at a higher rate in non-metropolitan areas as well. For additional information, regression #9 in the appendix shows the correlation between new firm entry as a percentage of total employment and the dummy variable metro.

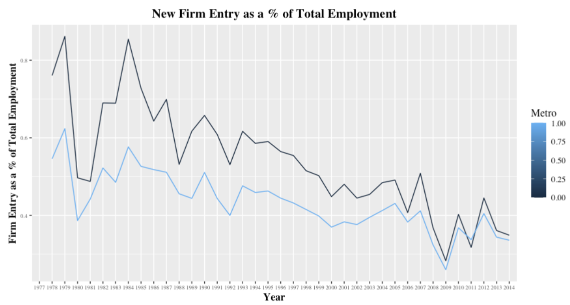


Figure 15

Radical innovation per employee has been greater in non-metropolitan areas than in metropolitan areas, despite economic and innovative troubles as mentioned by economic geographers in the theory section. For this reason, the hypothesis based on logic from Frenken and Boschma's branching process of product innovation has strong validity. Controlling for other economic indicators such as education and incomes would be an interesting project addressing the impact of 'lock-in' on the emergence of radical innovations.

The second hypothesis posits that metropolitan areas have experienced declining levels of radical innovation. As mentioned, absolute levels of new firm entry have been largely unchanged over the past 40 years. However, controlled for employment and total firms in metropolitan areas, there has been a decline in new firm entry in metropolitan areas as seen in the graphs above. Therefore, radical innovation has declined over time within metropolitan areas.

The third hypothesis argues that new firm entry is declining across the country, and therefore levels of radical innovation are declining across the country.

Figure 16

Just as in metropolitan levels of firm entry, levels of firm entry throughout the United States have been relatively stagnant over the time series with some strong fluctuations during economic downturns. However, as seen earlier, this is not the case when firm entry is controlled for employment and the total number of firms in the economy.

Figure 17

Figure 18

In conclusion, evidence of declining radical innovation supports understanding presented in the theory section, while strengthening the understanding of how innovation can impact the evolution of knowledge, geography, and industry through shifting routines towards less innovative trajectories. This understanding supports claims made in the introduction that past innovations are able to strongly impact the innovative capability of regions, either positively or negatively.

Sector Analysis

The U.S. Census Bureau provides data that had been listed above broken down into 9 separate sectors as well. The 9 separate sectors are listed as: Agriculture (including Forestry and Fishing), Mining, Construction, Manufacturing, Transportation and Public Utilities, Wholesale Trade, Retail Trade, FIRE (Finance, Insurance, and Real Estate), and Services. Using this data, the movement, creation and destruction of firms and employment can be analyzed.

To focus this analysis, regression analyses and graphs will point to the sectors with the largest changes with respect to firms, establishments, and employment.

Sector Data

This section will strongly focus on improving understanding in order to address the first research question, with particular regard to industry:

Where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry?

To begin, there is a clear distinction in the growth of certain sectors and the decline in others with the American economic landscape. For instance, shifting supply chains due to technological advancement and globalization have reduced the role of manufacturing within the US economy.

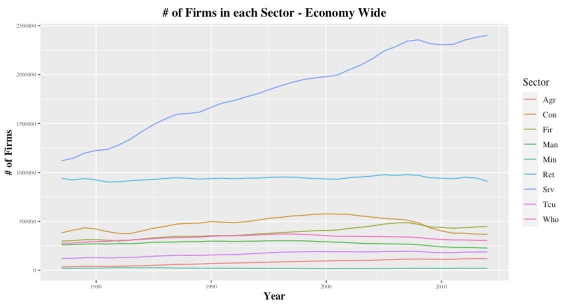


Figure 19

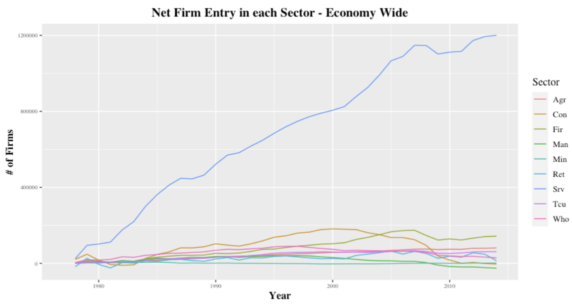


Figure 20

Since the beginning of the time series in 1977, the largest absolute growth in the number of firms within a sector has occurred in Services. A graph of net firm entry over the data's time period shows the services sector adding by far the largest amount of firms, with an additional 1.2 million firms in 2013 compared to 1977. The second largest increase in the number of firms occurred in the finance, insurance, and real estate sector (FIRE), adding around 160,000 firms. Unsurprisingly, manufacturing has had the largest decline in the number of firms, with 25,256 firms exiting. Given these figures, the

US economy has shifted increasingly towards being consumer and service-centric with an increasing focus on financialization.

However, as a % of each sector's initial firm and employment count in 1977, agriculture has grown the most in terms of the firms and employees. Services grew the second most regarding both firms and jobs, with TCU and finance sectors following closely in third for firm growth, while retail and finance sectors followed closely in third for job growth.

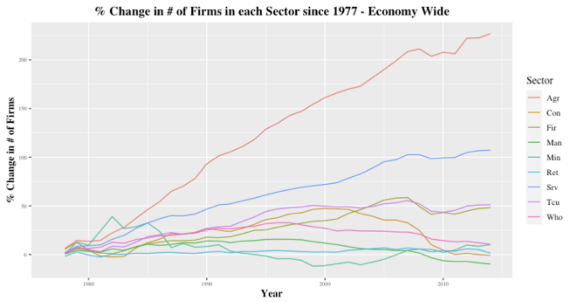


Figure 22

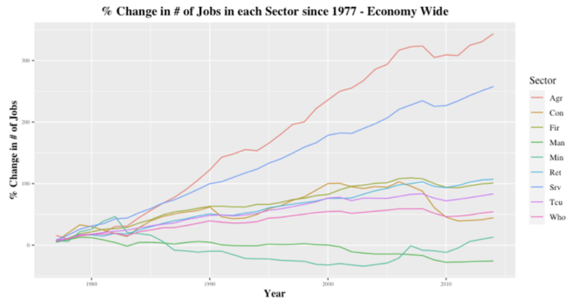


Figure 23

The number of establishments per firm is another indicator of consolidating and/or expanding business, depending on the context of whether or not there are a declining or increasing number of firms in the sector. According to the data, the finance, insurance, and real estate sector has had the greatest increase in the number of establishments per firm, with 1.6 establishments per firm, the highest ratio out of the nine sectors. Given that the finance sector has also had the second largest growth in the absolute number of firms of any sector, the sector has expanded greatly since 1977.

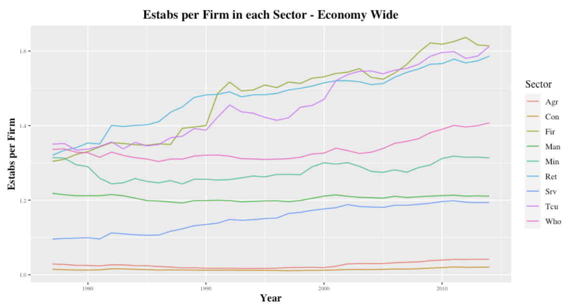


Figure 24

In terms of Employment, the sectors with the largest growth include Services, Retail, and Finance, with Services and Retail adding a larger percentage of the jobs. As expected, Manufacturing has declined heavily in terms of employment.

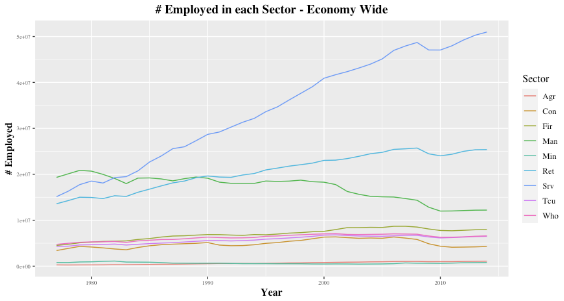


Figure 25

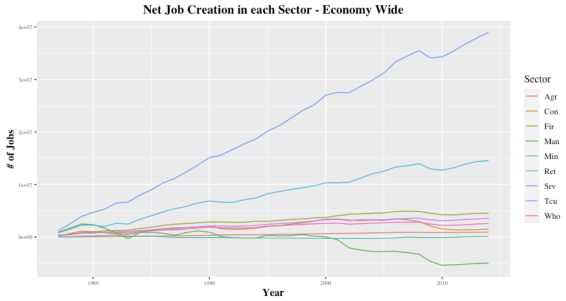


Figure 26

In the following section, there will be a closer look at each of the 4 largest sectors according to employment and firm totals: Services, Retail, Finance, and Manufacturing.

Services

According to the data, the services sector has grown by 1,200,463 firms since 1977, and added 39,004,906 jobs. In terms of percentages, the sector's # of firms has grown by 107.3% while the number of jobs has increased 257.8% over 36 years. This growth has occurred consistently and readily, despite economic downturns.

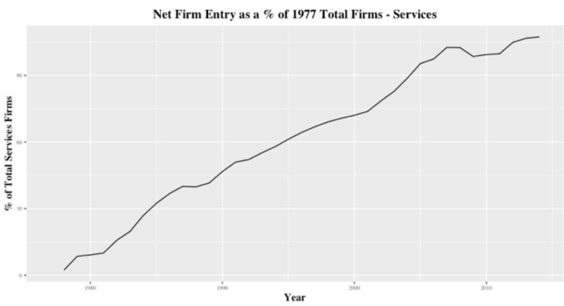


Figure 27

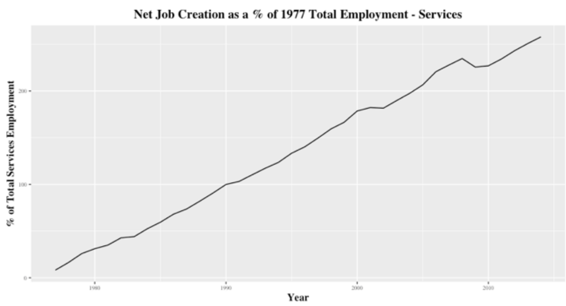


Figure 28

Retail

Retail has grown considerably in terms of employment, increasing 107% from 1977. However, the number of firms in the retail sector has not grown as much, with a modest increase of 5% from 1977 to 2014. The number of firms in the sector peaked around 2005 with 977,074 firms, about 6.97% higher than the total # of firms in 1977. Regarding employment, there has been a steady increase since 1977, with a sizable dip following the 2008 Great Recession.

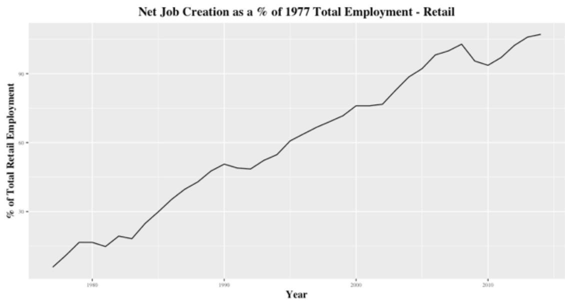


Figure 29 Figure 30

Finance, Insurance, and Real Estate

The Finance, Insurance, and Real Estate sector has grown considerably as the number of firms has increased by 48.2% since 1977, with a peak of 58.5% in 2007, as the total number of firms reached 487,866. After the Great Recession, the number of firms dropped 17.2% over a two year period, but has increased since. As of 2014, the number of firms was listed at 446,842. The sector's # of employees peaked in 2007 as well, reaching 8,684,724, a 109.3% increase from 1977. Similarly to the number of firms, the number of employees dropped 16.1% following the Great Recession. In 2014, the number of employees was listed as 7,949,967, a 100.8% increase from 1977.

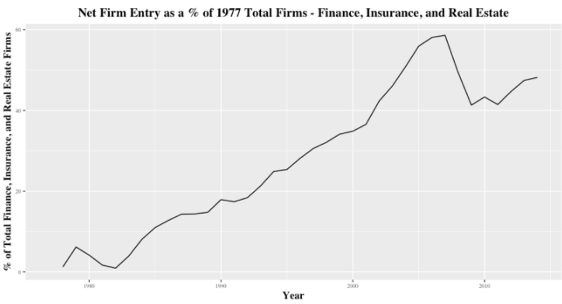


Figure 31 Figure 32

Manufacturing

As seen in some of the earlier graphs, when looking at Net Job Creation in each sector, manufacturing is the only sector to have had negative growth in the number of jobs created since 1977, with 25.6% fewer jobs in 2014 than 1977. As seen in figure 33, this drop in employment occurred mainly after 2000. As a % of 1977 manufacturing employment, the amount of jobs in the sector fell 25.6% after 2000. However, the number of firms in the manufacturing sector rose 15% from its 1977 total and peaked in 1996 with 302,231 firms. By 2014, the number of firms in manufacturing declined about 25% from its 1996 high, with 226,983 firms in the sector. As evidenced by employment figures, the decline in manufacturing in the United States began in the early 1980s, but has accelerated greatly in the mid to late 1990s and early 2000s. This is likely a consequence of stronger global capabilities due to technological advancement and globalization as well as regulatory changes making it economically advantageous to shift production overseas and internationally.

