A New Categorization of the U.S. Economy: The Role of Supply Chain Industries in Innovation and Economic Performance

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Abstract

An active debate has centered on the importance of manufacturing for driving innovation in the U.S. economy. This paper proposes an alternative framework that focuses on the role of suppliers of goods and services (the “supply chain economy”) in national performance. Using the 2002 Benchmark Input-Output Accounts, we introduce a new industry categorization that separates supply chain (SC) industries (i.e., those that sell their goods and services primarily to businesses or government) from business-to-consumer (B2C) industries (i.e., those that sell primarily to consumers). We find that the supply chain economy is a distinct and large segment of the economy, with a mix of manufacturers and more importantly service providers. Supply chain industries, especially traded services (i.e., those that are sold across regions, like software), have higher average wages than B2C industries. The supply chain economy also has a much larger intensity of STEM jobs and generates the majority of patents. While STEM jobs are most prevalent among suppliers of traded services, patents are concentrated primarily in manufacturing suppliers. We also find that employment in the economy has been evolving from manufacturing into different types of services for the period under examination (1998-2013): SC traded services (with the highest STEM intensity and wages) experienced high growth in employment and wages; and B2C local services (with the lowest STEM intensity and wages) experienced high growth in employment but a decline in wages. Overall, our findings suggest that supply chain traded services are particularly important to innovation and the economy.
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Keywords: Supply chain industries; business-to-consumer industries; science and technology intensity; innovation; economic growth.
1. **Introduction**

A long academic and policy debate has focused on the role of the manufacturing capacity of a country in its economic and innovative performance (see e.g., Rosenberg, 1963; Dertouzos et al., 1989; Carlsson and Jacobsson, 1991; Audretsch and Feldman, 1996; Pisano, 1997; Berger, 2013). This question has become even more relevant as the U.S. economy has shown a large decline in manufacturing employment in recent decades, in part due to increased import competition (Acemoglu et al., 2016). In this debate the predominant view is that a country’s manufacturing capacity drives innovation because of externalities associated with the production process that improve the efficiency (speed, cost, and diffusion) of the innovation process. In particular, learning externalities generated by suppliers of specialized intermediate goods (e.g., machine tools and automation equipment) have long been recognized as important for innovation (see Rosenberg, 1963; Carlsson and Jacobsson, 1991).

Most prior work on innovation focused on a narrow view of suppliers as manufacturers, but in today’s economy suppliers include producers of both intermediate goods (e.g., microprocessors) and, increasingly, services (e.g., enterprise software). To better understand the drivers of innovation and economic performance, we propose a new framework that focuses on the suppliers of goods and services to businesses and the government (i.e., the “supply chain economy”).

Building on a range of economic and strategy studies, we identify three related attributes of suppliers that make them particularly important for innovation. First, they produce specialized inputs that can make the innovation process more efficient (Rosenberg, 1963). Second, suppliers will tend to have more downstream linkages with other industries than firms whose products are sold for personal consumption (e.g., semiconductors versus breakfast cereals). Hence, inventions developed or used by suppliers may diffuse more broadly to other downstream industries. Third, suppliers’ business customers tend to be more geographically concentrated than consumers. Thus, suppliers and their customers can benefit from co-location and generate externalities that contribute to the innovation and economic performance of a country and its regions (see e.g., Chinitz, 1961; Porter, 1998; Helsley and Strange, 2002).
The goals of this paper are to quantify and characterize the suppliers in today's economy, and to examine their role in national innovation and economic performance. A significant literature has focused on the management of the supply chain of particular industries and firms (see e.g., Cusumano and Takeishi, 1991; Gereffi et al., 2005; Pisano and Shih, 2009; Delbufalo, 2012; Lessard, 2013; Helper and Henderson, 2014), but there has been a lack of quantification of the suppliers in the overall economy. Therefore, we develop a new industry categorization that separates “supply chain” (SC) industries (i.e. those that sell their goods and services primarily to businesses or the government) from business-to-consumer (B2C) industries (i.e., those that sell primarily to consumers).¹

This categorization complements the Manufacturing versus Services industry categorization that has influenced economists and policymakers throughout the 20th century. The innovation debate has centered on manufacturing because it accounts for the vast majority of patents. However, manufacturing currently comprises only around 10% of U.S. employment. On the other hand, services account for 90% of employment, and are extremely heterogeneous. We use our supply chain economy framework to characterize different subcategories of services.

