The Servicification of the U.S. Economy: The Role of Startups versus Incumbent Firms*

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Abstract. Over the last few decades, the U.S. economy has exhibited a significant shift from manufacturing towards services. This transition has been particularly prominent in an important subcategory of services industries that drives innovation and employs many high-wage workers: Supply Chain Traded Services (Delgado and Mills, 2020). These industries provide specialized service inputs to organizations and are characterized by high upstreamness, which allows innovations to cascade down to other buyer industries. In this chapter, we explore the role of startups versus incumbent firms in driving the transition from manufacturing to Supply Chain Traded Services between 1998 and 2015. Using the Longitudinal Business Database of the U.S. Census Bureau, we find that startups experienced a large decline in Supply Chain Traded Services, both in terms of entry of new firms and growth of young firms. Instead, job growth in this sector has been led by established firms: the transformation of incumbent manufacturing firms towards services (e.g., Intel), and the growth of incumbent Supply Chain Traded Service firms (e.g., Microsoft). To complement our empirical findings, we discuss potential barriers for entrepreneurial firms, and illustrate the servicification efforts of several established firms. We conclude by offering broad policy implications.

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1. Introduction

The last few decades have shown a fundamental shift in the U.S. economy from manufacturing towards services (Figure 1). This trend has raised concerns that the shrinking manufacturing sector may hamper the overall rate of innovation. However, unprecedented growth in one important subcategory of services – "Supply Chain Traded Services" – suggests a more optimistic view. Supply Chain Traded Services (i.e., service inputs sold to organizations) represents a set of industries that account for a disproportionately high share of Science, Technology, Engineering and Math (STEM) jobs in the U.S. economy (Delgado and Mills, 2020). The economic importance of these services is evidenced in the growth of industries such as computer programming, data processing and hosting, design, and logistics services (Gawer and Cusumano, 2002; Bitner, Ostrom, and Morgan, 2008; Sheffi, 2012; Low, 2013; Delgado and Mills, 2020).

While prior studies have documented the shift in the U.S. economy from manufacturing to innovative services (see e.g., Delgado and Mills, 2020; Eckert, Ganapati, and Walsh, 2019), understanding the causes and sources of this transition is in its infancy. In particular, little is known regarding the types of firms – startups or established firms – that are driving the transition to Supply Chain Traded Services. In this chapter, we explore the role of three types of firms as potential drivers of growth in these innovative services. First, we analyze the entry and growth of new and young firms enabled by new technology and data, like Okta and Rapid7. Second, we examine the transformation of incumbent manufacturing firms towards services over the past few decades, including Cisco, IBM, Intel, and Xerox (Vandermerwe and Rada, 1988; Visnjic Kastalli and Van Looy, 2013; Lodefalk, 2013; Baines et al., 2017). Third, we explore the growth of incumbent Supply Chain Traded Services firms such as Microsoft and Accenture.

To implement our analysis, we primarily use the Longitudinal Business Database (LBD) of the U.S. Census Bureau, which is a panel dataset of all establishments in the U.S. economy with at least one paid employee. The longitudinal nature of the LBD allows us to distinguish new and young startups from incumbent firms, and track important business characteristics including employment and payroll. We then categorize each establishment's underlying industry using the categorization developed by Delgado and Mills (2020). Our sample covers all U.S. establishments between 1998 and 2015, capturing the economic activity (employment and wages) in each sector by each firm type.

In this chapter, we focus on the types of firms and industries that are leading the transformation into high-wage, high-growth services. Our analysis provides a foundation for developing innovation and entrepreneurship policies specifically focused on building the skills and innovation ecosystems that better support innovative services, as this sector represents an important source of good jobs in the future.

2. Pessimistic View of the U.S. Economy: Manufacturing versus Services

Many U.S. politicians and policymakers appear to believe that the best way to rebuild the economy is to bring manufacturing back. The innovation debate has remained largely centered on manufacturing because it accounts for the vast majority of patents, while services tend to be viewed as low-technology and lower-wage. The focus on manufacturing has resulted in a pessimistic view of the economy reflecting the decline in manufacturing jobs, which has been attributed in part to an increase in imports from China (Acemoglu et al., 2016). From 1998 to 2015, manufacturing employment declined by more than 32%, while services grew by 25% (Figure 1). However, the pessimistic view about innovation is misleading: manufacturing currently comprises only about 9% of employment, and services are extremely heterogeneous – ranging from engineering and cloud computing to retail and restaurants. This chapter focuses on the hidden and growing role of suppliers of services in driving innovation and the jobs of the future.

2.1. A New Framework: The Supply Chain Economy

In recent work, Delgado and Mills (2020) develop a new innovation framework that focuses on the suppliers of goods and services to businesses and the government: the "Supply Chain Economy." It includes businesses producing inputs (versus consumer products) such as semiconductors, cloud computing, design, and engineering services.

Suppliers are a source of innovation due to three important conceptual attributes. First, they create specialized inputs that can make the innovation process more efficient (Rosenberg, 1963). Second, they tend to have numerous layers of buyer industries, so inventions developed by suppliers can diffuse broadly to multiple downstream industries. At the extreme, some innovative inputs (e.g., semiconductors) become general purpose technologies (GPTs) (Bresnahan and Trajtenberg, 1995). Service industries such as cloud computing and artificial intelligence are becoming the next wave of GPTs (Brynjolfsson et al., 2018; Cockburn, Henderson, and Stern, 2018; Trajtenberg, 2019; Delgado and Mills, 2020). A third important attribute of suppliers is that they fuel geographical clusters, which spur innovation through the generation of agglomeration benefits (Chinitz, 1961; Delgado, Porter, and Stern, 2014).

To quantify the role of suppliers on innovation and jobs, Delgado and Mills (2020) provide a new industry categorization: Supply Chain vs. Business-to-Consumer industries. Using the 2002 Benchmark Input-Output Accounts of the Bureau of Economic Analysis (BEA), they separate supply chain (SC) industries (i.e., those that sell primarily to businesses or government) from business-to-consumer (B2C) industries (i.e., those that sell primarily to consumers).[1] They find that there is a distinct and large supply

[1] SC industries are those with low sales to Personal Consumer Expenditures (≤ 35%); and B2C industries otherwise. Alternative SC industry definitions are tested in the Appendix of Delgado and Mills (2020).

chain economy that accounts for 43% of U.S. jobs (53 million) and for most STEM jobs and patents (87%) as of 2015 (Figure 2).