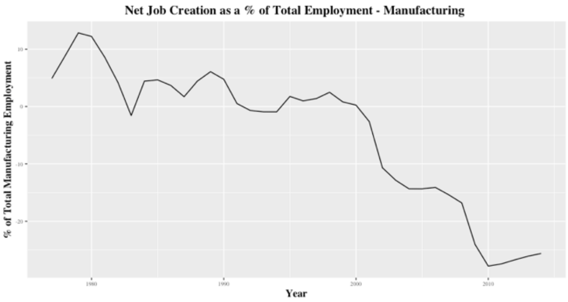


Figure 33

Figure 34

The evidence presented in this section adds context to address where innovation has been influential in driving the evolution of industry within the United States since 1977.

Analysis Conclusion

The analysis has built upon key knowledge from the theory section to build understandings in order to address the research question, with particular focus on the first two questions:

Where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry? How has the evolution of knowledge, geography, and industry affected innovative capabilities?

The analysis builds on understandings developed in past research regarding the extent to which innovation is influential to driving the evolution of knowledge, and how this knowledge influences the evolution of industry and ultimately, geography. The analysis addresses where innovation has been influential in leading to the evolution of industry while providing explicit evidence regarding where, and the extent to which, sectors have been helped or hindered by innovation in technology and globalization.

Additionally, the analysis tested theories concerning regional economic development with a focus on the branching process of product innovation hypothesis, as proposed by Frenken and Boschma. Their theory built on the foundations of Penrose's theory of the growth of the firm, arguing that regional development occurs from constant innovation, particularly incremental innovation. Regions that become established have developed routines, institutions, and businesses that exist and co-evolve. Over time, these routines, institutions, and established businesses become entrenched as firms often prefer to innovate incrementally in order to capitalize on their existing routines, making radical innovations less likely to develop in these areas. Frenken and Boschma then argued that internal firm growth, and regional growth, occurs when firms successfully innovate incrementally, thus hiring more employees. Conversely, firms will experience declining internal growth with increasing radicalness, as the more radical the innovation, the likelier it will lead to spinoff firms and employees leaving the firm. It is argued that radical innovation is likelier to occur outside of established firms with established routines. Frenken and Boschma then applied this logic to regions, stating that radical innovations are more likely to develop outside of economically established regions with established routines, behaviors, and institutions.

Based on this framework, hypotheses are developed that link innovation to regional economic evolution.

In the first section of the Analysis concerning incremental innovation, it is hypothesized that metropolitan areas have experienced greater levels of incremental innovation than non-metropolitan areas, and thus internal firm growth, due to the ‘re-urbanization’ of the United States. When strictly considering average firm size growth between the two areas, this hypothesis is rejected as growth in the average firm size of non-metropolitan firms has been greater, inferring that incremental innovation has been greater in non-metropolitan areas than in metropolitan areas.

However, the details are more nuanced as firm exits have played a greater role in influencing the metric of average firm size in non-metropolitan areas. Examining the growth of the largest firms in both areas suggests that metropolitan areas have had greater internal firm growth, indicating higher levels of incremental innovation within metropolitan areas. Ultimately, intangible concepts such as innovation and their conversion into measurable quantities is an imperfect process, which must continue to be refined.

In the second section regarding radical innovation, there are three interlinked hypotheses concerning levels of new firm entry on metropolitan, non-metropolitan and national levels.

The first hypothesis posits that new firm entry has been greater in non-metropolitan areas, as they are less subject to ‘lock-in’ in both established firms and established regions. Again, the results are nuanced. On a per employee basis, levels of radical innovation have been greater in non-metropolitan than metropolitan areas since the start of the times series, suggesting ‘lock-in’ and the processes underpinning it are instrumental to reducing radical innovative output. However, on a per firm basis, as well as absolute levels of new firm entry, non-metropolitan areas have had lower levels of new firm entry.

The second hypothesis concerning radical innovation argues that metropolitan areas have had declining levels of radicalness, as ‘lock-in’ grows with greater and greater incremental innovation. This follows logic from the branching process hypothesis that locked-in areas will increasingly innovate incrementally over time, as institutions, businesses, and routines become more entrenched. An analysis of firm entry in metropolitan areas found there to be declining levels of new firm entry both in terms of new firm entry per firm and new firm entry per employee, as hypothesized. This suggests that radical innovation has been declining in metropolitan areas, suggesting lock-in has increased with higher levels of incremental innovation.

The third and final hypothesis concerning radical innovation posits that radical innovation has been declining nationwide, as there have been more and more people moving to large urban centers in search of economic opportunity. This hypothesis has also held true, as new firm entry has been declining across the United States.

The final section of the analysis develops greater context for an understanding of the explicit effects of innovation, such as globalization and technological advancement. This section directly addresses the first research question, ‘where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry’, with a specific focus on industry, and the effect innovation has had on economic and innovative outcomes within each sector.

Ultimately, the analysis contributes to the theory section in providing additional context to the ‘what’, ‘where’, and ‘how’ concerning the drivers of economic divergence in the United States economy, while also testing hypotheses made by evolutionary economic geographers. By leveraging Frenken and Boschma’s branching process of product innovations framework, the analysis is able to generate a deeper understanding of the extent to which innovative capabilities and capacities are influenced by geography. Multiple hypotheses contribute to a more holistic understanding of how innovation arises and contributes to the evolution of geography, knowledge, industry and future innovative capabilities. Furthermore, the inclusion of geography is able to build a bridge between diverging opportunities caused by innovation in various areas, and the impact that diverging opportunities have on future innovative capabilities, in effect proving the existence of a ‘dark side of innovation.’

Therefore, the analysis, with foundations in evolutionary economic geography theory presented in the theory section, is able to address the first two questions of the research question:

Where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry? How has the evolution of knowledge, geography, and industry affected innovative capabilities? To what degree is innovation responsible for declining economic opportunities and outcomes?

The degree to which innovation has contributed to diverging economic opportunities and outcomes in the United States remains. Despite the existence of a ‘dark side of innovation’, understanding the extent to which innovation has driven declining levels of economic opportunity and outcomes. Developing a better understanding of the reasons and mechanisms by which innovation has resulted in negative outcomes can be beneficial to understanding the ‘dark side of innovation’ in greater detail.

The following discussion will probe deeper into the economic geography literature surrounding complexity thinking, which can add insight in order to better understand the drivers of economic opportunities and outcomes within the United States. Thus, this discussion will attempt to develop an understanding of the degree to which innovation is responsible for declining economic opportunities and outcomes.

Discussion

As the analysis demonstrates a simultaneous shift in the economy towards service sector jobs and away from manufacturing jobs, non-metropolitan areas have experienced declining economic opportunities and outcomes. To better understand the drivers of divergence in the United States' economy with respect to complexity, it is possible to leverage the framework posited by "*The Wealth of Regions*".

This discussion will be based upon the Storper and Scott's four drivers of regional decline, which include transactional failures within: industrial relation and networks, development and diffusion of knowledge, technology, and practical know-how, labor markets, and the hardening of place specific order. These four drivers of regional decline will be synthesized with facets of complexity theory. This discussion will be qualitatively driven, as both complexity, and the four drivers of regional decline, are difficult to quantify.

Complexity theory and its various perspectives can build a deeper understanding of the drivers of economic opportunities and outcomes. In particular, the concept of 'complexity catastrophe' can contribute to understanding the degree to which innovation is responsible for declining economic opportunities and outcomes across the United States.

An Introduction to Complexity Catastrophes

Complexity theory focuses on the co-evolution of knowledge and the economic landscape in the form of connections and networks (Martin and Sunley, 2007). Particularly important to complexity is the role of self-organization in systems, which operates together with selection in determining the future development of a system. However, self-organization and selection can lead systems toward 'complexity catastrophes' on various levels. Complexity catastrophes occur when an excessive number of interdependencies trap a system within a suboptimal 'basin in a fitness landscape' where selection cannot operate effectively (Martin and Sunley, 2007). Interdependencies and connections built up through self-organization and selection can trap a system with suboptimal options to resolve issues and problems. This idea is similar to what Storper and Scott refer to as 'institutional sclerosis', as well as path dependency, which often develops in firms, organizations, and regions (1995).

Catastrophes of varying degrees can exist in all complex systems and economies. Dispersing control across an economic system to dissolve interdependencies is difficult, if not impossible, as power inequalities exist in nearly every economic landscape (Martin and Sunley, 2007). For this reason, Martin and Sunley argue that the assumption that connections and configurations within complex economic systems are selected solely due to 'fitness' leads to an uncritical understanding of the functioning of a system (Martin and Sunley, 2007). Connections within the economy are selected by several different criteria, often simultaneously, which includes the vested interests of powerful groups and their ability to channel and control flows (Martin and Sunley, 2007).

In their article titled, "*Complexity Thinking and Evolutionary Economic Geography*", Martin and Sunley suggested that complexity catastrophes will become increasingly common in the future unless excessive interdependencies are offset by trends in innovation and the evolution of knowledge (2007). Additionally, all complex systems will degrade over time unless connections are renewed by continuous flows of new information, energy and resources (Foster, 1997). If connections are not renewed and reconfigured when necessary, the system will specialize by adapting to a particular environment, and if the particular environment changes then even the most highly complex systems can disintegrate (Foster, 1997).

As mentioned, complexity economics is particularly concerned with networks and connections. Connections are considered central to the evolutionary dynamics of economic systems, especially in the establishment of order and the emergence of chaos within complex systems (Potts, 2000). Ordered systems are considered to consist of low connectivity, where a change in any point or element of the system has little effect on the rest of the system, while chaotic systems are considered to have high levels of connectivity, as a change at any point in the system impacts many other elements and even the entire system (Potts, 2000). Complex systems often exist within the middle of these two extremes, as "complexity forms a narrow window of low-to-intermediate connectivity between order and chaos" (Potts, 2000, pg. 90) (Martin and Sunley, 2007). Economic systems are therefore not chaotic or ordered, but exist in a balance where information, routines, and coordination are combined.

With that said, systems often can move to a state called the 'edge of chaos', as referred to by Potts (2000). In this state, the system balances between no order and too much order and therefore must adapt to evolutionary and environmental pressures. If the system is excessively ordered or chaotic, then it is eliminated (Martin and Sunley, 2007). Complexity catastrophes operate within this framework, as excessively ordered systems with entrenched interdependencies must add new connections so that the system does not remain in a suboptimal basin where selection and self-organization cannot effectively function.

The breakdown of networks, knowledge, labor markets, and capabilities in the United States, particularly in regions that have seen declining levels of economic opportunity and development, can be attributed to a variety of complexity catastrophes.

Breakdown of Networks

Networks are considered fundamental within both evolutionary economic geography and complexity economics. To reiterate Storper and Scott, fostering effective interfirm networks and relationships are important to the long-term dynamic competitive advantage within regions (1995). Similarly, Metcalfe and Ramlogan argued that innovation and novelty are produced by local co-evolutionary and micro-behaviors within networks that combine diverse ideas, routines, and knowledge (2005). Areas within the United States have declined due to a lack of new information, routines, and innovations to fuel regional development. However, the deficit of new ideas and resources can be considered a result of shifts within the economy.

Economic systems transform when individual agents become dissatisfied or concerned about their returns, driving their search for new ideas and routines to combine and produce knowledge which can develop better opportunities and outcomes (Martin and Sunley, 2007). This logic follows Penrose's evolutionary theory of the firm, which states that firms must constantly innovate in order to maintain or increase profits, as profits decline over time through competition and saturating market demand. In the case of manufacturing, advances in technology and global capabilities enabled firms to shift production elsewhere to capitalize on other countries' labor costs, thereby improving profits. In this case, the search for new routines and innovation to improve returns focused on the supply side, rather than product innovations.

Market pressure to take advantage of cheaper production costs brought on by technological innovation and new global capabilities drove many manufacturing firms to exit the United States to varying degrees. Complexity economics and economic geography refer to this as an example of the selection mechanism known as the "Red Queen" or competitive coevolution effect (Martin and Sunley, 2007). The "Red Queen" occurs when two or more competitors are locked into an adaptive race, equivalent to running in order to stand still (Martin and Sunley, 2007). This effect is relevant to all forms of competition in the marketplace. As a result of this 'Red Queen' effect, it has nearly become a necessity for manufacturing firms to leverage cheaper labor costs abroad.