Our categorization also complements the Traded versus Local industry categorization introduced by Porter (1998, 2003). He separated traded industries, which are geographically clustered and sell across regions and countries (e.g., automotive manufacturing and financial services), from local industries (e.g., restaurants and retail). The traded economy has been associated with higher innovation than the local economy because it can exploit economies of agglomeration (Porter, 2003; Feldman and Audretsch, 1999; Delgado, Porter, and Stern, 2014). Our framework proposes that suppliers are a distinct subcategory within the traded and local categories.

We use the 2002 Benchmark Input-Output Accounts from the U.S. Bureau of Economic Analysis to systematically identify SC and B2C industries (six-digit NAICS codes) based on

¹ We do not examine the supply chain of individual firms (e.g., the suppliers of General Motors) or individual industries (e.g., the suppliers to the automaker industry). Instead, our framework focuses on the suppliers to the value chain of the economy: businesses that generate inputs that are sold to other firms or used for own-firm consumption. For example, businesses that primarily produce engines will be part of the supply chain economy.
observable measures of industry-level sales for personal consumption. We examine the supply chain economy during the 1998–2013 period across several metrics: employment and number of firms; wages; Science, Technology, Engineering and Math (STEM) occupations (innovation input); patenting (innovation output); and growth dynamics. One important finding is that the supply chain economy is very different from the B2C economy across each of these metrics.

The supply chain industries are a distinct and large segment of the economy. In 2012, they accounted for 37% of U.S. private employment and 43% of all employer firms. These estimates are the first comprehensive attempt to measure the size of the supply chain economy.

We separate SC and B2C industries into subcategories -- traded versus local and manufacturing versus services -- to define and analyze important sub-segments of the economy such as SC Traded Manufacturing industries (like Semiconductor Manufacturing) and SC Traded Services industries (like Engineering Services).

Another key finding of this paper is the size and economic importance of the suppliers of traded services – a result that challenges most prior work focusing on a narrow view of suppliers as manufacturers. Suppliers of traded services accounted for almost 18 million jobs (15% of all U.S. employment), while suppliers of traded manufactured goods accounted for about 8 million jobs.

The SC industries, especially traded services, have much higher average wages than B2C industries. This could be explained in part by their labor occupation composition. Building on Hecker (2005), we estimate that the STEM intensity (i.e., percentage of employment in STEM occupations) was 11% in SC industries versus 2% in B2C industries in 2013. Surprisingly, the SC Traded Services subcategory had the highest STEM intensity (19%) in the economy. This suggests that studies of technological innovation need to focus more on supply chain services.

A traditional measure of innovation outcome, patenting, is highly concentrated in the supply chain economy (representing over 88% of the U.S. utility patents granted in 2013), but is primarily in manufacturing suppliers. While the suppliers of traded services have the highest prevalence of STEM occupations (55% of all STEM jobs), they account only for a small percentage of all patents granted (10%). This large STEM-patenting gap suggests that the contribution to

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2 We code a firm as part of the supply chain economy or “supplier” if their primary industry is categorized as SC.
innovation of these suppliers of services may be much higher than predicted based on their low patenting.

Finally, we examine the growth trends of the economy (1998–2013). We find that the employment composition of the supply chain economy has been evolving away from manufacturing and towards services for the entire period. Suppliers of traded services have experienced high growth in employment and wages. This compositional change reflects the increasing importance of some service industries, like computer programming, data processing and hosting, software publishers, R&D, design, engineering, and logistics services (Gawer and Cusumano, 2002; Bitner, Ostrom, and Morgan, 2008; Sheffi, 2012; Low, 2013; Helper and Kuan, 2016). It also is consistent with the evolution towards traded services that some firms have experienced over the past few decades (e.g., IBM, Intel, and Dell Technologies).

The B2C economy also has experienced a decline in manufacturing employment, with high growth in primarily local services. We separate B2C Local industries into Healthcare services and “Main Street” (i.e., traditional consumer-facing services, such as retail stores and restaurants). Healthcare has registered high employment and wage growth. In contrast, the Main Street subcategory grew fast in terms of employment, but experienced a decline in real wages.

The analysis of the growth trends of the SC versus B2C subcategories contributes to explain the job polarization in services identified in prior work (Autor and Dorn, 2013; Autor, 2015). The two subcategories that have created more jobs during 1998–2013 are: supply chain traded services (with the highest STEM intensity and wages) and B2C Main Street services (with the lowest STEM intensity and wages).