In contrast to other industry categorizations that condition on industries that are STEM or knowledge-intensive (e.g., "knowledge-intensive business services" (Muller and Doloreux, 2009); "advanced industries" (Muro et al., 2015); or "skilled traded services" (Eckert, Ganapati, and Walsh, 2019)), the supply chain industry categorization does not rely ex-ante on innovation metrics. Industries that sell inputs to organizations are examined because of their conceptual importance for innovation, as described above. The empirical findings show that supply chain industries do, in fact, have a high concentration of innovative activity, as measured by STEM jobs and patents. Thus, the supply chain economy categorization reveals important insights on the sources of innovation in the U.S. economy. [2]

Delgado and Mills (2020) combine their categorization with two prior industry categorizations, Traded versus Local (Porter, 2003) and Manufacturing versus Services, to analyze specific subcategories of the economy (see full SC versus B2C categorization in Figure 2).[3] They find that SC Traded Services are a large and distinct segment that is a key driver of innovation. This subcategory encompasses more than 200 industries, including data processing and hosting, software, many professional services (like design, engineering, R&D, advertising), financial, and logistics services. SC Traded Services constitute a significant part of the economy, with 20% of all jobs and 17% of firms. These services have the highest-wage jobs and are marked by the highest STEM Intensity (17 out of 100 jobs are in STEM occupations), though interestingly they account for relatively few patents (9%). Importantly, they have experienced fast growth in terms of jobs and wages during the 1998-2015 period (Figure 1).

What could explain the high growth of these innovative service inputs? One answer is that these industries have many layers of buyer industries (based on the measure of industry upstreamness developed by Antràs et al. (2012)).[4] This attribute, together with high STEM intensity, can increase their ability to produce specialized inputs for distinct industries, and cascade and diffuse innovation. In an increasingly knowledge and data-driven economy, many of these services, like cloud computing, have become centrally important.

[2] These alternative categorizations select industries based on particular innovation metrics, and therefore often include a mix of SC and B2C industries. For example, Eckert et al. (2019) classifies as Skilled Tradable Services the NAICS codes 51 (*Information*), 52 (*Finance and Insurance*), 53 (*Real Estate and Rental and Leasing*), 54 (*Professional, Scientific, and Technical Services*) and 55 (*Management of Companies and Enterprises*). These services include 88 SC industries and 55 B2C industries (six-digit NAICS-2012 code). Among the 218 SC Traded Services industries in Delgado and Mills (2020) only a subset of 67 industries are also included in Eckert et al. (2019)'s Skilled Tradable Services. Industry categorizations based on innovation metrics can be very useful, but do not explore the conceptual reasons why an industry might be, or evolve to be, more STEM or innovation-intensive.

[3] Traded industries are those that sell their output across regions and countries, as opposed to industries that primarily serve the local market (e.g., retail). This categorization was initially developed by Porter (2003).

[4] See Delgado and Mills (2020) for a detailed explanation of the upstreamness scores of SC versus B2C industries.

What firms are driving the growth in SC Traded Services? We examine three types of firms that may be contributing to the growth: new and young firms (e.g., Rapid7 and ShipHawk); manufacturing incumbents (e.g., IBM and Intel); and service incumbents (e.g., Microsoft and IDEO). Understanding the types of firms driving this change is important, as each may require distinct policy initiatives to access skilled labor, capital, buyers, and other growth-enhancing resources.

3. Data: Mapping Firms by Sector and Age

In this study, the Longitudinal Business Database (LBD) of the U.S. Census Bureau serves as the primary dataset. The LBD is a panel dataset of all employer establishments in the U.S. economy. The LBD provides important establishment-level characteristics including employment, payroll, industry, and location. Spanning 1976 to 2015, the LBD covers all industries in the private non-farm economy and every state in the U.S. While the underlying observations are at the level of the establishment, the LBD assigns a unique firm identifier to each establishment – a useful feature for tracking establishment-level activity for firms with multiple establishments.[5]

We also use the 2017 National Establishment Time-Series (NETS) database to examine and illustrate three incumbent firms who have been increasing their service activities: IBM, Intel, and Microsoft. The NETS database (by Walls & Associates, in collaboration with Dun and Bradstreet) is public and provides establishment-level employment data for many firms, but with some limitations in its coverage and estimates.[6]

Our analysis is at the establishment level. Each LBD firm is decomposed into its portfolio of establishments. We then aggregate economic activity at the sector-level by summing up across all establishments in a given sector (e.g., manufacturing versus services). Therefore, a multi-unit firm with establishments spanning multiple sectors contributes to each sector based on its establishment-level activity. In measuring economic activity, we primarily use employment and payroll (adjusted to $2015).

3.1. Firm-Level Attributes: Primary Industry and Age

As mentioned above, in measuring aggregate activity, we use establishment-level statistics to capture a multi-unit firm's contributions across multiple sectors. However, for analyses that examine firms in certain sectors (e.g., incumbent manufacturing firms in 1998; Figures 6-9), we define each firm's primary

[5] See Jarmin and Miranda (2002) for more information regarding the LBD.

[6] The NETS dataset follows over 60 million establishments during the 1990-2017 period. Data are available for the whole country. Informed by Delgado and Mills (2020), we acquired data for a selected group of firms. While the NETS data is useful to examine firm dynamics, it also has some limitations, including that data are often initially imputed for new establishments, there is considerable rounding of employment, and short-term employment changes are not measured very accurately (see Neumark, Zhang, and Wall, 2005).

industry using its firm-industry employment.[7] We then use the primary industry (six-digit NAICS) to classify whether an incumbent firm is in Manufacturing or SC Traded Services.

We also use the LBD to separate new firms (age 0), young firms (ages 1-10), and mature or incumbent firms (ages 11+). These cut-offs are based on the first year in which a firm's establishment appears in the LBD. It is important to note that there is a non-trivial share of establishments that have a missing (six-digit) industry in the LBD (e.g., see "unmatched" in Table 1).[8] As a result, the overall levels in economic activity may be underestimated, but trends relative to 1998 should not be affected.

To quantify the economic activity in SC Traded Services in the U.S. economy, we use the Supply Chain versus B2C Industry Categorization for 6-digit NAICS (Delgado and Mills, 2020).[9] For most of our analyses, we report aggregate economic activity in each sector (e.g., service) by each firm type (i.e., new, young, and mature).

4. Supply Chain Traded Services: Employment and Wage Trends by Firm Age

The U.S. economy has witnessed a puzzling contraction in the rate of entrepreneurship. While research has demonstrated an overall decline in startup activity (Decker et al., 2014), there has simultaneously been a gradual rise in high-quality startups (Guzman and Stern, 2019). One hypothesis might be that the decline in new firm formation is concentrated in B2C Main Street services, but that high-growth startups are increasing in supply chain services that leverage STEM skills. Surprisingly, our preliminary findings suggest that this is not the case. We find a decline over time in the employment created by new and young firms in SC Traded Services as well as in total Services (Figure 3).