The breakdown of interfirm networks in the manufacturing sector across the industrial United States, although driven by advances in technology, globalization, and market pressures, are not completely market-driven. Complexity theory argues that there are numerous institutional and political preconditions which both allow for and influence the coordination of markets (Martin and Sunley, 2007). A good example of political preconditions that have altered the market is the role of free trade agreements. Although employment in manufacturing had been declining since the 1980s, it is not a coincidence that net firm entry into the sector was positive until the mid-1990s before dropping dramatically as free trade agreements, such as NAFTA, went into effect (see figure 34).

Institutional preconditions involved in driving the coordination of markets are not exclusive to the manufacturing sector, but to many of the largest firms and industries in the American economy. As mentioned by Yamamoto, the divergence in incomes and economic opportunities between regions has been impacted by structural shifts in both the real economy and the financial sphere of the economy (2007). As seen in the analysis, the finance sector has expanded both in terms of employment and number of firms and establishments, suggesting that finance has experienced a large amount of innovation and market growth. In describing the “Red Queen” effect, Martin and Sunley note that the financial sector is notorious for it, as competitors must constantly introduce new variety (2007). However, this variety has also been enabled by institutional shifts, such as deregulation and a larger emphasis being placed upon the stock market.

The stock market is an example of a complexity catastrophe which has impacted the entire American economy through influencing the drivers of economic evolution and innovation, principally the search for new routines. There have been a variety of stock market deregulations over the past 40 years that have both strengthened the financial sphere of the economy, as well as strongly shifted and influenced the behavior of firms as well as individuals.

One example of an institutional precondition influencing the coordination of markets was the passing of rule 10b-18 by President Ronald Reagan in 1982. Prior to this deregulation stock buybacks were illegal for most of the 20th century as they were considered a form of stock market manipulation. Since then, stock buybacks have been used to increase the share prices, thus enriching shareholders and executives at the cost of lowering the amount of reinvestment into a firm’s own businesses (Reeves, 2016). One notorious example of egregious stock buybacks involves IBM, who, after having spent $140 billion buying back their own stock between 2000 and 2020, as of April 2020, had a market cap of $105 billion while also having reported their lowest levels of revenue since 1998 (Malik, 2020).

Another deregulation that had empowered the stock market was the 1999 repeal of the Glass Steagall Act, which was enacted by President Franklin D. Roosevelt as part of the New Deal to separate investment banking from retail banking. With the repeal of the Glass Steagall Act, shareholders and investors were able to benefit as banks became able to use depositors' funds for securities, mergers and acquisitions, and other riskier investments (Gillian B. White, 2016).

In light of complexity economics, the importance of the stock market in the American economy can be considered a driver of a number of interdependencies which trap the United States in a suboptimal basin of fitness. The role of the stock market in the American economy has shifted publicly traded firms' methods for profit renewal away from innovation as theorized by Penrose, and towards other means, in order to maintain and improve returns. These means include cost control, in order to maintain profit margins and investor sentiment, to stock buybacks and mergers and acquisitions. In effect, the increased importance of the stock market has further shifted firms away from searching for new routines, ideas, and innovation, and towards regressive measures to ensure profits.

In addition, the classification of success via stock price has led to a stronger focus on profit margins rather than on innovative ability (Caleb Foote, 2018). This has led to a systemic reduction in R&D spending among publicly traded companies, and a higher priority placed on cutting costs (Knott, 2017). The relevance of product innovations as a driver of growth has declined over time, as increasingly more money is funneled into the stock market, which is supported by declining levels of innovation across the United States. As a result, interfirm networks in the United States have become less dense as consolidation has increased (Thomas, 2017), in addition to networks becoming less dynamic as new firm entry has declined. Job creation as a percentage of employment has declined among established firms (see figure 35), indicating the prioritization of meeting financial goals over improving innovative capacity, products and services. This institutional shift has caused what Boschma and Frenken consider to be central to economic development, the disruption of convergence, to be in decline across the United States economic landscape, as evidenced by declining levels of innovation (2006).

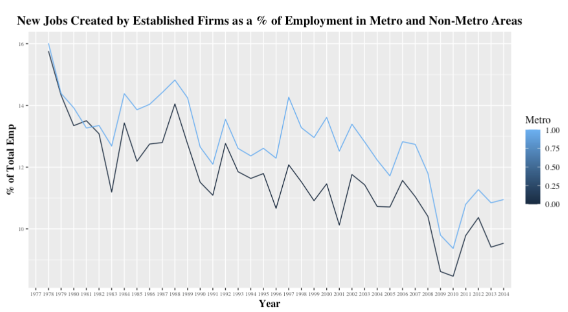


Figure 35

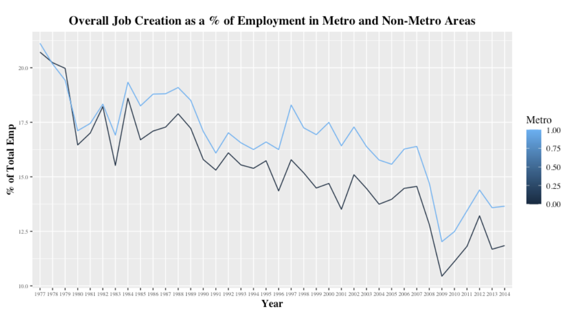


Figure 36

Martin and Sunley stated that self-organized systems have a high degree of resilience and robustness as they often have distributed and dispersed control, rather than centralized control, in addition to possessing efficient positive and negative feedback loops (2007). With the current influence of powerful vested interest groups controlling flows throughout multiple networks of the American economy, the ability of feedback loops to operate effectively is heavily influenced. As a whole, networks and interfirm relations have been strongly influenced by both shifts in institutionalized finance as well as by shifts in the real economy. It is the combination of globalization and the institutionally endorsed search for increasingly lower production costs that have broken down common local business relationships and networks which would have otherwise been more likely to strengthen the economic evolution of regional 'left-behinds'.

Breakdown in Diffusion of Knowledge, Technology and Know-How

Complexity perspectives argue that knowledge is central to regional economic evolution, especially the knowledge that is able to create connections between ideas, individuals, and routines (Martin and Sunley, 2007). Martin and Sunley argue that these connections are key to the coordination, diffusion, and generation of knowledge. It is different types of knowledge, such as competences, routines, and technology, that are the connections within networks that drive function in an environment (Martin and Sunley, 2007). The creation of knowledge, which is the engine of economic growth, is a spatially emergent effect that then influences and becomes part of the properties of economic agents (Plummer and Sheppard, 2006).

Additionally, self-organization occurs when there is an established consensus surrounding knowledge within a network (Martin and Sunley, 2007). It is argued that self-organization is based upon micro-level behaviors and rules that require "acquired energy and acquired knowledge, which in combination, yield creativity in economic evolution" (Foster, 1997, pg 444). Self-organization is considered to be a critical balance between order and chaos and is where economic growth and development occurs (Potts, 2000). The development of knowledge can be restricted by excessive order, just as the coordination of knowledge can be hindered by excessive chaos. Ramlogan and Metcalfe stated that "if beliefs are too fluid, order will descend into chaos; if beliefs are too rigid then order descends into lifeless equilibrium" (2006, 118).

The geography of knowledge is important to understanding different rates of economic growth. Economic changes are considered to be the result of balancing innovative new knowledge and variety with the selection and ageing of knowledge (Martin and Sunley, 2007). Across different regions, sectors, and systems, this process is uneven, as evidenced by the analysis. Similarly, Ramlogan and Metcalfe described how “growth does not occur without the continual emergence of innovation and persistent changes in the relative importance of products, methods of production, firms, industries, regions and whole economies, that adaptation to innovation implies, and these changes in structure are a consequence and a cause of the growth of knowledge” (Ramlogan and Metcalfe, 2006, pg. 134). This holds true in the opposite direction as well.

In numerous regions of the American economic landscape, both the supply of employment is declining, as is the demand for employment as workers’ skill levels are not adequate enough for employers to locate there, thus leaving innovation in a stagnant, if not declining, state (Holzer, 2015). A decline in education, knowledge, technology and know-how is both a consequence and a cause of declining economic growth. Thus, regions that have experienced declining employment, education standards, and incomes will have had declining levels of variety in knowledge and innovation. Just as feedback loops can strengthen innovative processes, they may also weaken them.

In addition, without the continual emergence of innovation and constant changes brought on by innovation, ideas, relationships, connections, and networks become hardened. In complexity theory, rules and knowledge are considered to undergo chreodic development (Martin and Sunley, 2007). Beinhocker argues that people’s decision-making is mainly driven by inductive reasoning, where if-then rules applied in the past are re-used in uncertain environments and experienced mental models become resistant to change (2006). Inductive reasoning is what drives firms, organizations, and regions towards innovative inertia, unless there is an influx of new knowledge that can reconfigure connections within a system.

Therefore, not only does a lack of new knowledge, resources, and innovation result in stagnation and decline within regions, it can result in a reduced ability to generate new knowledge and innovation. An economic system consists of preferences, technology and institutions which are affected by the continuous experimentation and search for new routines in order for the system to maintain its flexibility and adaptability (Potts, 2000). Without continuous experimentation, the system will not remain adaptable or be able to withstand larger structural shifts. This logic can be applied at all levels, from the individual to an entire economy.

Additionally, injecting knowledge and innovation within a region is not sufficient, it is necessary that the information is willfully received. One of the most important components of connections and the evolution of knowledge involves social understanding. Metcalfe and Ramlogan argued that social understanding, or trust, allows for the growth of new idiosyncratic and specialized knowledge through the exchange and combination of information as it allows for personal knowledge to be selected, tested and put to use (2005). This is an issue within regions of the United States, as areas with stagnation often develop hardened views and mental models, which then influence the ability to select, test, and reconfigure both new and existing knowledge.

For example, hardened ideas have developed particularly strongly on both sides of the 'political aisle', thus limiting the ability to sharpen, strengthen, and develop different understandings of varying concepts and issues. Social understanding and trust is necessary to test knowledge with others. Not only does the state of knowledge in different areas of the country affect social cohesion, but it harms the development of new ideas. Emergent economic knowledge that is able to reconfigure existing networks develops from the exchange of information that differs in some way from established macro patterns (Potts, 2000; Metcalfe et al., 2006; Ramlogan and Metcalfe, 2006).

One of the largest barriers to having knowledge, experience, and ideas resonate and further develop within the United States is the structure and funding of education. Public school systems often vary substantially in quality as funding is dependent on property values and local taxes (Turner et al., 2016). Poorer areas receive less funding for education, reinforcing their already sizable disadvantages. However, not only does this impact the economic opportunities within poor areas, it restricts the ability to generate new knowledge, ideas, and connections within a complex system. In addition to improving one's own value, education and knowledge creates value when it can effectively coordinate knowledge and understanding between members of a society. For example, the functioning of a system, such as transportation, is improved when everyone knows the rules of the road. This failure to provide adequate education to all American citizens is a complexity catastrophe. The resulting consequences of having such varying knowledge levels and understandings not only influences the ability of regional 'left-behinds' to reinvigorate themselves and evolve, it has large knock-on effects that influence the entire system.

In addition to this structural defect in the American economic system, the diffusion of knowledge, technology, and practical know-how within the United States has also been heavily influenced by the aforementioned changes in firm-level behavior and incentives caused by macro-level shifts in both the real and financial spheres of the economy. Prior to the excessive emphasis placed upon stock market returns, Storper and Scott argued in 1995 that there is a systematic failure to develop improved technology and diffuse practical know-how, as firms systematically underinvest in basic R&D compared to socially optimal levels. Furthermore, the exit of established manufacturing firms, particularly from non-metropolitan areas, quickly contributed to regional decline. This decline is not only a result of immediate economic loss, but future economic loss as well. Declining education standards as a result of lower tax revenue, fewer relatively well-paid jobs, and regional brain-drain strongly affect the ability of a region to innovate and improve or even maintain its prior economic levels.

Ultimately, the belief that regional economic evolution both shapes and is shaped by the growth and transformation of knowledge is key to complexity-based evolutionary economic geography (Martin and Sunley, 2007). As a result of shifts in technology, globalization, and financial incentives, regional innovation is restricted by transactional failure as disconnects between socially desired levels of innovation, long-term commitment to a region and an individual firm's incentives harm the creation of new knowledge (Storper and Scott, 1995). This complexity catastrophe, particularly in non-metropolitan areas, are becoming increasingly common as business incentives strengthened by institutional, financial and political forces rarely aim to benefit workers or the regions in which businesses operate.