Overall, our findings suggest that the supply chain category is a distinct part of the economy. It matters for innovation and has created well-paid jobs (especially in traded services). This calls for targeted research and policies that recognize that suppliers are a large part of the economy, are a mix of manufacturers and more importantly service providers, and contain the majority of STEM jobs and patents. To the extent that the high-wage and high-STEM supply chain services can foster innovation and growth opportunities for the U.S. economy, the academic and policy debate would benefit from considering services as crucial to innovation.
The remainder of the paper is organized as follows: Section 2 describes the literature on the role of suppliers in innovation and economic performance. Section 3 presents the methodology and data used to define SC and B2C industries. Section 4 describes the size and wages of the SC versus B2C industry categories. Section 5 examines their distinct labor occupations. The role of the supply chain economy in innovation is discussed in Section 6. The employment and wage growth trends of the SC and B2C categories are the subject of Section 7. A final section concludes and offers implications for policy and future research.

2. **The Role of Suppliers in Innovation and Economic Performance**

In the academic and policy debate the predominant view is that manufacturing drives innovation and growth (see e.g., Rosenberg, 1963; Dertouzos et al., 1989; Pisano and Shih, 2009; Berger, 2013; EOP, 2015). Building on prior work, we propose a new innovation framework that focuses on the suppliers of goods and services to businesses and the government: the supply chain economy. We discuss three attributes of suppliers (supply chain industries) that can make them particularly important for the innovative activity of a country: they produce inputs; they have important downstream linkages with other industries; and their customers are geographically clustered. Importantly, our framework emphasizes that these attributes apply to the suppliers of both goods (e.g., semiconductors) and services (e.g., software publishers).

One key attribute of suppliers is that they produce inputs that are part of the value chain of other organizations, and these inputs must offer tangible benefits to their customers. In the economic literature, the production of inputs has been linked to the innovative capacity of a country (see e.g., Rosenberg, 1963; Dertouzos et al., 1989; Carlsson and Jacobsson, 1991). Specifically, there can be learning externalities from producing specialized inputs that improve the efficiency (speed, cost, and diffusion) of the innovation process. For example, Rosenberg (1963) highlights the crucial role of the suppliers of capital goods (“machine producers”) in the process of technological innovation. A country needs a large capital goods sector (supported by domestic demand) in order for suppliers of capital goods to specialize in creating tailored inputs for their buyers. This specialization among suppliers creates learning externalities that can improve the national innovative capacity.
Rosenberg’s (1963) work influenced later studies of the potential negative effects of offshoring manufacturing on subsequent innovation (see e.g., Dertouzos et al. (1989) who study multiple countries, industries, and firms; Carlsson and Jacobsson (1991) for the automation industry; Pisano (1997) for the biopharmaceutical industry; and Fuchs and Kirchain (2010) for the optoelectronics industry). Since the 2011 Advanced Manufacturing Partnership, the innovation debate has focused on increasing “advanced manufacturing”: innovative manufacturing technologies and related processes, like advanced materials, nanotechnology, and smart production processes (Berger, 2013). In these manufacturing-centric frameworks, services often play a secondary role in innovation. The underlying assumption is that services only grow to the extent that they are tied to manufactured goods (e.g., software for smart machines). However, in today’s economy many services can scale up independently (e.g., enterprise software). Our supply chain framework considers that suppliers of services (e.g., design, engineering, data processing, or finance) are important in their own right for the innovation capacity of a country.

A second attribute of suppliers is that they tend to have more downstream linkages with other industries than firms in industries whose products are sold for personal consumption (e.g., semiconductors versus breakfast cereals; or data processing services versus retail stores). Hence, inventions developed or used by suppliers may diffuse more broadly to other downstream and complementary industries, thereby generating more innovation opportunities. This multiplier effect can be somewhat similar to that of general purpose technologies (GPTs), such as semiconductors (the “4004” microprocessor introduced by Intel) or the Internet. GPTs are characterized by the potential to be used as inputs in many industries (“pervasive use”); over time, they spawn innovations to the economy (Bresnahan and Trajtenberg, 1995).