Table 1 shows the level and growth in aggregate employment and payroll in the SC Traded Services sector for three firm types. Mature firms represent 11% of total U.S. employment (with over 14 million jobs in 2015), followed by young firms (with 3.5 million jobs) and new firms (with barely 0.3 million). In terms of wages, all SC Traded Service firms have higher wages than the U.S. average ($50,400), with the highest wages for mature firms ($80,500).

We find that the employment growth in SC Traded Services has been concentrated in mature firms (Figure 3a), which created 5.3 million net jobs between 1998 and 2015, and also experienced significant

[7] Specifically, for each multi-unit firm, we first identify the two-digit NAICS sector that accounts for the highest share of the firm's employment. Within this two-digit industry, we then identify the three-digit NAICS industry with the highest share of firm's employment. This process is repeated until the six-digit NAICS industry is determined – the firm's "primary" industry.

[8] The unmatched SC Traded Services employment primarily reflects LBD establishments with NAICS codes that are more aggregated (e.g., 4-digit) and therefore cannot be matched into the 6-digit NAICS industry categorization in Delgado and Mills (2020). In these cases, we can distinguish whether the establishment operates in Manufacturing versus Services, but cannot identify the type of service subcategory (e.g., SC Traded Services or SC Local Services). Some of these non-matches could be reduced in future work.

[9] The full classification of the six-digit industries (NAICS-2012 definition) into these SC and B2C subcategories is available in Delgado and Mills (2020) in the supplemental online Appendix B: Supply Chain and Business-to-Consumer Industry Categorization.

growth in wages. In contrast, our analysis suggests a significant decline in the employment created by new firms and young firms (-50% and -15% growth rate, respectively), with a job loss of 1 million. For total Services, we find similar trends but less variance across firm types (Figure 3b).

5. The Declining Presence of New Firms in Services

As Figure 4 illustrates, the decline in startup employment in SC Traded Services is largely due to a 20% decline in new firm entry (from 97,000 in 1998 to 78,000 firms in 2015). There was a similar reduction in the rate of startup entry in total Services (-18%).

While several studies have examined the decline of startup activity in the U.S. economy (e.g. Decker et al., 2014; Guzman and Stern, 2019), no conclusive answer has been found as to the underlying causes. Some high-quality startups have grown fast and, in some cases, have been acquired by established competitors (Kim, 2020). Acquisitions of young firms could perhaps explain some of the decline in the employment created by young firms.[10]

Despite the decline in the overall startup entry, SC Traded Services startups continue to play an important role in innovation and employment, accounting for a steady 19% of U.S. startups during the 1998 to 2015 period (Figure 5). In contrast, in 2015, new manufacturing firms only accounted for 3% of U.S. startups. Assuming startups are an important source of innovation (Romer, 1990), a significant share of new ideas and new firms therefore reside in the SC Services industries. Removing barriers to startups in this sector could play a vital role in policies to promote and diffuse innovation across the economy.

5.1. Company Examples: Potential Challenges Faced by SC Traded Services Startups

There are many examples of new and young firms in SC Traded Services in the U.S. economy (e.g., DirectDefense, Tulip, ShipHawk, Symbia Logistics, and WP Engine).[11] However, SC Traded Services firms, and startups in particular, face barriers that may limit their growth, particularly in access to skills and capital (Delgado and Mills, 2021). To scale up, they must integrate their specialized service inputs in the value chain of business customers. For example, Tulip Interfaces produces an industrial app for the organization of work in manufacturing plants. To grow, they must create software that can be tailored to the needs of distinct customers, requiring access to capital, data, and nearby customers.

Another challenge is the protection of startup innovations from (Big Tech) competitors in the absence of intellectual property. Services are not patent-intensive, and can be easily copied or simultaneously developed by established firms with better access to complementary resources (e.g., data). For example, MIT startup Point API (previously called EasyEmail) launched in 2016 with a software to predict and autofill e-mail replies. Soon after their launch, Google announced a similar tool during its annual

[10] We should recognize that the inflow of new establishments may be recorded in the LBD data with some delay, with Census years being most accurate in recording new establishments.

[11] These examples are based on public databases (including Crunchbase), an interview with Mark Gillett at Silver Lake Partners, and a startup panel (including the founders of Tulip Interfaces and Point API) organized by the authors.

conference for software developers, which discouraged some Point API investors.[12] The startup responded by positioning its software for customer support businesses, but it experienced difficulty in retaining users after Google released Smart Compose, and closed operations by 2019.

6. Servicification of Manufacturing Incumbents

The employment growth in SC Traded Services has been concentrated in mature firms (Figure 3). This raises the question of whether this growth is associated with manufacturing incumbents transforming into services, a phenomenon referred to as "servicification" in the economic literature (Low, 2013) and "servitization" in the strategy literature (Vandermerwe and Rada, 1988). Recent trade studies show an increasing servicification of manufacturing firms, which refers to the increased use of service inputs for the production of goods and increased sales of services (Low, 2013; Lodefalk, 2013, 2017; Timmer et al., 2014).[13] In the strategy literature, there has been a growing interest in understanding the servitization of mature manufacturing firms – a process of adding revenue streams from selling services (Vandermerwe and Rada, 1988; Visnjic Kastalli and Van Looy, 2013; Baines et al., 2017). Relatedly, new information and communication technologies (ICT) and management practices can facilitate the modularity and separation of research, development, design, and manufacturing (Tripathy and Eppinger, 2013; Fort, 2017), making service inputs more tradable domestically and globally.

We are interested in quantifying the servicification of manufacturing firms and understanding whether or not this trend has resulted in net job creation. To quantify the transformation of manufacturing firms into services, we use a sample of about 2,000 incumbent manufacturing firms that have successfully survived between 1998 and 2015. We condition on firms that in 1998 (our initial year) are mature (11+ age), large (500+ jobs), and have their primary industry in manufacturing. In 1998, these firms accounted for 5.6 million jobs, 33% of total manufacturing employment.

We find that there is a large servicification of manufacturing incumbents that occurs gradually and continuously during the examined period (Figures 6-9). The aggregated employment of the manufacturing incumbent sample is used to compute the share of employment in Manufacturing versus SC Traded Services versus Other Services over time (Figure 6). The share of employment in total Services increased by 13 percentage points (24% to 37%). Most of the growth is in the share of employment in SC Traded Services, which increased by 10 percentage points (18% to 28%).