Breakdown of Efficient Labor Markets

Complexity economics discusses the role of bottom up and top down influences which shape the nature of knowledge, connections and economic evolution. Dopfer et al. argued that the accumulation of micro-level individual behaviors and actions form 'meso units', such as firms, industrial districts, and clusters, which are considered the dynamic building blocks of an economic system (2004). Economic geographers contend that meso units are both emergent, unplanned outcomes of a variety of individual micro-level actions as well as sources of externalities and spillovers which influence, shape, and regulate the micro-level behavior of individuals, including ideas, routines, and actions (Martin and Sunley, 2007). Labor markets are prime examples of this relationship. The behaviors of individuals influence firms through determining their efficiency, products, and success, just as firms are able to shape the competencies, ideas, and skills of their employees, as well as the ideas and routines within the regions they operate.

The breakdown of efficient labor markets are often related to the breakdown in the diffusion of knowledge, routines, and technology, as well as networks. For the same reasons that firms tend to underinvest in R&D relative to socially optimal levels, firms tend to underinvest in training employees as they fear employees may leave their position, thus weakening the labor market. Similarly to education, Storper and Scott suggest that when training is not publicly subsidized, there will be an undersupply of relevant job skills which harms firms' efficiency, the abilities of employees, and the competitiveness of the overall region (1995). If skills are not at socially desirable levels, there are higher costs both privately and socially as there is a misallocation of human capital, higher drop-out rates from the labor force, higher levels of underemployment, greater losses from training programs, and decreased future ability to maximize the potential of the labor force (Storper and Scott, 1995).

Complexity catastrophes exist on various levels within labor markets. Particularly in non-metropolitan areas, the lack of public support to contribute taxes towards improving training programs grows as firms exit. Additionally, as firms leave over time, there is fewer and fewer tax revenue to contribute towards ensuring employees are adequately trained and able to contribute to the success of new firms, thus creating negative feedback loops that harm the innovative ability of the region and the skills of the local workforce. A combination of underinvestment in training programs and lower levels of education result in a competitive disadvantage for the region to attract business, resources or generate new innovative routines and ideas.

Breakdown in the Dynamic Capabilities of Regions

Complex systems become progressively specialized as their order, integration and knowledge increases (Foster, 1997). As coherence within a system increases, the system specializes in adapting to particular environmental niches and if these niches suffer from resource depletion or the entry of new competitors, then even highly complex systems may disintegrate. Thus, greater levels of conformity result in complexity catastrophes which harms the long-term adaptability of a system. Due to the inductive nature of decision-making and behavior, individuals, businesses and regions tend to develop innovative inertia, causing established businesses to exit over time, while regions experience economic and social decline.

In order to prevent declines in the capabilities of regions via hardening place-specific culture and order, it is imperative that new knowledge and rules reconfigure understandings and routines. The emergence of a new rule disrupts the coordinated structure and produces a period of de-coordination in actualizations at the micro level (Martin and Sunley, 2007). Then, as the new rule is diffused and retained, re-coordination occurs as the rule stabilizes (Martin and Sunley, 2007).

The most effective complex systems, and most innovative systems, are able to balance inertia and innovation, or order and chaos (Martin and Sunley, 2007). As mentioned, if all knowledge, capabilities, and beliefs in an organization or region are changing rapidly and simultaneously, then it is difficult to exploit existing routines, rules, and future innovations (Martin and Sunley, 2007). Likewise, if stagnation builds, the inductive nature of knowledge creation, development, and decision-making make it increasingly difficult to introduce new ideas and connections. Therefore, achieving higher fitness within a complex organization or system requires an intermediate mixture of inertia and innovativeness (Hodgson and Knudsen, 2006).

Additionally, Storper and Scott argue that shared tendencies, beliefs, and behaviors can reduce the ability of regions to adjust to competitive pressure (1995). As mentioned in the theory section, the inability to change due to a build up of existing culture and routines is referred to as institutional sclerosis and requires collective action to shift the region towards improved innovative and developmental trajectories (Storper and Scott, 1995). Complexity economics also argues that once co-evolutionary complexity, in terms of a system's internal and external co-evolutionary linkages, passes a certain threshold, the system may become unresponsive to environmental pressures. Therefore, not only does knowledge harden over time, but so do existing interdependencies and connections.

Macro-level constructions that both influence and are influenced by micro-level behavior and meso-level behavior, such as media outlets who are funded by powerful interest groups, often work to prevent changing connections to the system. Interdependencies between mainstream information sources, powerful vested interest groups, and the political system prevent the diffusion of information that would reinvigorate place-specific culture and order within systems (Mansell & Javary, 2002). As a result, the capacity of individuals, firms, and regions to drive development and new knowledge within areas is strongly reduced by macro-level influences. As mentioned prior, emergent economic knowledge that is able to reconfigure existing networks develops from the exchange of information that differs in some way from established macro patterns (Potts, 2000; Metcalfe et al., 2006; Ramlogan and Metcalfe, 2006).

Ultimately, hardening interdepecncies both harms the innovative capabilities of a system to adapt to competitive and societal pressures, while further contributing to the reinforcement of interdependent connections. In effect, there has been reinforcing negative feedback loops which have broken down place-specific order and trust which have harmed the dynamic capabilities of regions to adapt and grow via knowledge creation and connections, leaving them economically and socially dependent on firms for growth.

Conclusion to the Discussion

The ‘dark side of innovation’ is not solely to blame for driving divergence in economic and social opportunities. The declining innovative ability of the United States can be considered a result of a myriad of interdependent changes in the structure of the economy. Breakdowns in social understanding and trust, the generation of new knowledge, shifting interfirm relationships and business networks from local towards a global perspective, and hardening interdependencies between the stock market, political interests and economic output have left the United States in a suboptimal ‘basin in a fitness landscape’. Complexity catastrophes exist on multiple levels within the economic landscape, from micro to meso to macro levels, and require large structural shifts to address them. These structural shifts remain unlikely to occur due to the very interdependencies which have hardened over time and contributed to the resulting complexity catastrophes.

Perhaps one of the most obvious examples of the hardening interdependencies that has led to a complexity catastrophe has been the economic response to the coronavirus crisis. Despite millions becoming unemployed or underemployed in the United States due to a lack of legislative protection, the Federal Reserve and Congress provided, and continue to provide, enormous amounts of stimulus to firms and speculators to ensure stock prices remain stable (Winck, 2020). The bailout of the stock market and large publicly traded firms then reduced the incentives upon firms to hire back employees, as executives' pay, and the ‘health’ of firms remained somewhat stable due to higher stock prices. In some cases, it has arguably become a disincentive for firms to hire or maintain their workforce, as profit margins and other metrics that improve stock prices are prioritized. As evidence of this complexity catastrophe, as of October 2020, new weekly jobless claims in the United States were reported at just under one million, which is the lowest number of new unemployed since the shutdown of the economy, but is still greater than at any point during the Great Recession (St. Louis Fed, 2020).

In the real economy, demand for goods and services in multiple sectors remains low as consumers save in case of a larger recession, or simply have less disposable income due to losing employment . Therefore, demand remains lower due to higher unemployment levels, and unemployment levels remain higher due to a lack of necessity and incentives on behalf of firms to hire, keeping demand lower. In this case, firms are not only underinvesting in R&D and training employees relative to socially optimal levels, but have contributed to underemployment relative to socially optimal levels. It is imperative that public policy addresses the disconnect between firms and socially optimal levels on both regional and national levels (Storper and Scott, 1995). However, as mentioned by Storper and Scott, the United States has failed to synthesize regional and national policy, as the country’s minor shift to regional policy was “stimulated essentially by a retreat of the federal government from the economic development field" which left a vacuum that many states and localities attempted to fill (Storper and Scott, 1995, pg. 520).

Even in 2020, the regional policy vacuum left by the federal government has remained, if not expanded to the national level. In the current economic climate, interdependencies between powerful vested interest groups and politicians ensure that the political body would rather have millions, regardless of region, remain perpetually underemployed than harm the firms' profits. This continues despite continually declining knowledge creation, innovation, and economic development as the United States sinks further into the suboptimal 'basin in the fitness landscape'. As mentioned, Potts referred to a state called the 'edge of chaos', where systems balance between too much order and no order (2000). The system must adapt to environmental and evolutionary pressures, otherwise excessive order or chaos will lead to systemic collapse (Martin and Sunley, 2007). It is critical that the United States addresses declining levels of education, economic opportunities, and innovation throughout the economic landscape, in order to reconfigure and revive effective democracy to maintain the system.

Innovation is in decline in the United States precisely due to the inability to reconfigure the production of knowledge, innovation, and economic opportunities. Selection and self-organization have become increasingly ineffective as they are unable to reconfigure networks to produce innovation and economic growth, which has led to civil unrest. Excessive interdependencies developed and hardened over time have meant that the United States is unable to shift direction to address declining economic development and systemic social unrest. If these issues are to be addressed, it will require collective action to improve innovative and developmental trajectories.

In essence, innovation alone is not responsible for the divergence of economic opportunities and outcomes, but is dependent on a multitude of interconnected structures. Foundationally, the divergence in economic opportunity had begun once power inequalities quickly began to develop and spread throughout multiple systems. However, this does not mean that innovation and the 'dark side of innovation' has played no role, as technological advancement and globalization have facilitated shifts away from established economic and innovative networks. More likely, it is a combination of power inequalities within complex systems, as well as creative destruction, that can develop into a divergence in economic outcomes and opportunities.

Conclusion

The aim of the project was to examine the 'dark side of innovation' through analyzing the divergence in opportunities within the United States, which resulted in the development of a deeper understanding of evolutionary economic geography and complexity theory, while leveraging empirical evidence of firm-level entry, exit and growth in order to address the following research question:

Where and to what extent has innovation been influential in driving the evolution of knowledge, geography, and industry? How has the evolution of knowledge, geography, and industry affected innovative capabilities? To what degree is innovation responsible for declining economic opportunities and outcomes?

In order to answer the first question, it required an understanding of the extent to which innovation has impacted the evolution of knowledge, geography, and industry. This understanding was developed jointly between the theory section, including information that pertains to diverging economic outcomes, as well within the sectoral analysis section of the analysis, which highlighted where innovation has been influential in driving change within the financial, manufacturing, and service sectors. Additionally, innovation, especially globalization and general technological advances, has shifted the structural makeup of the economy away from a manufacturing-based economy, which was the sector with the largest employment in 1977, to a services-based economy. As evidenced by literature presented in the theory section, innovation has also helped drive the increasing economic divergence in opportunity, which has caused the concept of the 'American Dream' to become peripheral to most Americans. Knowledge and industrial centers, as well as general economic opportunity have increasingly shifted towards large metropolitan areas, as the "dual role of technological change in the form of the rise of new, spatially-concentrated sectors, and globalization, through a generalized revolution in trade costs" has led to a divergence in knowledge, skills, and economic opportunity across the United States (Storper, 2018, pg. 262).

Addressing the extent of, and the ways in which the evolution of knowledge, geography, and industry have affected innovative capabilities in the United States involved creating a foundational understanding of evolutionary economic geography. By exploring theory relevant to the development of regions, the role of firms in regional development, and causes of regional decline, an understanding of how knowledge, geography, and industry influence innovation was solidified. Leveraging concepts within the theory section, particularly Frenken and Boschma's branching process of product innovations, allowed for an analysis of both the evolution of knowledge and geography in metropolitan and non-metropolitan areas, as well as an understanding of how the innovative capabilities of both areas have been affected by the changing distributions of knowledge and industry. Therefore, an understanding of how to address the second research question was developed within both the theory section as well as the analysis.

Lastly, the ability to leverage geography to link diverging opportunities caused by innovation, and the impact that diverging opportunities have on future innovative capabilities provided a greater understanding of the 'dark side of innovation.' However, this understanding did not address the degree to which innovation has resulted in declining economic opportunities and outcomes. The discussion section was necessary to build upon existing frameworks in the literature while using complexity theory to add insight to the potential causes of declining economic and innovative output. Ultimately, through a qualitative discussion linking complexity with evolutionary economic geography, it was determined that innovation, and creative destruction, are not the lone causes of declining economic output and innovation. Complexity catastrophes play a large role in causing both self-organization and selection to be unable to address the suboptimal trajectories of systems. Excessive interdependencies and power inequalities throughout the American economic landscape have resulted in trapping the economic system in a suboptimal basin of fitness. To address this, the United States must collectively shift towards new innovative trajectories. Bourguignon argued that countries with larger financial sectors, less progressive taxation, as well as less regulated labor markets have reacted to technological change and globalization with more income inequality than other countries (2015). Contrasting this may present a blueprint for avoiding the development of excessive interdependencies and avoiding, or at least delaying, future complexity catastrophes.