A third unique attribute of suppliers is that their business customers tend to be more geographically concentrated than consumers (i.e., people are everywhere but businesses are geographically clustered by economic fields). In economic geography, the co-location of suppliers

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3 The Advanced Manufacturing Partnership was created in 2011 by the White House to foster collaboration between the industry, universities, and the Government in innovative or “advanced” manufacturing. See Berger (2013).
4 A future research question is whether GPTs are more likely to arise in supply chain industries; or it could be though that a new GPT transforms the nature of the industry in which it occurs, turning it into a significant supply chain industry. Furthermore, GPTs that are generated by supply chain industries may have broader and faster diffusion into other industries than those generated by B2C industries.
and buyers has been identified as a driver of external economies that improve innovation and employment growth (Marshall, 1920; Chinitz, 1961; Porter 1990, 1998; Saxenian, 1994; Feldman and Audretsch, 1999; Glaeser and Kerr, 2009; Delgado, Porter, and Stern, 2014).\(^5\) When suppliers are clustered together and located near their buyers, they can create agglomeration benefits through shared pools of skills, technologies, knowledge, and specialized inputs. Prior work has highlighted the importance of nearby small suppliers for fostering entrepreneurship and innovation (Helsley and Strange, 2002; Glaeser and Kerr, 2009).

In the strategy and international business literature, decisions regarding the internal versus external sourcing of inputs are at the cornerstone of firm strategy and performance (Porter, 1996; Pisano, 1997; Cohen and Levinthal, 1990; Lessard, 2013). In particular, effective collaboration between buyers and suppliers is associated with greater innovation. A firm’s innovation process can leverage innovations by its suppliers (see e.g., Cusumano and Takeishi (1991), Helper, MacDuffie, and Sabel (2000) and Helper and Henderson (2014) in automotive; Primo and Amundson (2002) in electronics industries). On the other hand, a supplier’s innovations also can benefit from the innovative activities of its buyers (see e.g., Von Hippel’s (2005) work on user innovation and follow-on studies by De Jong and Von Hippel (2009) and Isaksson, Simeth, and Seifert (2016), among others). These innovative buyer firms may be selling their products to other businesses (i.e., they are suppliers themselves). Hence, supplier innovations can diffuse both upstream and downstream and be critical contributors to innovation in the economy as a whole.

Overall, the prior economic and strategy literature has suggested that suppliers are important for the innovativeness and performance of firms, regions, and countries. But who are the suppliers to the economy? While there are important studies that characterize the supply chain of particular industries and firms (see e.g., Cusumano and Takeishi, 1991; Gereffi et al., 2005; Helper and Kuan, 2016), there is a lack of quantification of the size and types of suppliers in the economy. This may have led to an underestimation of suppliers’ role in innovation and economic performance. In particular, influenced by the view that manufacturing drives innovation, most of the prior work has focused on manufactured goods and their suppliers of

\(^5\) In these studies suppliers are often measured by the presence of businesses in upstream industries.
goods (e.g., automakers and their suppliers of auto parts). This does not capture the increasingly important role of service suppliers (e.g., managerial, financial, design, engineering, and software services) in the value of final goods and final services.

Some studies have indeed examined the crucial contribution of service suppliers to innovation. For example, Gawer and Cusumano (2002) showed the importance of industry-wide service platforms like Microsoft Windows for innovation. Ali-Yrkkö et al. (2011) examined the global supply chain of the Nokia N95 smartphone, and they found that supply chain services and other intangibles accounted for most of the value added generated. Sheffi (2012) focused on the importance of capital-intensive logistical and transportation services (or “logistics clusters”) for driving job growth. And, Helper and Kuan (2016) examined the innovative activities of the suppliers of engineering services to automakers.

In order to quantify the suppliers in the U.S. economy, we provide a new industry categorization that separates supply chain (SC) industries from Business-to-Consumer (B2C) industries. This categorization allows us to measure the size of the supply chain economy. It also helps us to understand the role of suppliers of goods and services in national innovation and economic performance. Combining our SC versus B2C categorization with prior industry categorizations (manufacturing versus services; traded versus local), we characterize the different subcategories of services in the economy, and examine their potential for creating high wage, high technology jobs.

3. **The Supply Chain Categorization of the U.S. Economy**

In this section, we first explain prior industry categorizations: Manufacturing versus Services, and Traded versus Local. Then we describe the method for defining SC industries and B2C industries. The detailed classification of industries (six-digit NAICS-2012) into the SC and B2C subcategories is available in the online Appendix B: Supply Chain and Business-to-Consumer Industry Categorization.