The servicification of manufacturing incumbents is even more pronounced when we examine payroll, indicating that the jobs in services exhibit higher average wages (Figure 7). The share of payroll in

[12] "American Tech Giants Are Making Life Tough for Startups," *The Economist*, June 2, 2018.
[13] In these studies, service inputs are often classified as "intangibles," and their contribution to the value added of final goods or services is poorly measured (Low, 2013; Timmer et al., 2014).

Services has increased by 17 percentage points (31% to 48%) and in SC Traded Services by 15 percentage points (26% to 41%).

This servicification took place through the destruction of many manufacturing jobs, and the creation of fewer, yet very high-wage jobs (Figures 8-9). From 1998 to 2015, these firms experienced a total job loss of 1.2 million, but a payroll increase of $4.2 million. Manufacturing lost 1.7 million jobs and $80 million in payroll. In contrast, SC Traded Services gained 400 thousand high-wage jobs and payroll increased by $76 million (in 2015 USD).

Our results are not driven by a few 'superstar' firms (Autor et al., 2020). The analysis suggests that many large manufacturing incumbents experienced servicification. We find that by the end of the period, about 20% of the firms have transformed into primarily SC Traded Service firms (i.e., the primary 6-digit industry by employment is in SC Traded Services). Furthermore, we find similar servicification patterns for a large sample of small and medium manufacturing incumbents. To complement our empirical findings, we provide particular examples of manufacturing firms that have successfully evolved into SC Traded Services over the years.

6.1. Company Examples: The Continued Servicification of IBM and Intel

IBM: International Business Machines Corporation (IBM) was founded in 1896 as a punch-card data processing machine manufacturer. It found its footing as a hardware manufacturing company in the 1900s. Making all of its components in-house, IBM became the leading computer company in the 1960s (Rothaermel et al., 2015). But with the emergence of Apple in 1976 and other competitors in the personal computer and related hardware space, IBM was forced to revise its strategy. Each change in top leadership has been associated with an increased focus on software and other services, particularly the bundling of these components together in an integrated sales offering.

When Louis Gerstner stood at the helm of IBM from 1993 to 2002, the company coined the term "e-business" in its marketing campaigns, highlighting the firm's strategy and new focus on the Internet and its capabilities for businesses. In 2002, Sam Palmisano stepped into the CEO role, reorganizing IBM around three complementary segments: hardware, software, and services. His focus on the services component was undeniable. During his tenure, IBM sold its PC business to Lenovo and over a four year period, spent $11.8 billion to acquire numerous software and computer service firms (Rothaermel et al., 2015).

Virginia Rometty continued the journey into services when she became CEO in 2012. She told the Wall Street Journal in 2015 that "Hardware was the original soul of this company," but "we can't hold on to our past" (Langley, 2015). In a speech to shareholders in 2016, Rometty highlighted the company's transformation: "IBM…has reinvented itself through multiple technology eras and economic cycles…IBM is becoming much more than a 'hardware, software, services' company. We are emerging as a cognitive solutions and cloud platform company" (IBM, 2016).

We used NETS data to quantify IBM's servicification. The analysis shows that while IBM's primary industry (6-digit NAICS) by employment in 1998 was *Electronic Computer Manufacturing*, it has transformed into a primarily SC Traded Service firm, with *Custom Computer Programming Services* as the primary industry in 2015. Specifically, the share of employment in SC Traded Services increased from 45% to 59% during the 1998-2015 period. This transformation was accompanied by a large reduction of IBM's manufacturing and service jobs in the U.S. (the compound annual growth rate was -5%).

Intel: Founded in 1968, Intel Corporation made a name for itself as a semiconductor chip manufacturer. It created a general purpose technology (GPT) and a whole industry – semiconductors – with the Intel 4004 microprocessor (Bresnahan and Trajtenberg, 1995). The success of the personal computer industry in the 1980s led to the prime positioning of the company as the go-to supplier of chips for PC manufacturers like IBM. Intel excelled at continuously developing improved versions of its popular microprocessor chips—faster and with increased capabilities—but ran into a significant hurdle when adoption of new models slowed. To combat this lag in sales, the company rolled out a brilliant marketing and branding campaign centered on the now ubiquitous "Intel Inside" tagline and logo (Moon, 2005).

Since those early days, Intel has maintained its dominance in manufacturing PC components, but as the company faced declining PC sales, it has diversified into components for other devices, software, and cloud computing. Using NETS data, we find that while the company's primary industry remains in SC Manufacturing (*Semiconductor and Related Device Manufacturing*), it has continuously and rapidly increased its presence in SC Traded Services in the U.S. economy (in particular in *Custom Computer Programming Services*). The percentage of firm employment in SC Traded Services increased from about 4% in 1998 to 26% by 2015, creating many service jobs (the compound annual growth rate was 8%). In 2016, Intel announced a significant restructuring effort, stating in a press release that the move was necessary to "accelerate its evolution from a PC company to one that powers the cloud and billions of smart, connected computing devices…" (Intel, 2016).

The servicification of this supply chain firm has been reflected in its branding and communication strategy. In January 2016, in a plan to expand beyond the extremely successful "Intel Inside" campaign, the company revamped its brand messaging: "Intel Inside makes amazing experiences outside." Penny Baldwin, VP and GM of global brand management and reputation explained, "By putting the focus on Intel Inside, we'd gone brand invisible… We're trying to bring our brand from the inside to the outside. From being seen as a PC component to being an experiential exponent and an enabler of experience" (Schiff, 2016).

7. The Growth of SC Traded Service Incumbents

Finally, we examine the role of large incumbent SC Traded Service firms (e.g., Microsoft) in the growth of this sector. Industries in SC Traded Services often have many layers of buyer industries, and

therefore can themselves be important engines of innovation and growth. In fact, modern equivalents of GPTs like semiconductors reside increasingly in service or "digital" inputs, such as cloud computing and artificial intelligence (Brynjolfsson et al., 2018; Cockburn, Henderson, and Stern, 2018; Trajtenberg, 2019; Delgado and Mills, 2020).

For this analysis, we use a sample of about 1,000 incumbent SC Traded Service firms that survived from 1998 to 2015. These firms have the following attributes in our initial year (1998): they are mature (11+ age), large (500+ jobs), and their primary industry is in SC Traded Services. Preliminary analysis shows that these firms experienced significantly high rates of net job creation during the 1998-2015 period. Thus, while the job creation debate often focuses on manufacturing, the reality is that large service inputs firms have created many well-paying jobs. These firms play an important role in the servicification of the U.S. economy.