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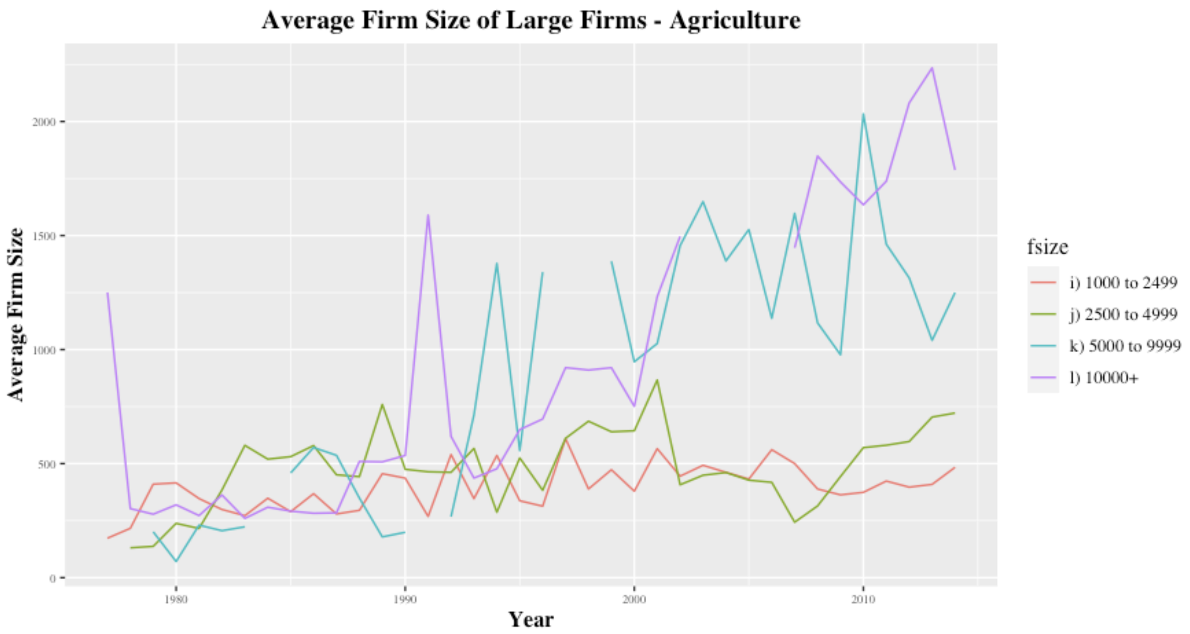
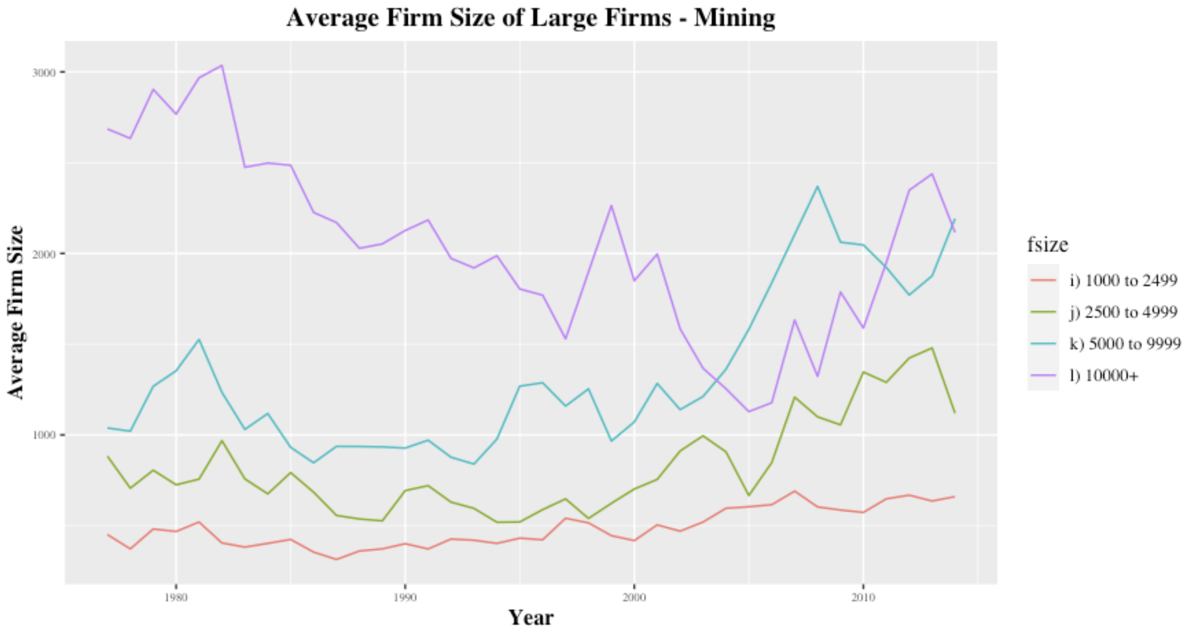
Appendix:

Average Firm Size of Largest Firms in Each Sector and Economy-Wide

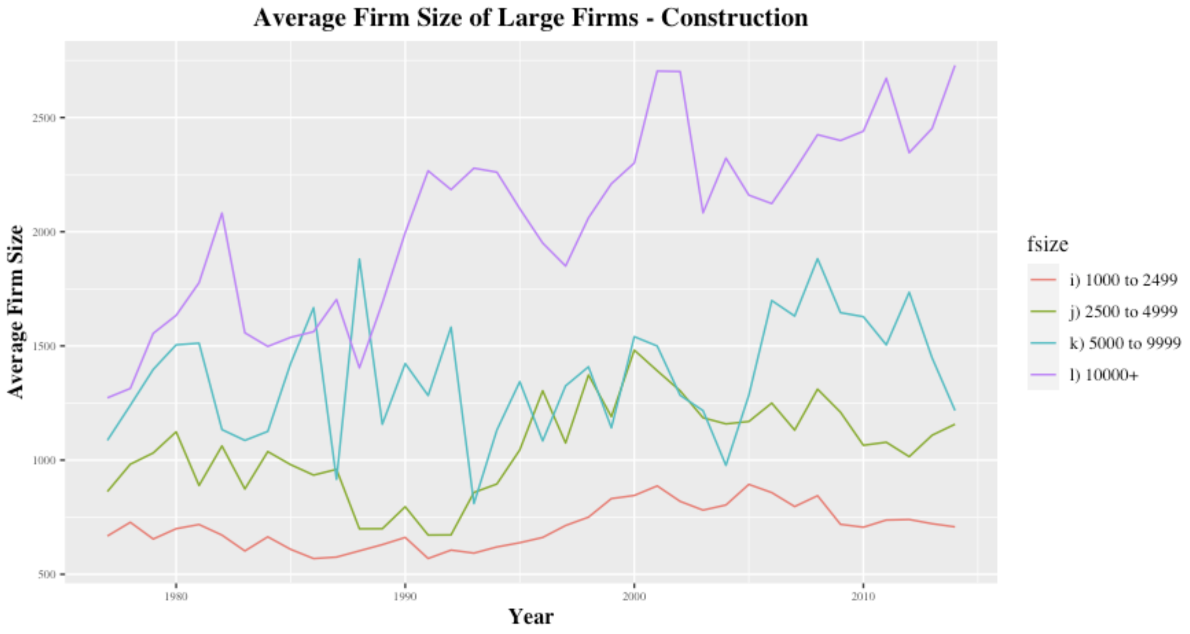
Agriculture:



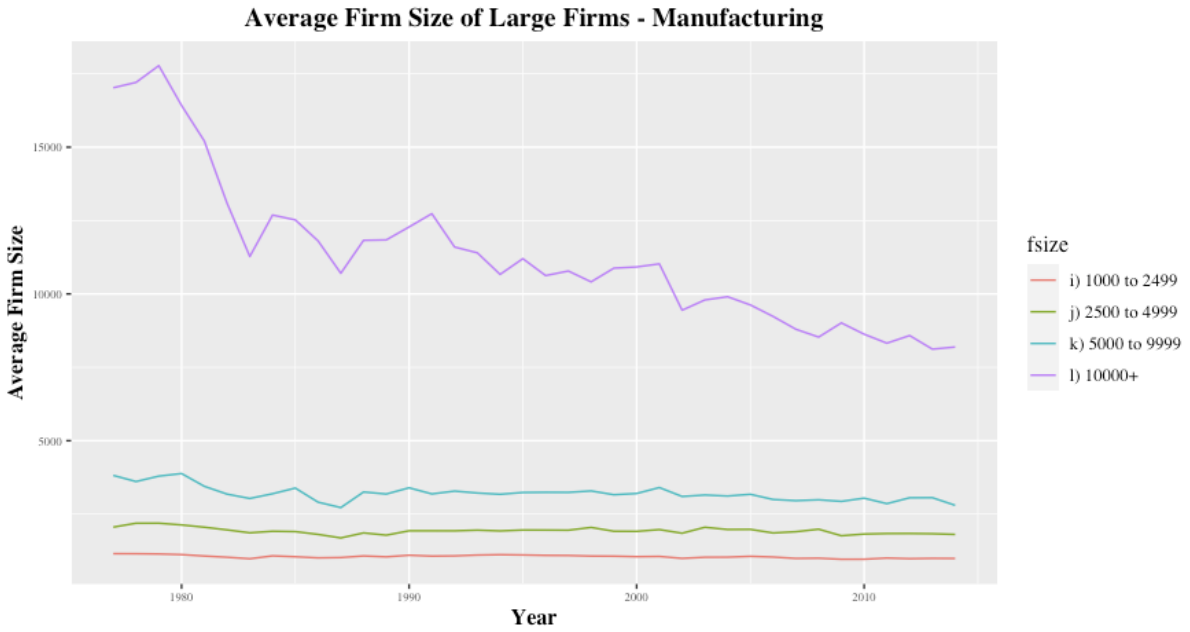
Mining:



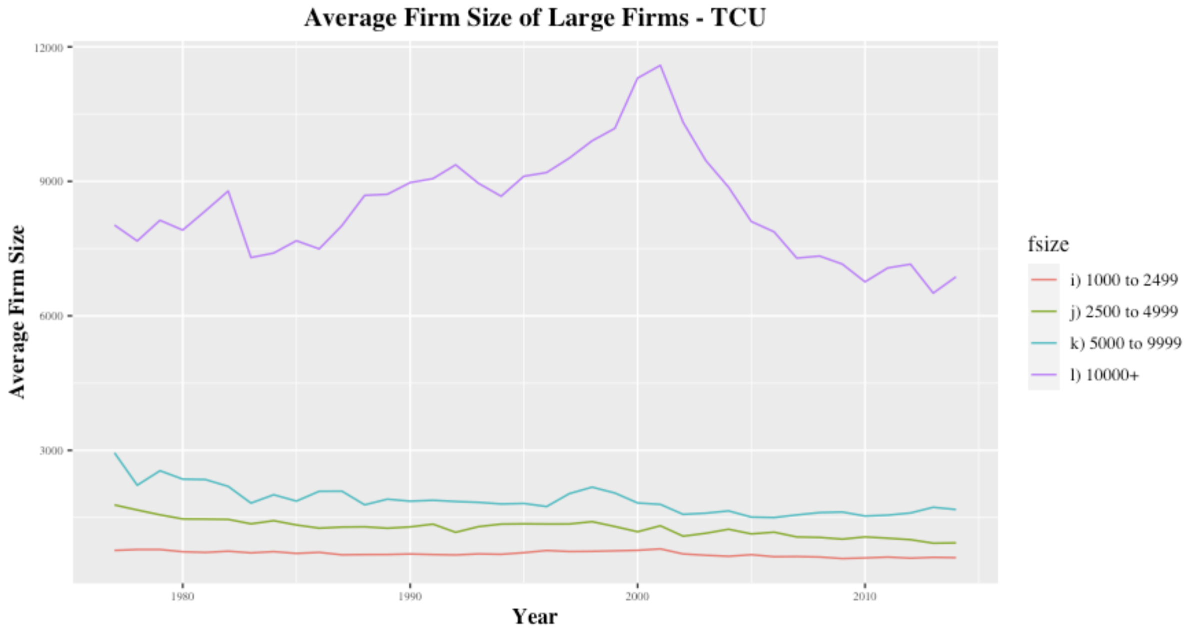
Construction:



Manufacturing:

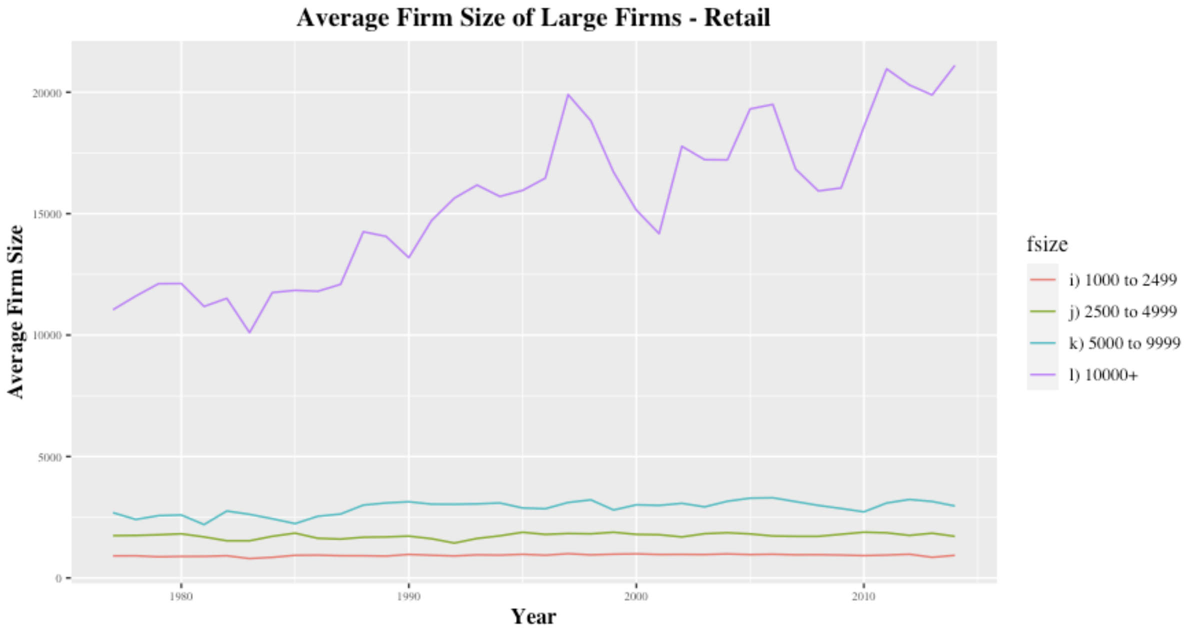


TCU:

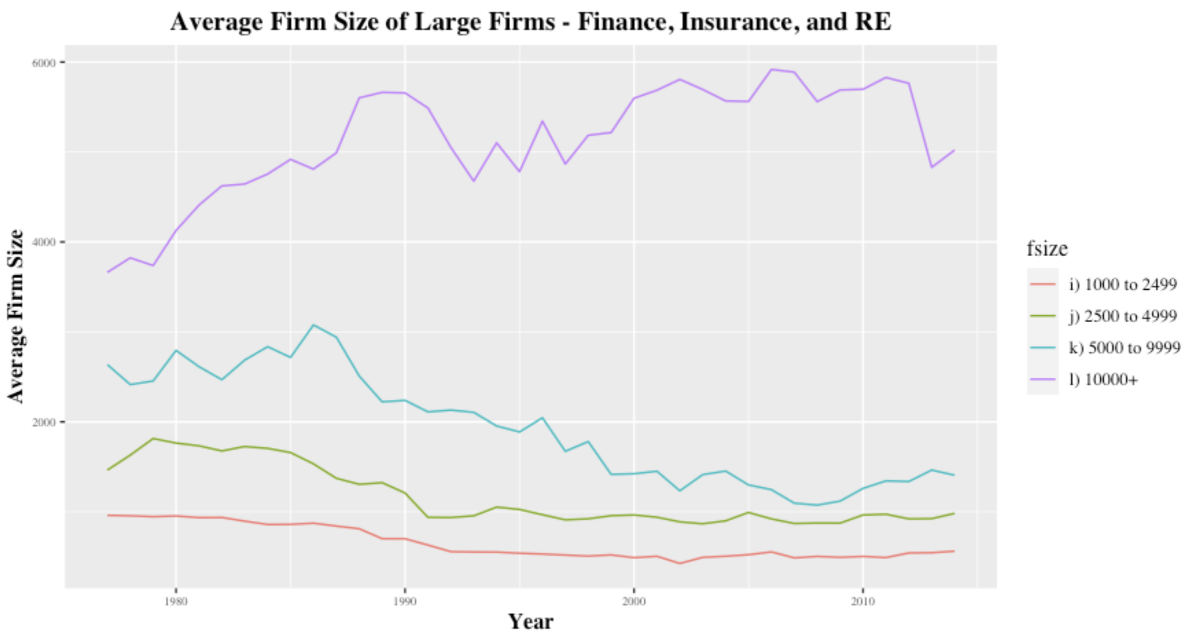


Wholesale Trade:

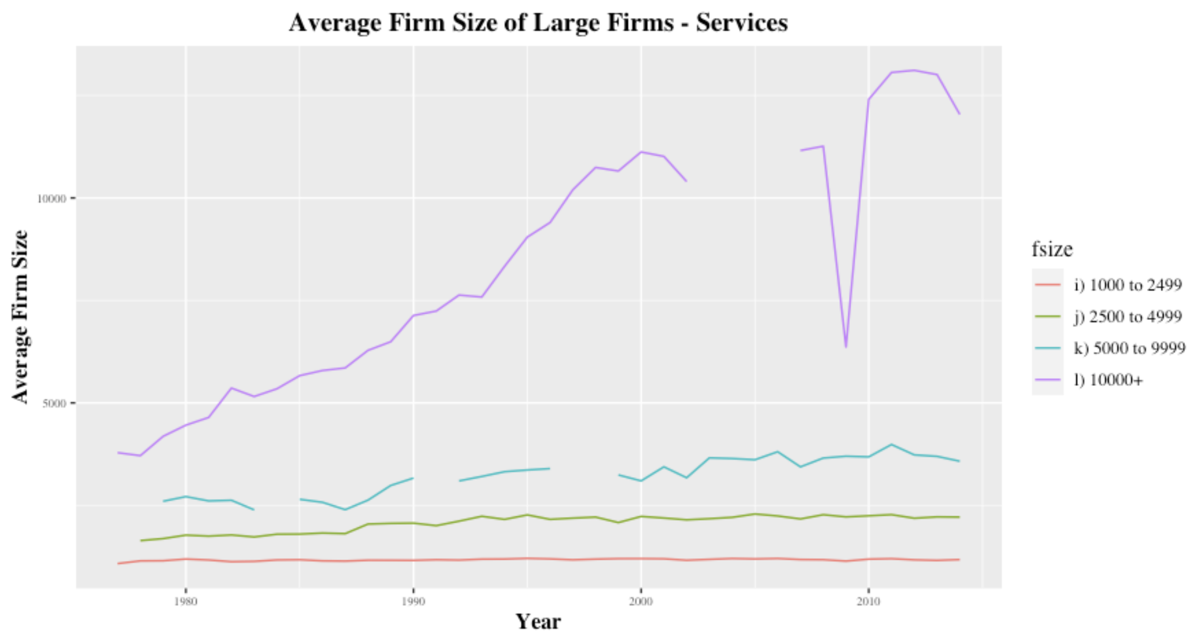
Retail Trade:



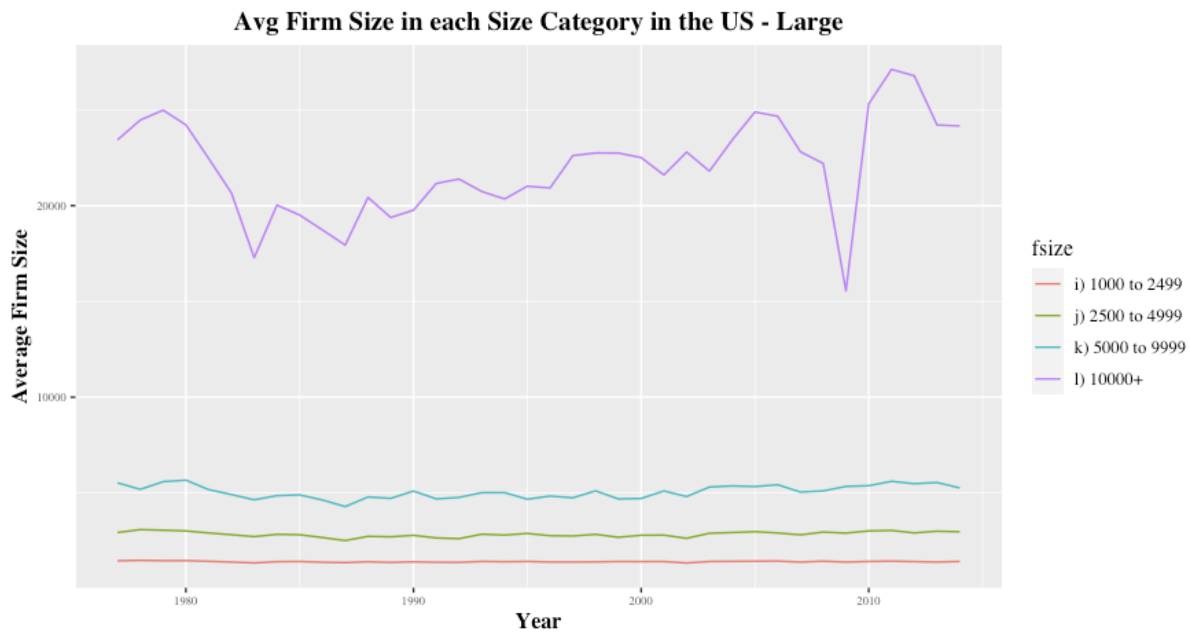
FIRE:



Services:



Economy Wide:



Regression Analyses

1.

```
#Analysis of Changes in Firm Sizes dependent on Metro vs Non-Metro
Call:
lm(formula = Change_in_Avg_Emp_per_Firm ~ Metro, data = BDS_MvN)

Residuals:
     Min        1Q    Median        3Q       Max
-0.124339 -0.044529 -0.000895  0.046437  0.101895

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.133864   0.009444  14.175   <2e-16 ***
Metro       -0.029191   0.013356  -2.186   0.0322 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.05666 on 70 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.06389,	Adjusted R-squared:  0.05051
F-statistic: 4.777 on 1 and 70 DF,  p-value: 0.03219
```

2.

```
#Analysis of Change in Establishments Sizes dependent on Metro vs Non-Metro
Call:
lm(formula = Change_in_Avg_Emp_per_Estab ~ Metro, data = BDS_MvN)

Residuals:
     Min       1Q   Median       3Q      Max
-0.09239 -0.02402  0.00027  0.02161  0.07545

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.085953   0.005324  16.145  < 2e-16 ***
Metro       -0.026842   0.007529  -3.565  0.00066 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03194 on 70 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.1537,	Adjusted R-squared:  0.1416
F-statistic: 12.71 on 1 and 70 DF,  p-value: 0.0006602
```

3.

```
#Analysis of Effect of Firmdeaths on Average Firm Size in Non-Metro Areas
Call:
lm(formula = Avg_Employment_per_Firm ~ Firmdeath_Firms_as_a_PER_of_Total_Firms,
    data = BDS_nonmetro)

Residuals:
```

```
    Min       1Q   Median       3Q      Max
-1.63122 -0.59047  0.07331  0.58236  1.31008

Coefficients:
                                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                                   21.116      1.173  18.004  < 2e-16 ***
Firmdeath_Firms_as_a_PER_of_Total_Firms      -64.466     14.016  -4.599 5.35e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.7448 on 35 degrees of freedom
Multiple R-squared:  0.3767,	Adjusted R-squared:  0.3589
F-statistic: 21.15 on 1 and 35 DF,  p-value: 5.346e-05
```

4.

```
# Analysis of Effect of Firmdeaths on Average Firm Size in Metro Areas
Call:
lm(formula = Avg_Employment_per_Firm ~ Firmdeath_Firms_as_a_PER_of_Total_Firms,
   data = BDS_metro)

Residuals:
    Min       1Q   Median       3Q      Max
-1.73929 -0.76674  0.09612  0.71666  1.54161

Coefficients:
                                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                                   28.314      1.964  14.416 2.74e-16 ***
Firmdeath_Firms_as_a_PER_of_Total_Firms      -63.876     22.368  -2.856  0.00718 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9546 on 35 degrees of freedom
Multiple R-squared:  0.189,	Adjusted R-squared:  0.1658
F-statistic: 8.155 on 1 and 35 DF,  p-value: 0.007176
```

5.

```
#Analysis of Effect of Firmdeaths on Change in Avg Firm Size in Non-Metro Areas
Call:
lm(formula = Change_in_Avg_Emp_per_Firm ~ Firmdeath_Firms_as_a_PER_of_Total_Firms,
   data = BDS_nonmetro)

Residuals:
     Min        1Q    Median        3Q       Max
-0.117435 -0.045102  0.005542  0.043236  0.092617

Coefficients:
                                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                                  0.48752    0.08898   5.479  4.1e-06 ***
Firmdeath_Firms_as_a_PER_of_Total_Firms     -4.27495    1.07019  -3.995 0.000329 ***
---
```