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6 For instance, a recent report by the Executive Office of the President (EOP) and the U.S. Department of Commerce (EOP, 2015) describes the importance of suppliers in the manufacturing sector, and highlights government initiatives to support manufacturing suppliers (like the Manufacturing Extension Partnership).
3.1 Prior Categorizations of the U.S. Economy

The Manufacturing versus Services categorization of industries has been broadly used in economics and policy since the creation of the Standard Industrial Classification (SIC) by the U.S. Government in 1937. The later NAICS industry classification (as well as the prior SIC) separates out manufacturing and services industries based on what they produce. The 2-digit NAICS codes 31-to-33 correspond to manufactured goods; the other codes correspond to services. In total, there are 978 (six-digit NAICS-2012) industries (excluding farming and some government activity), which are classified into 364 manufacturing and 614 service industries. In 2012, manufacturing industries accounted for less than 10% of total U.S. employment and only 5% of firms (Figure 1).

A related categorization separates goods-producing from service-producing industries. Goods-producing industries include both manufactured and non-manufactured goods (Agriculture, Forestry, Fishing, and Hunting (NAICS code 11); Mining (NAICS code 21); and Construction (NAICS code 23)). The non-manufactured goods represented only 4% of total employment in 2012. They are included in our “Services” category, but the sensitivity analysis considers an alternative definition that excludes them.

The Traded versus Local categorization developed by Porter (2003) classifies industries based on their patterns of spatial concentration and competition. Traded industries are geographically concentrated because of agglomeration economies, and they sell their goods and services across regions and countries (e.g., automotive and financial services). Local industries are geographically dispersed (i.e., their employment in a region is proportional to the size of the population) and they sell their services primarily in the local market (e.g., retail stores and restaurants). In this paper, we use the most recent traded categorization defined in Delgado, Porter, and Stern (2016), which is based on the employment specialization and concentration patterns of each industry across U.S. regions. In the 6-digit NAICS-2012 code, there are 675 traded industries and 303 local industries. In 2012, the traded industries accounted for 36% of total U.S. employment and 25% of firms (Figure 1).
This framework has helped researchers to examine the role of the traded economy in national competitiveness and innovativeness, and to shed light in particular on the role of industry clusters (i.e., groups of related and co-located traded industries, like Biopharmaceuticals in Boston) in regional performance (see e.g., Delgado, Porter, and Stern, 2010, 2014).

### 3.2 New Categorization: Supply Chain and Business-to-Consumer Industries

To identify and characterize the suppliers in the U.S. economy, we distinguish between Supply Chain (SC) and Business-to-Consumer (B2C) industries. Conceptually, SC industries primarily sell goods and services to businesses and the government. In contrast, B2C industries primarily sell final goods and services to personal consumers. To measure the extent to which industries sell for personal consumption, we use the 2002 U.S. Benchmark Input-Output (IO) Accounts of the Bureau of Economic Analysis (BEA). The IO Accounts allow for capturing input-output flows between industries and output flows from each industry into final use for personal consumption (see e.g., Feldman et al., 2014; McElheran, 2015; Delgado et al., 2016).

To our knowledge, we offer the most systematic and comprehensive classification of industries into SC and B2C. Building on prior work, we classify all 6-digit NAICS industries into SC or B2C based on the output sold to Personal Consumption Expenditure (PCE). The PCE is a final use item in the IO Accounts that captures the value of the goods and services that are purchased by households, such as food, cars, and college education.\(^7\) We identify industries as SC if they sell less than one-third of their output to PCE (i.e., PCE score ≤ 33.3%); the rest are classified as B2C (i.e., PCE score > 33.3%). Thus, in our definition those industries that sell most of their products to other organizations are classified as SC.\(^8\)

Table 1 shows some representative examples of SC and B2C industries. In manufacturing, **Biological Product Manufacturing** (NAICS code 325414) is a SC industry that sells 0% of its value to PCE; **Breakfast Cereal Manufacturing** (NAICS code 311230) is a B2C industry that sells 90% of their products to personal consumption.

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\(^7\) The PCE item defines household consumption as a final use. However, households can transform the products and services they buy and give away their innovations (Von Hippel, 2017). This would imply that some industries may be less consumption-oriented than is suggested by the PCE score.

\(^8\) It is worthwhile to clarify that the concept of supply chain industry is different from upstream industry. The latter is a relative term that refers to an industry that sells part of its output to a focal downstream industry (i.e., the seller-industry is upstream to the buyer-industry). Most industries are upstream to other industries, with the exception of a few industries that sell all their output to personal consumption (e.g., Religious Organizations).
its value to PCE. Among traded services, *Engineering Services* (NAICS code 541330) is a SC industry that sells 0% of its value to PCE; *Computer Training* (NAICS code 611420) is a B2C industry that sells more than 91% of its value to PCE. Among local services, there are also both SC industries (e.g., *Temporary Help Services* – establishments engaged in supplying temporary workers to businesses – with a PCE score of 0.5%) and B2C industries (e.g., *Full-Service Restaurants* with a PCE score of 81%).