7.1. Company Examples: Microsoft and Service Platforms

There is no shortage of incumbent service firms that have grown significantly during our time frame, capitalizing on the increasing use of data and the Internet, cloud computing, and AI technology. Examples range from high-growth enterprise software firms and consulting firms such as Salesforce, Workday, SAP, and Red Ventures, to engineering and design service firms like Aecom and IDEO. Microsoft, a well-known incumbent services firm, illustrates the scalability of service inputs.

Microsoft: Founded in 1975, Microsoft was a software company from its outset, developing tools for the emerging PC industry. Microsoft Word was first released in 1983 and quickly took over the marketplace along with the Office suite of applications. Gawer and Cusumano (2002) demonstrated the importance of the Windows platform for the innovation capacity of many of Microsoft's customers. Focusing heavily on Windows and Office, Microsoft covered the enterprise software market through licensing agreements up through the 2000s.

By 2013, however, "the sale of prepackaged operating systems and software on PCs" was declining. Consumers were interacting with technology in varied ways with the increasing adoption of smartphones, tablets, and other mobile devices. Responding to these trends, Microsoft reorganized itself as a "devices and services company" and later under Satya Nadella's leadership, as a company focused on a "mobile-first, cloud-first" strategy (Foley, Mayfield, and Boland, 2017). The company developed its fast-growing cloud service, Microsoft Azure, and shifted to a constantly updating subscription model for Office 365. Related cloud-based products such as Skype and SharePoint have followed, as Microsoft continues to build out its software-as-a-service (SaaS) platform.

Our analysis (based on NETS data) illustrates the high scalability of this firm. During the entire period 1998-2015, over 90% of Microsoft's employment is in SC Traded Services, mainly in *Software Publishing*. These services experienced fast growth in employment (CAGR of 6%).

8. Conclusion: How to Support Innovative Service Firms

The servicification of the U.S. economy is a significant source of anxiety due to the loss of well-paying jobs in manufacturing. However, strong growth in Supply Chain Traded Services businesses provides an important source of new, high-wage jobs (many of which require STEM skills). This raises important questions, particularly around policy initiatives that might support more of these businesses and create innovative service jobs.

One puzzling and alarming finding of our study is the decline in the number of entrepreneurial firms in Supply Chain Traded Services. While young firms in this sector continue to represent a large share of the overall entrepreneurial activity in the U.S. economy, their decline raises questions regarding the missing startups in this increasingly important services sector. What are the barriers that stifle the entry and growth of entrepreneurial firms in high-tech services? Given the outsized role of startups in generating technological innovations and growth (e.g., Romer, 1990), future research is needed to advance our understanding of the sources and solutions to these barriers. In particular, barriers related to access to STEM skills, capital, buyers, and data, as well as the ability to protect innovations, should be examined (Delgado and Mills, 2021).

Another key finding in this study is that job creation in Supply Chain Traded Services is driven primarily by mature firms: the transformation of incumbent manufacturing firms into services and, especially, the growth of incumbent service firms. This pattern raises new questions on how incumbent firms are able to successfully transform from manufacturing into product-service or pure service firms. This transformation may be associated with firms moving manufacturing activities overseas (Fuchs et al. 2021), while choosing to produce innovative services in the U.S. The servicification of incumbent firms can generally occur by either organically developing their capabilities in-house (e.g., retraining their workers) or externally sourcing the necessary technology and skills. Organically, firms may train their workers with new skills that enable an effective response to the evolving competitive environment. Externally, firms may partner with – or acquire – other firms as a way to outsource new technology and talent. Relative to organic growth, how might an acquisition-based approach shape the incumbents' long-run innovation and growth? Relatedly, what is the role of industry clusters and specialized STEM skills in the growth of these innovative services across regions (Delgado and Porter, 2017; Eckert, Ganapati, and Walsh, 2019)?

We conclude by discussing the future prospects of Supply Chain Traded Services. We point to two directions. First, in terms of the overall size, we expect that this sector will continue to grow in both absolute and relative size. Especially with the global coronavirus pandemic accelerating the economic trend towards digitization, the rising importance of data-driven services that rely on AI and Internet technologies (see e.g., Trajtenberg, 2019; Mills, 2019; Jones and Tonetti, 2020) will likely catalyze further growth in many areas of Supply Chain Traded Services, such as cloud computing, financial technology, logistics, and health care.

Second, in terms of the composition of firms, we expect that incumbents will continue to outpace the startups in this sector unless barriers to accessing data and other critical resources are addressed. Consistent with this view, a concurrent trend is the rise of superstar firms, which are industry giants with disproportionately high market shares (Autor et al. 2020). Another supporting trend is the growing prevalence of startup acquisitions in many industries (e.g., Kim, 2020), which may further tilt the competitive landscape towards incumbent firms. A natural consequence of a startup acquisition is the transfer of market power from entrepreneurial firms to the acquiring incumbents before ventures can sufficiently mature and reach their innovation and size potential. As a result, young firms may play a declining role in driving jobs in Supply Chain Traded Services.

Overall, creating an appropriate business environment for new and young firms to overcome barriers to entry and growth, and for incumbent firms to adapt to changing trends, is essential to encourage growth in Supply Chain Services and innovation in the U.S. economy.