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.05349 on 34 degrees of freedom
(1 observation deleted due to missingness)
Multiple R-squared: 0.3194, Adjusted R-squared: 0.2994
F-statistic: 15.96 on 1 and 34 DF, p-value: 0.0003289

6.
#Analysis of Effect of Firmdeaths on Change in Avg Firm Size in Metro Areas

```
Call:
lm(formula = Change_in_Avg_Emp_per_Firm ~ Firmdeath_Firms_as_a_PER_of_Total_Firms,
    data = BDS_metro)

Residuals:
      Min        1Q    Median        3Q       Max
-0.086033 -0.037511  0.001096  0.036163  0.072670

Coefficients:
                                        Estimate Std. Error t value Pr(>|t|)
(Intercept)                               0.3281     0.1001   3.277  0.00242 **
Firmdeath_Firms_as_a_PER_of_Total_Firms  -2.5643     1.1458  -2.238  0.03188 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.04579 on 34 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.1284,	Adjusted R-squared:  0.1028
F-statistic: 5.009 on 1 and 34 DF,  p-value: 0.03188
```

7. #Analysis of the correlation between the % of jobs created by new firms each year with the year in Metro areas

```
Call:
lm(formula = Year ~ PER_of_New_Jobs_Created_by_New_Firms, data = Metro)

Residuals:
    Min      1Q  Median      3Q     Max
-25.820  -6.677   1.661   6.080  18.941

Coefficients:
                                     Estimate Std. Error t value Pr(>|t|)
(Intercept)                           2049.13      17.17 119.332  < 2e-16 ***
PER_of_New_Jobs_Created_by_New_Firms  -232.24      74.74  -3.107  0.00373 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.719 on 35 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.2162,	Adjusted R-squared:  0.1938
F-statistic: 9.656 on 1 and 35 DF,  p-value: 0.003735
```

8. #Analysis of the correlation between the % of jobs created by new firms each year with the year in Non-Metro areas

Call:

```
lm(formula = Year ~ PER_of_New_Jobs_Created_by_New_Firms, data = NonMetro)

Residuals:
   Min      1Q  Median      3Q     Max
-24.534  -3.969   1.656   4.597  15.000

Coefficients:
                                      Estimate Std. Error t value Pr(>|t|)
(Intercept)                            2041.15      11.35 179.762  < 2e-16 ***
PER_of_New_Jobs_Created_by_New_Firms  -193.44      48.23  -4.011 0.000302 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.086 on 35 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.3149,       Adjusted R-squared:  0.2953
F-statistic: 16.09 on 1 and 35 DF,  p-value: 0.0003025
```

9. #Analysis of the correlation between the change in firm entry as a % of employment and the dummy variable metro (where metro=1 means metropolitan area)

```
Call:
lm(formula = NewFirmPerTotalEmp ~ Metro, data = FullMetNon)

Residuals:
     Min       1Q   Median       3Q      Max
-0.25814 -0.06001 -0.01408  0.07337  0.32010

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.54135    0.01846  29.320  < 2e-16 ***
Metro       -0.10840    0.02611  -4.152 8.95e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1123 on 72 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.1931,       Adjusted R-squared:  0.1819
F-statistic: 17.24 on 1 and 72 DF,  p-value: 8.947e-05
```

10. #Analysis of the correlation between the change in firm entry as a % of firms and the dummy variable metro (where metro=1 means metropolitan area)

```
Call:
lm(formula = NewFirmPerTotalFirms ~ Metro, data = FullMetNon)

Residuals:
    Min      1Q  Median      3Q     Max
-3.7663 -0.9302 -0.1055  0.9216  4.4666

Coefficients:
```

```
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   8.5406     0.2606  32.768  < 2e-16 ***
Metro         1.2894     0.3686   3.498 0.000808 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.585 on 72 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.1453,	Adjusted R-squared:  0.1334
F-statistic: 12.24 on 1 and 72 DF,  p-value: 0.0008075
```

11. #Analysis of New Firm Entry per Emp per Year in Metro areas

```
Call:
lm(formula = Year ~ NewFirmPerTotalEmp, data = Metro)

Residuals:
    Min      1Q  Median      3Q     Max
-21.304  -3.765  -0.020   4.271  12.778

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        2045.621      6.393 320.003  < 2e-16 ***
NewFirmPerTotalEmp -114.611     14.551  -7.876 2.93e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.593 on 35 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.6393,	Adjusted R-squared:  0.629
F-statistic: 62.04 on 1 and 35 DF,  p-value: 2.933e-09
```

12. #Analysis of New Firm Entry per Emp per Year in NonMetro Areas

```
Call:
lm(formula = Year ~ NewFirmPerTotalEmp, data = NonMetro)

Residuals:
    Min      1Q  Median      3Q     Max
-18.868  -2.119   1.008   2.169   9.784

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        2030.929      4.048 501.692  < 2e-16 ***
NewFirmPerTotalEmp  -64.521      7.247  -8.904 1.62e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.075 on 35 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.6937,	Adjusted R-squared:  0.685
F-statistic: 79.27 on 1 and 35 DF,  p-value: 1.615e-10
```

13. #Analysis of NewFirmEntryperFirm per Year in Metro Areas

```
Call:
lm(formula = Year ~ NewFirmPerTotalFirms, data = Metro)

Residuals:
    Min      1Q  Median      3Q     Max
-23.2199  -5.1172   0.9628   4.4814  15.2240

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)          2049.8685     9.2520 221.559  < 2e-16 ***
NewFirmPerTotalFirms   -5.4801     0.9322  -5.879 1.11e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.787 on 35 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.4968,	Adjusted R-squared:  0.4825
F-statistic: 34.56 on 1 and 35 DF,  p-value: 1.115e-06
```

14.#Analysis of New Firm Entry per Firm per Year in NonMetro Areas

```
Call:
lm(formula = Year ~ NewFirmPerTotalFirms, data = NonMetro)

Residuals:
   Min      1Q  Median      3Q     Max
-21.025  -2.633   1.563   3.148  12.444

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)          2035.5151     5.9889 339.884  < 2e-16 ***
NewFirmPerTotalFirms   -4.6268     0.6872  -6.733 8.48e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.246 on 35 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.5643,	Adjusted R-squared:  0.5518
F-statistic: 45.33 on 1 and 35 DF,  p-value: 8.48e-08
```

Sector Regression Analyses - Employment, Firms, and Estabs

Year ~ Employment

Agriculture

```
Call:
lm(formula = year2 ~ emp, data = BasicAgr)

Residuals:
   Min      1Q  Median      3Q     Max
-3.2168 -1.1550  0.2823  1.0049  3.0593
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.969e+03  6.790e-01 2900.29   <2e-16 ***
emp         3.945e-05  9.406e-07   41.95   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.595 on 36 degrees of freedom
Multiple R-squared:   0.98,	Adjusted R-squared:  0.9794
F-statistic:  1760 on 1 and 36 DF,  p-value: < 2.2e-16
```

Mining

```
Call:
lm(formula = year2 ~ emp, data = BasicMin)

Residuals:
    Min      1Q  Median      3Q     Max
-14.047  -5.968  -3.373   2.700  22.760

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.019e+03  6.279e+00 321.517  < 2e-16 ***
emp         -3.464e-05  9.061e-06  -3.823 0.000504 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.502 on 36 degrees of freedom
Multiple R-squared:  0.2887,	Adjusted R-squared:  0.269
F-statistic: 14.61 on 1 and 36 DF,  p-value: 0.0005037
```

Construction

```
Call:
lm(formula = year2 ~ emp, data = BasicCon)

Residuals:
    Min      1Q  Median      3Q     Max
-12.745  -6.876  -1.705   1.434  22.328

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.965e+03  9.165e+00 214.411  < 2e-16 ***
emp         6.187e-06  1.836e-06   3.369  0.00181 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.824 on 36 degrees of freedom
Multiple R-squared:  0.2397,	Adjusted R-squared:  0.2186
F-statistic: 11.35 on 1 and 36 DF,  p-value: 0.001809
```

Manufacturing

```
Call:
lm(formula = year2 ~ emp, data = BasicMan)
```

```
Residuals:
    Min      1Q  Median      3Q     Max 
-10.410  -2.814  -0.144   2.257   8.677 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  2.060e+03  5.025e+00  409.92  < 2e-16 ***
emp         -3.743e-06  2.893e-07  -12.94 4.21e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.74 on 36 degrees of freedom
Multiple R-squared:  0.823,	Adjusted R-squared:  0.8181 
F-statistic: 167.4 on 1 and 36 DF,  p-value: 4.213e-15
```

Transportation, Communications, and Utilities

```
Call:
lm(formula = year2 ~ emp, data = BasicTcu)

Residuals:
    Min      1Q  Median      3Q     Max 
-8.0951 -2.1128 -0.4469  0.4062  9.6643 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.922e+03  5.446e+00  352.88  < 2e-16 ***
emp         1.277e-05  9.357e-07   13.64 8.54e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.535 on 36 degrees of freedom
Multiple R-squared:  0.8379,	Adjusted R-squared:  0.8334 
F-statistic: 186.1 on 1 and 36 DF,  p-value: 8.537e-16
```

WholesaleTrade

```
Call:
lm(formula = year2 ~ emp, data = BasicWho)

Residuals:
    Min      1Q  Median      3Q     Max 
-6.6965 -4.0470 -1.6193  0.7007 14.6011 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.910e+03  9.858e+00 193.707  < 2e-16 ***
emp         1.377e-05  1.571e-06   8.766 1.86e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 6.364 on 36 degrees of freedom
Multiple R-squared:  0.6809,	Adjusted R-squared:  0.6721
```

```
F-statistic: 76.83 on 1 and 36 DF,  p-value: 1.856e-10
```

Retail Trade

```
Call:
lm(formula = year2 ~ emp, data = BasicRet)

Residuals:
    Min      1Q  Median      3Q     Max 
-2.8967 -1.6523 -0.8943  1.2484  5.2366 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.938e+03  2.151e+00  900.82   <2e-16 ***
emp         2.799e-06  1.025e-07   27.31   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.417 on 36 degrees of freedom
Multiple R-squared:  0.954,	Adjusted R-squared:  0.9527 
F-statistic:   746 on 1 and 36 DF,  p-value: < 2.2e-16
```

Finance, Insurance, and Real Estate

```
Call:
lm(formula = year2 ~ emp, data = BasicFir)

Residuals:
    Min      1Q  Median      3Q     Max 
-5.5286 -3.2327 -0.4725  0.6558 10.2831 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.934e+03  4.346e+00  445.11  < 2e-16 ***
emp         8.720e-06  6.119e-07   14.25 2.25e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.372 on 36 degrees of freedom
Multiple R-squared:  0.8494,	Adjusted R-squared:  0.8453 
F-statistic: 203.1 on 1 and 36 DF,  p-value: 2.254e-16
```

Services

```
Call:
lm(formula = year2 ~ emp, data = BasicSrv)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.98195 -0.90228 -0.02343  0.64657  2.40462 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.963e+03  6.317e-01 3107.11   <2e-16 ***
emp         9.560e-07  1.756e-08   54.46   <2e-16 ***
---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.234 on 36 degrees of freedom
Multiple R-squared:  0.988,	Adjusted R-squared:  0.9877
F-statistic:  2966 on 1 and 36 DF,  p-value: < 2.2e-16
```

Year ~ Firms

Agriculture

```
Call:
lm(formula = year2 ~ firms, data = BasicAgr)

Residuals:
    Min      1Q  Median      3Q     Max
-1.6686 -1.1603 -0.3027  0.9768  2.9403

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.964e+03  7.058e-01  2782.1   <2e-16 ***
firms       3.941e-04  8.280e-06    47.6   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.409 on 36 degrees of freedom
Multiple R-squared:  0.9844,	Adjusted R-squared:  0.9839
F-statistic:  2266 on 1 and 36 DF,  p-value: < 2.2e-16
```

Mining

```
Call:
lm(formula = year2 ~ firms, data = BasicMin)

Residuals:
    Min      1Q  Median      3Q     Max
-20.707  -3.820  -2.329   3.070  19.662

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.037e+03  1.087e+01 187.366  < 2e-16 ***
firms       -2.049e-03  5.267e-04  -3.891 0.000414 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 9.453 on 36 degrees of freedom
Multiple R-squared:  0.296,	Adjusted R-squared:  0.2765
F-statistic: 15.14 on 1 and 36 DF,  p-value: 0.000414
```