We implement a series of sensitivity tests for validating our supply chain categorization. We examine the NAICS definition of the SC industries (i.e., the list of products in each industry) and corroborated that their goods and services are oriented primarily to businesses and the government. We also explore the size distribution of the supply chain economy for different PCE scores. Our estimate of the size of the SC economy is robust for values around our baseline PCE score (25-34%) with small changes in employment size.

Finally, in addition to our baseline definition of SC versus B2C industries (SC if PCE ≤ 33.3% and B2C if PCE > 33.3%), we use three alternative definitions: (1) we broaden the definition of SC industry by increasing the PCE cut-off (SC if PCE < 40% and B2C if PCE ≥ 40%);9 (2) we re-define B2C industries as those with more than two-thirds of their output sold to PCE (SC if PCE ≤ 33.3% and B2C if PCE ≥ 66.7%) to better contrast SC and B2C industries; and (3) we develop a “proportional” definition of SC industry that uses the PCE score to proportionally allocate each industry’s outcome (e.g., employment) to the SC and B2C categories (e.g., if the PCE is 25%, then 75% of the industry employment is allocated to the SC category and the rest to the B2C category). Our core findings on wages, STEM intensity, patenting, and growth dynamics are robust to these alternative SC versus B2C categorizations.

### 3.3 Combining Industry Categorizations

We examine the three pairs of industry categories described above: Manufacturing versus Services, Traded versus Local, and SC versus B2C (Figure 1). We separate SC and B2C industries into Traded and Local because traded industries exploit agglomeration economies and can be particularly important for innovation (Porter, 2003; Delgado, Porter and Stern, 2014). In doing

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9 The main difference with the baseline definition is that the *Merchant Wholesaler* industries (with PCE score of 34.9%) are included as part of the SC industries.
so, we create four mutually exclusive subcategories that add up to the total economy: SC Traded, B2C Traded, SC Local, and B2C Local (Figure 2). 

In the traded economy, we further separate SC and B2C industries into Manufacturing and Services, creating four subcategories (SC Traded Manufacturing, SC Traded Services, B2C Traded Manufacturing, and B2C Traded Services). In the local economy, we divide the B2C industries into Healthcare services (e.g., hospitals) and “Main Street” (e.g., retail). Hence, there are three mutually exclusive local subcategories: SC Local, B2C Main Street, and B2C Healthcare. This distinction allows us to shed some light on the labor composition and dynamics of the local services.  

At the most disaggregated level of analysis, the total economy is divided into seven subsegments (four traded subcategories and three local subcategories). The full classification of the six-digit industries (NAICS-2012 definition) into these SC and B2C subcategories is available in the supplemental online Appendix B: Supply Chain and Business-to-Consumer Industry Categorization.

3.4 Data

We use the County Business Patterns (CBP) dataset produced by the U.S. Census Bureau to measure the employment and wages of the industry categories (and their subcategories) over the 1998–2013 period. The CBP is a publicly available database that provides annual county-level measures of private-sector non-agricultural employment (excluding self-employed) and payroll at the level of six-digit NAICS codes (which we refer to as industries). Data on the number of firms by industry is sourced from the U.S. Census Bureau’s 2012 Economic Census (available at 5-year intervals). We use the Occupational Employment Statistics (OES) Survey administered by the Bureau of Labor Statistics (BLS) to calculate the labor occupation composition of each industry (see Section 5.1). The employment, number of firms, payroll data, and labor occupation data is aggregated from individual industries into our categories and subcategories.

Patent data is drawn from the U.S. Patent and Trademark Office (USPTO). Our analysis uses utility patents of U.S. origin that are granted to organizations. Constructing patenting

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10 The local economy contains primarily services. See Appendix B.
11 More detail about the Economic Census can be found at https://bhs.econ.census.gov.
measures for each of our industry categories is complicated because USPTO patents are assigned
to patent classes but are not directly matched to industry codes. Building on Delgado, Porter, and
Stern (2016) and the U.S. Cluster Mapping Project, we have created a bridge between the four-
digit SIC-1987 code and our (NAICS-code based) industry subcategories. We then use a newly
revised version of the patent class-SIC code concordance algorithm developed by Silverman
(2002): patents are assigned, on a fractional basis, to four-digit SIC codes in a consistent (but
somewhat noisy) manner.