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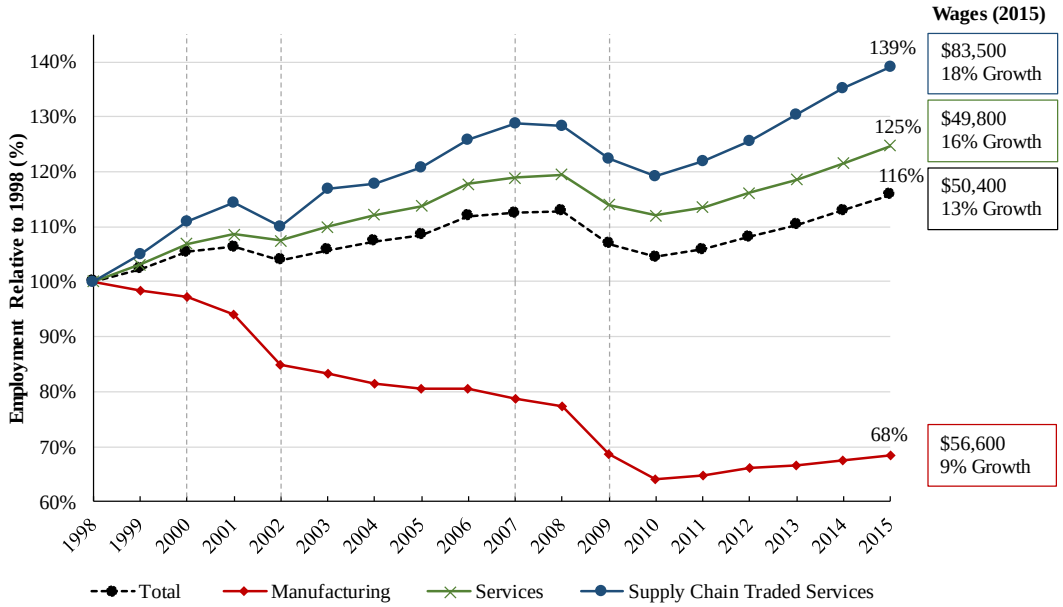
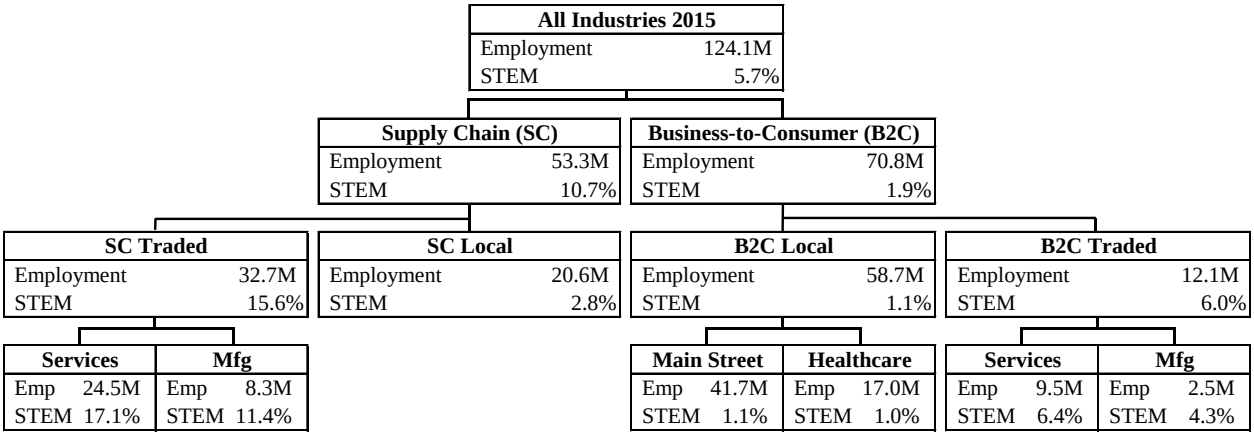
Figure 1. Optimistic View of the Economy: High Growth of Suppliers of Service Inputs



Notes: Source Delgado and Mills (2020). Supply Chain (SC) industries are those that sell their goods and services primarily to businesses or the government.

Figure 2. Full Supply Chain Categorization: Employment and STEM Intensity, 2015



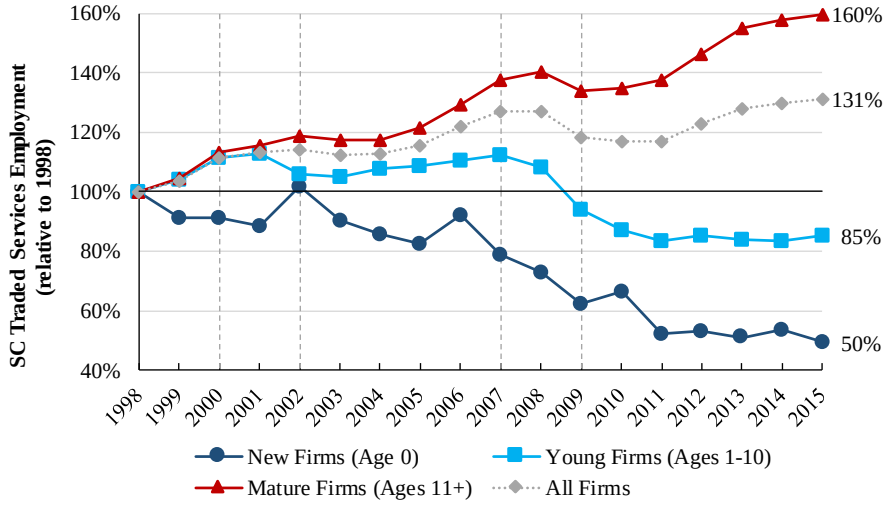
Note: Sourced from Delgado and Mills (2020). Private-sector non-agricultural employment (excluding self-employed). Employment in millions (M) is sourced from CBP 2015 data. STEM % is the intensity of STEM jobs – the % of the subcategory jobs that are in STEM (e.g., 10.7 out of 100 SC jobs). Services includes Non-Manufactured Goods.

Table 1. Supply Chain Traded Services: Employment and Wages by Firm Type (New, Young, Mature)

	Employment				Real Wages (2015 USD)	
	2015 Mill	% Total	1998-2015 Growth	1998-2015 Net Mill	2015 $000	1998-2015 Growth
	1	2	3	4	5	6
Total	**124.1**	**100%**	**16%**	**16.9**	**$50.4**	**13%**
Services	112.5	91%	25%	22.3	$49.8	15%
Supply Chain (SC) Traded Services	24.5	20%	39%	6.9	$83.5	18%
SC Traded Svc: New Firms (Age 0)	0.3	0%	-50%	-0.4	$53.1	-2%
SC Traded Svc: Young Firms (Ages 1-10)	3.5	3%	-15%	-0.6	$62.3	14%
SC Traded Svc: Mature Firms (Ages 11+)	14.1	11%	60%	5.3	$80.5	16%
SC Traded Svc (unmatched)	6.5	5%	66%	2.6		