Construction

```
Call:
lm(formula = year2 ~ firms, data = BasicCon)

Residuals:
```

```
   Min      1Q  Median      3Q     Max
-15.577  -8.662  -2.070   7.255  21.933

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.980e+03  1.242e+01 159.382   <2e-16 ***
firms       3.268e-05  2.600e-05   1.257    0.217
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 11.03 on 36 degrees of freedom
Multiple R-squared:  0.04203,	Adjusted R-squared:  0.01542
F-statistic:  1.58 on 1 and 36 DF,  p-value: 0.2169
```

Manufacturing

```
Call:
lm(formula = year2 ~ firms, data = BasicMan)

Residuals:
   Min      1Q  Median      3Q     Max
-22.127  -6.510   5.794   7.690   9.465

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.058e+03  2.105e+01   97.80   <2e-16 ***
firms       -2.274e-04  7.604e-05   -2.99    0.005 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.08 on 36 degrees of freedom
Multiple R-squared:  0.199,	Adjusted R-squared:  0.1767
F-statistic: 8.942 on 1 and 36 DF,  p-value: 0.005003
```

Transportation, Communication, and Utilities

```
Call:
lm(formula = year2 ~ firms, data = BasicTcu)

Residuals:
   Min      1Q  Median      3Q     Max
-6.7954 -2.5703 -0.7508  1.4260  9.8986

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.927e+03  5.312e+00  362.78  < 2e-16 ***
firms       4.101e-04  3.148e-05   13.03 3.42e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.713 on 36 degrees of freedom
Multiple R-squared:  0.825,	Adjusted R-squared:  0.8201
```

```
F-statistic: 169.7 on 1 and 36 DF,  p-value: 3.423e-15
```

Wholesale Trade

```
Call:
lm(formula = year2 ~ firms, data = BasicWho)

Residuals:
    Min      1Q  Median      3Q     Max 
-11.091  -9.254  -4.864   7.647  22.247 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.952e+03  2.227e+01  87.646   <2e-16 ***
firms       1.319e-04  6.700e-05   1.969   0.0567 .  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 10.7 on 36 degrees of freedom
Multiple R-squared:  0.09721,	Adjusted R-squared:  0.07213 
F-statistic: 3.876 on 1 and 36 DF,  p-value: 0.05671
```

Retail Trade

```
Call:
lm(formula = year2 ~ firms, data = BasicRet)

Residuals:
    Min      1Q  Median      3Q     Max 
-18.262  -4.908  -2.130   4.099  28.478 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.688e+03  8.523e+01  19.807  < 2e-16 ***
firms       3.267e-04  9.060e-05   3.606 0.000934 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.656 on 36 degrees of freedom
Multiple R-squared:  0.2654,	Adjusted R-squared:  0.245 
F-statistic: 13.01 on 1 and 36 DF,  p-value: 0.0009343
```

Finance, Insurance and Real Estate

```
Call:
lm(formula = year2 ~ firms, data = BasicFir)

Residuals:
    Min      1Q  Median      3Q     Max 
-7.2745 -2.2876  0.1556  1.1970  7.4177 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
```

```
(Intercept) 1.926e+03  3.976e+00  484.35   <2e-16 ***
firms       1.807e-04  1.023e-05   17.67   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.622 on 36 degrees of freedom
Multiple R-squared:  0.8967,	Adjusted R-squared:  0.8938
F-statistic: 312.3 on 1 and 36 DF,  p-value: < 2.2e-16
```

Services

```
Call:
lm(formula = year2 ~ firms, data = BasicSrv)

Residuals:
    Min      1Q  Median      3Q     Max
-2.3600 -0.9390 -0.3537  0.9945  2.9664

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.945e+03  1.092e+00 1781.43   <2e-16 ***
firms       2.730e-05  5.824e-07   46.87   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.431 on 36 degrees of freedom
Multiple R-squared:  0.9839,	Adjusted R-squared:  0.9834
F-statistic:  2197 on 1 and 36 DF,  p-value: < 2.2e-16
```

Year ~ Estabs

Agriculture

```
Call:
lm(formula = year2 ~ estabs, data = BasicAgr)

Residuals:
    Min      1Q  Median      3Q     Max
-1.6134 -1.0491 -0.4376  0.8697  2.5103

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.964e+03  5.992e-01 3277.64   <2e-16 ***
estabs      3.788e-04  6.831e-06   55.45   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.212 on 36 degrees of freedom
Multiple R-squared:  0.9884,	Adjusted R-squared:  0.9881
F-statistic:  3074 on 1 and 36 DF,  p-value: < 2.2e-16
```

Mining

```
Call:
```

```
lm(formula = year2 ~ estabs, data = BasicMin)

Residuals:
    Min      1Q  Median      3Q     Max
-19.536  -4.364  -2.147   2.849  20.942

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.038e+03  1.202e+01 169.578  < 2e-16 ***
estabs      -1.619e-03  4.567e-04  -3.546  0.00111 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.699 on 36 degrees of freedom
Multiple R-squared:  0.2589,	Adjusted R-squared:  0.2383
F-statistic: 12.57 on 1 and 36 DF,  p-value: 0.001107
```

Construction

```
Call:
lm(formula = year2 ~ estabs, data = BasicCon)

Residuals:
    Min      1Q  Median      3Q     Max
-15.389  -8.603  -2.162   7.114  22.081

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.979e+03  1.253e+01  158.00   <2e-16 ***
estabs      3.439e-05  2.586e-05    1.33    0.192
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 11 on 36 degrees of freedom
Multiple R-squared:  0.04683,	Adjusted R-squared:  0.02035
F-statistic: 1.769 on 1 and 36 DF,  p-value: 0.1919
```

Manufacturing

```
Call:
lm(formula = year2 ~ estabs, data = BasicMan)

Residuals:
    Min      1Q  Median      3Q     Max
-21.755  -6.766   5.608   7.719   9.376

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.064e+03  2.198e+01  93.883  < 2e-16 ***
estabs      -2.051e-04  6.591e-05  -3.112  0.00363 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Residual standard error: 10 on 36 degrees of freedom
Multiple R-squared:  0.212,	Adjusted R-squared:  0.1901
F-statistic: 9.686 on 1 and 36 DF,  p-value: 0.003627
```

Transportation, Communication, and Utilities

```
Call:
lm(formula = year2 ~ estabs, data = BasicTcu)

Residuals:
    Min      1Q  Median      3Q     Max
-3.8694 -1.8184 -0.5753  1.2394  6.2431

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.942e+03  2.455e+00  791.07   <2e-16 ***
estabs      2.189e-04  9.839e-06   22.25   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.934 on 36 degrees of freedom
Multiple R-squared:  0.9322,	Adjusted R-squared:  0.9303
F-statistic: 494.9 on 1 and 36 DF,  p-value: < 2.2e-16
```

Wholesale Trade

```
Call:
lm(formula = year2 ~ estabs, data = BasicWho)

Residuals:
   Min     1Q Median     3Q    Max
-8.765 -7.165 -4.727  6.077 21.514

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.912e+03  2.133e+01  89.644  < 2e-16 ***
estabs      1.895e-04  4.809e-05   3.941 0.000358 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.416 on 36 degrees of freedom
Multiple R-squared:  0.3014,	Adjusted R-squared:  0.282
F-statistic: 15.53 on 1 and 36 DF,  p-value: 0.0003577
```

Retail Trade

```
Call:
lm(formula = year2 ~ estabs, data = BasicRet)

Residuals:
    Min      1Q  Median      3Q     Max
-5.5813 -2.5978  0.0763  1.5840 11.8493
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.824e+03  9.971e+00  182.93   <2e-16 ***
estabs      1.234e-04  7.162e-06   17.23   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.706 on 36 degrees of freedom
Multiple R-squared:  0.8918,	Adjusted R-squared:  0.8888
F-statistic: 296.8 on 1 and 36 DF,  p-value: < 2.2e-16
```

Finance, Insurance and Real Estate

```
Call:
lm(formula = year2 ~ firms, data = BasicFir)

Residuals:
    Min      1Q  Median      3Q     Max
-7.2745 -2.2876  0.1556  1.1970  7.4177

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.926e+03  3.976e+00  484.35   <2e-16 ***
firms       1.807e-04  1.023e-05   17.67   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.622 on 36 degrees of freedom
Multiple R-squared:  0.8967,	Adjusted R-squared:  0.8938
F-statistic: 312.3 on 1 and 36 DF,  p-value: < 2.2e-16
```

Services

```
Call:
lm(formula = year2 ~ estabs, data = BasicSrv)

Residuals:
    Min      1Q  Median      3Q     Max
-2.2029 -0.7154 -0.3484  0.6419  2.9042

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.951e+03  8.128e-01 2400.27   <2e-16 ***
estabs      2.099e-05  3.719e-07   56.43   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.191 on 36 degrees of freedom
Multiple R-squared:  0.9888,	Adjusted R-squared:  0.9885
F-statistic:  3185 on 1 and 36 DF,  p-value: < 2.2e-16
```

Email Correspondence with U.S. Census Bureau's Business Dynamic Statistics

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Christian Koudal <cskoudal@gmail.com> Thu, Sep 10, 2020 at 5:18 PM

To: ces.bds@census.gov

To Whom It May Concern,

I am currently working on a thesis project using data from BDS, particularly data surrounding Metro vs. NonMetro growth in employment, # of firms, etc, and it is quite interesting so far. I have a few questions about data categorization.

Is there any overlap between firms who are Metro and NonMetro or are they completely separate? For example, is employment in NonMetro areas by a firm based in Metro areas counted only in NonMetro statistics or Metro statistics? Is that firm considered a NonMetro firm, a Metro firm or both?

I ask because when calculating the average firm size for firms within certain size ranges, the average size is sometimes at or below the range. For example, the average firm size for firms in Metro areas with 5,000 to 9,999 employees is often close to or below 5,000.

Is this due to self-reporting by firms or by counting employees based outside Metro areas separately? Some other reason?

One more thing, why is 50,000 the number chosen to separate Metro from Non-Metro areas?

Any help with these questions would be greatly appreciated!

Sincerely,

Christian Koudal

CES BDS (CENSUS/CES) <ces.bds@census.gov> Tue, Sep 15, 2020 at 2:45 PM

To: Christian Koudal <cskoudal@gmail.com>

Hello,

For a national level table, where there is no geographic or industrial breakout, the data on firms is simple. In the Economy-wide table, we see that in 2014 there were 5,058,018 firms operating in the U.S. But once you breakout a table by geography or industry, it gets a little more complicated, because geography and industry are defined at the establishment level. So when you're counting up firms say at the metro versus non-metro tables, the firm count in metro areas represents the number of firms that had at least one estab in a metro area, and the firm count in non-metro areas represents the number of firms that had at least one estab in a non-metro area. So the same firm can show up in both the metro and non-metro tables.
Let me know if you still have questions.

regards,

Jim Lawrence

Christian Koudal <cskoudal@gmail.com> Tue, Sep 15, 2020 at 5:28 PM
To: "CES BDS (CENSUS/CES)" <ces.bds@census.gov>

Hi Jim,

Thank you for your response - that makes perfect sense. I do have a question regarding the number of firms in the various size ranges across the entire economy and the number of firms in the various size ranges in each of the nine sectors.

In 2014, across the economy, there are 1370 firms that employ 10,000 or more people, but when adding up the number of 10,000+ size firms in each industry in 2014, there are 3260 firms. The overall number of firms economy wide in 2014 using the bds_f_sz_release.csv datatable is 5,060,326, while the overall number of firms in 2014 in the bds_f_szsic_release.csv datatable is 4,987,000, so it doesn't seem to be an issue of double counting. Why is this the case?

Thank you again for your help!

Best regards,

Christian Koudal

CES BDS (CENSUS/CES) <ces.bds@census.gov> Mon, Sep 21, 2020 at 5:00 PM
To: Christian Koudal <cskoudal@gmail.com>

Hello,

While geography and industry are assigned at the establishment level, firm size and firm age are assigned at the firm level, and refers to the entire firm, not just the part that operates within a given geography or industry.
Hope that helps.

Jim

Christian Koudal <cskoudal@gmail.com> Mon, Sep 21, 2020 at 6:50 PM
To: "CES BDS (CENSUS/CES)" <ces.bds@census.gov>

Hi Jim,

Thank you for your response, however, I am still a bit confused.

Your explanation does explain the higher totals of firms in the industrial 10,000+ size range vs economy-wide 10,000+ size range, as a firm can have establishments in multiple industries or sectors. However, shouldn't there then be more firms in the industry firm sizes dataset than in the economy firm sizes dataset overall as well? The total amount of firms economy wide is greater than the total amount of firms in the industry datatable as mentioned in the previous email. Are there firms listed in the economy dataset that are not categorized into any of the sectors?

Thank you again for your time and help, it is greatly appreciated!

Best regards,

Christian Koudal