4. The Supply Chain Economy Matters: Size and Wages

Our new categorization allows for a better understanding of the supply chain economy
across several metrics: the size in terms of employment and number of firms (Section 4.1); wages
(Section 4.2); labor occupation composition (Section 5); innovation (Section 6); and national
growth (Section 7).

4.1 Size of the Supply Chain Economy: Employment and Firms

Figure 2 shows the size, in terms of employment and number of firms, across the SC and
B2C industry subcategories. We find that suppliers are a large part of the economy. SC industries
accounted for 43 million jobs (37% of U.S. employment), and roughly 2.5 million firms (43% of
U.S. firms) in 2012. These estimates of the size of the SC economy may be conservative.

To characterize the different types of suppliers, we separate SC industries into Traded and
Local. Traded suppliers account for 26 million jobs (22% of U.S. employment) and nearly one
million firms. Prior work on the role of suppliers in the economy has focused primarily on
manufacturers, but Figure 2 shows that traded suppliers are not just manufacturers. Suppliers of
traded services account for 18 million jobs (more than 15% of U.S. employment), while suppliers
of traded manufactured goods account for around 8 million jobs (7% of U.S. employment).

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12 We use the year 2012 for the analysis because the data on the number of firms is available at 5-year intervals. We
code firms as part of the supply chain economy or suppliers if their primary industry in the 2012 Economic Census is
categorized as SC. The estimates on the number of firms may be somewhat noisy because some firms have
establishments in both SC and B2C industries.
13 If we vary the SC industry definition from PCE ≤ 33.3% (baseline) to PCE < 40%, the supply chain economy size
estimates range from 37% to 44% of employment and from 43% to 52% of firms; and if we use the SC-proportional
definition the size is 49% of employment and 53% of firms.
14 If we exclude non-manufactured goods from SC Traded Services, the employment declines slightly to 16.4 million
(14%). The employment size of SC Traded Services increases from 16% to 20% when we use less conservative
definitions of SC industries (PCE < 40% or SC-proportional).
Furthermore, there are four times as many traded supplier firms in services as in manufacturing (770,000 versus 169,000). Some examples of large SC Traded Service industries are Professional Employer Organizations, Engineering Services, and Custom Computer Programming Services.

Suppliers of local services are also important, with more than 17 million jobs (15% of U.S. employment) and 1.6 million firms. Large SC Local industries include Temporary Help Services, Janitorial Services, and Security Guards and Patrol Services, among others.

**4.2 Wages in the Supply Chain Economy versus B2C Economy**

Figure 3 shows the average wages (weighted by industry employment) for the total economy and for each industry subcategory in 2013. The average wage in the total economy ($47,700) is computed by dividing total payroll by total employment. We find that the jobs in the supply chain economy have wages 57% higher than those in B2C industries ($61,700 versus $39,200). Importantly, this SC wage premium holds within the traded and local industries, and within manufacturing and services. Thus, SC industries of all types have greater wages than their B2C counterparts. Furthermore, the average wages of B2C industries are even lower for those with a higher consumer orientation.\(^{15}\)

Where are the best paid jobs? Surprisingly, the SC Traded Services subcategory has the highest average wage of $80,800 (i.e., 70% higher wages than in the total economy). The higher wages are not a recent phenomenon; in 1998, SC Traded Services wages were already the highest (64% higher wages than in the total economy; Table 3). Thus, there is much heterogeneity across services in terms of wages that has persisted over time, with SC Traded Services consistently creating high wage jobs. This important finding often gets lost in the simplistic debate about manufacturing versus services, where all manufacturing jobs are viewed as high tech and high wage and all services as low tech and low wage.

To understand whether the higher average wage in the SC Traded Services subcategory is driven by a few industries, we study the wage distribution across its industries in 2013 (Figure 4).\(^ {16}\) Financial services is an important part of this subcategory (representing 21 industries and 9% of the employment in SC Traded Services). The average wages of these set of industries are

\(^{15}\) The B2C wage declines from $39,200 to $31,300 for industries with PCE ≥ 66.7%.