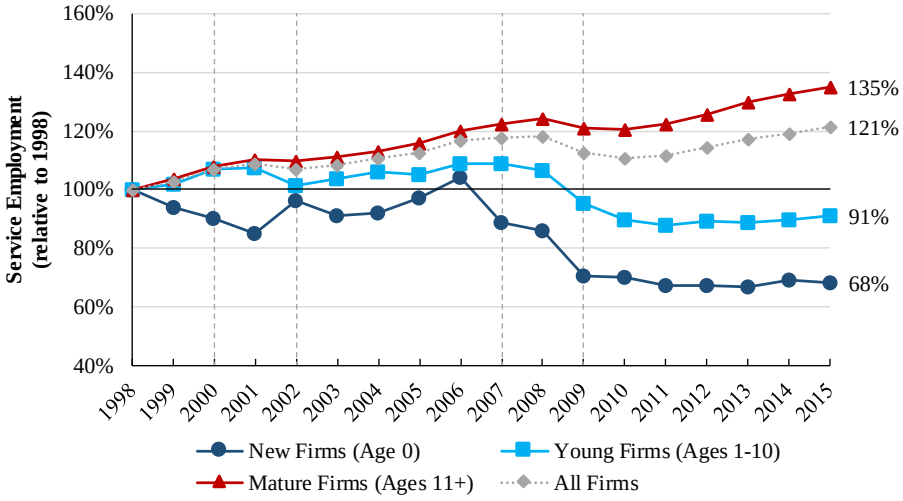
Note: The analysis of SC Traded Services by firm age uses the LBD. Firm age is a firm-level attribute based on the oldest establishment in the particular year. Total, Services, and SC Traded Services figures are sourced from Delgado and Mills (2020) and uses the CBP data. Real wages in 2015 USD using CPI-U (All Urban Consumers; BLS).

Figure 3a. Supply Chain Traded Services: Employment Trends by Firm Type (New, Young, Mature)



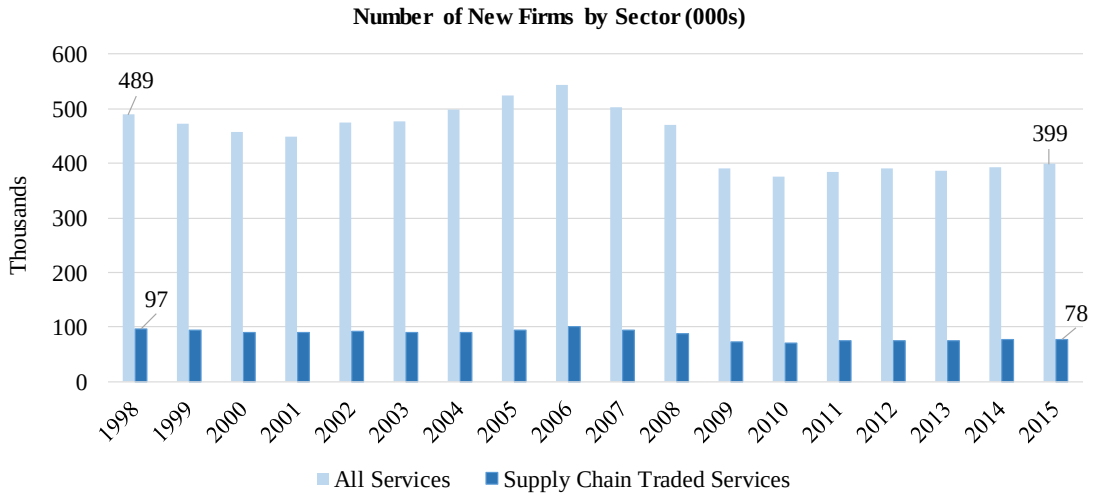
Note: Age based on the oldest establishment of the firm in the particular year. Analysis based on the LBD.

Figure 3b. Total Services: Employment Trends by Firm Type (New, Young, Mature)



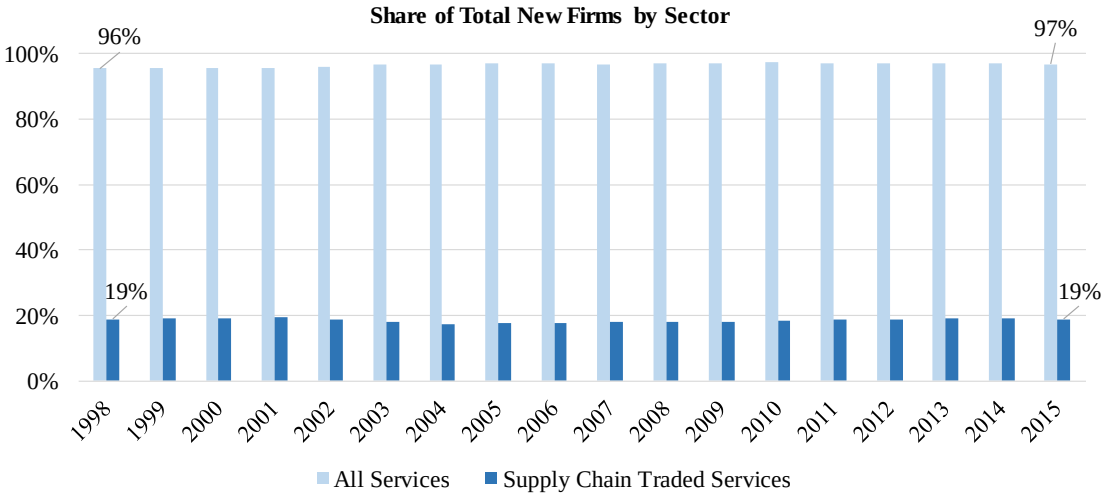
Note: Age based on the oldest establishment of the firm in the particular year. Analysis based on the LBD.

Figure 4. Entry of New Firms in Services



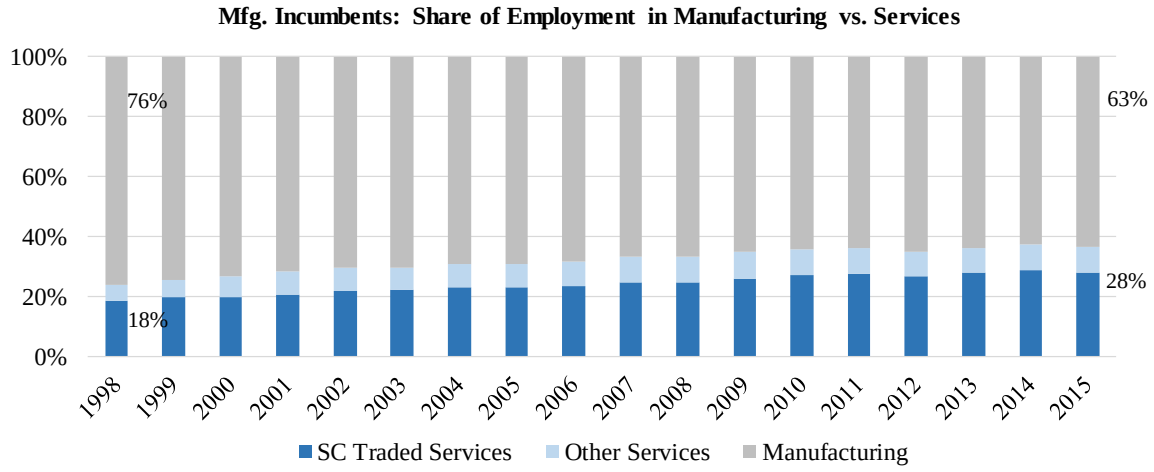
Note: New firms are those with zero age. Analysis based on the LBD.

Figure 5. Share of Total New Firms in Services



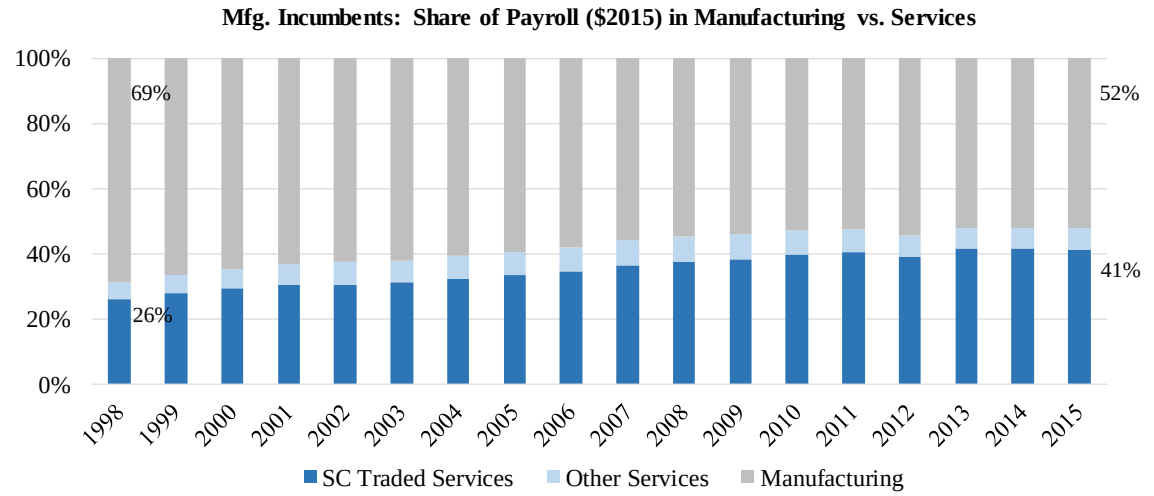
Note: New firms are those with zero age. Analysis based on the LBD.

Figure 6. Manufacturing Incumbents: Share of Employment in Supply Chain Traded Services



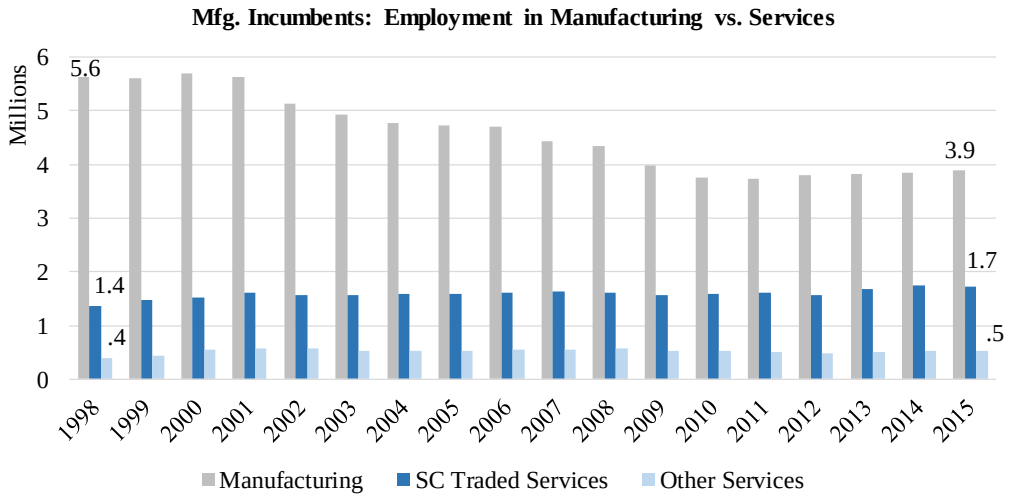
Note: LBD sample of large firms that are manufacturing incumbents in 1998 and survive 1998-2015. Their share of employment in SC Traded Services increased from 18% to 28%.

Figure 7. Manufacturing Incumbents: Share of Payroll in Supply Chain Traded Services



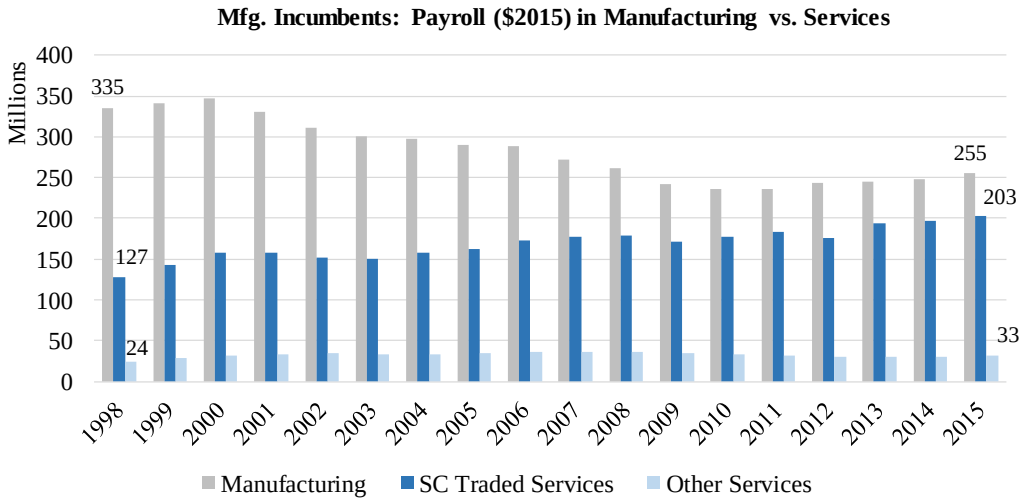
Note: LBD sample of large firms that are manufacturing incumbents in 1998 and survive 1998-2015. Their share of payroll in SC Traded Services increased from 26% to 41%.

Figure 8. Manufacturing Incumbents: Employment Trends, 1998-2015



Note: LBD sample of large firms that are manufacturing incumbents in 1998 and survive 1998-2015.

Figure 9. Manufacturing Incumbents: Payroll Trends, 1998-2015



Note: LBD sample of large firms that are manufacturing incumbents in 1998 and survive 1998-2015.