\(^{16}\) The analysis is based on 159 industries (out of 165) for which wage data is available in the CBP data.
high ($133,500), and they include the top-3 industries by wages within the subcategory: Investment Banking and Securities Dealing with the highest wage in the economy at +$300,000, followed by Portfolio Management, and Securities and Commodity Exchanges. However, financial services are not driving the high wage observed in SC Traded Services. There are many other industries (e.g., software, business, marketing, design, transportation and logistics, energy, and R&D services) with high-paying jobs.\(^\text{17}\) Figure 4 shows that 30% of the industries have wages above $80,800 (e.g., the wage of the Software Publishers industry is +$137,000). Furthermore, 70% of the industries have wages above the total average wage in the economy.\(^\text{18}\)

While SC Traded Services have the highest wage, B2C Local Main Street industries have the lowest average wage, $28,900 (39% lower than the average wage for the entire economy as of 2013).\(^\text{19}\) For the sub-set of Main Street industries with a high percentage sold to personal consumption (including retail stores, restaurants, and repair shops, among others), the average wage is even lower ($21,900 for the 127 industries with PCE ≥ 66.7%).\(^\text{20}\)

Importantly, these findings – higher wages in SC versus B2C subcategories – hold when we compute the wages separately for the sub-groups of small firms (1-500 jobs) and large firms (+500 jobs). As expected, average wages are higher for large firms. But for each sub-group of firms, the SC subcategories have significantly higher wages than the B2C subcategories. Hence, the higher wages in the SC economy do not seem to be driven by economies of scale associated with firm size.

5. **Labor Occupations in the Supply Chain Economy**

We examine the labor occupation composition of the SC and B2C industries to assess whether they have distinct labor pools and technological intensity. In particular, we identify the sub-set of Science, Technology, Engineering and Math (STEM) occupations in each subcategory of the economy. This analysis helps to explain the observed higher wages and growth in the SC economy.

\(^{17}\) The average wage of the SC Traded Services excluding finance services is $75,300 in 2013. The largest wages of the SC Traded Services is also robust to excluding non-manufactured goods ($81,500).

\(^{18}\) Figure 4 shows that the 30\(^{\text{th}}\) percentile value of wages across the industries is $51,000 (above the U.S. wage of $47,700).

\(^{19}\) The median wage across the 179 Main Street industries is only $29,800.

\(^{20}\) For instance, the retail industries within Main Street (63 industries with PCE scores above 86%; Appendix B) have an average wage of $24,500 and account for 12% of the nation’s employment in 2013.
Traded Services industries. It also informs labor policies that could support the supply chain economy.

5.1 Measuring the Labor Composition across Industry Categories

We use the Occupational Employment Statistics (OES) Survey administered by the Bureau of Labor Statistics (BLS; 2009 and 2013), which provides information on the prevalence of over 800 occupations (six-digit SOC codes) within each industry. The OES data include the percentage of an industry $i$ employment in a given occupation $o$ ($occupation_{oi} = emp_{oi}/emp_i$). We compute the percentage of an industry subcategory employment in the occupation using a weighted average of $occupation_{oi}$, as follows:

$$\text{Occupation Intensity}_{Subcategory, 2013}^{Subcategory} = \sum_{i} \frac{emp_{i}}{emp_{S}} \cdot occupation_{oi}$$

where $o$ indexes the labor occupation (e.g., Software Developers, Applications) and $i$ indexes the industries (six-digit NAICS) that belong to the subcategory $S$ (e.g., SC Traded Services); and $occupation_{oi}$ is weighted by the industry's share of the subcategory employment ($emp_{i}/emp_{S}$).

We also identify and aggregate the sub-set of STEM occupations using Hecker's (2005) definition of high-technology (scientific, engineering, and technician) occupations (84 six-digit SOC codes). This allows us to measure the prevalence of STEM jobs in the supply chain and B2C economy. As in equation (1), the percentage of employees with STEM occupations (i.e., “STEM intensity”) in each subcategory and in the U.S. economy are computed as follows:

$$\text{STEM Intensity}_{Subcategory, 2013}^{Subcategory} = \sum_{o \in \text{STEM}} \sum_{i} \frac{emp_{i}}{emp_{S}} \cdot Occupation_{oi}$$

$$\text{STEM Intensity}_{Total, 2013}^{Total} = \sum_{o \in \text{STEM}} \sum_{i \in \text{Total}} \frac{emp_{i}}{emp_{Total}} \cdot Occupation_{oi}$$

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21 We are using six-digit Standard Occupational Classification (SOC) codes and four-digit NAICS data because of better coverage than using less aggregated NAICS. Note that six-digit NAICS industries with the same four-digit NAICS will have the same occupational composition. The data can be accessed at http://www.bls.gov/oes.

22 The employment in the industry and its subcategory ($emp_{i}$ and $emp_{S}$) are sourced from the CBP data.

23 Hecker (2005; p. 58) identifies as high-technology occupations: Computer and Mathematical Scientists (SOC 15-0000); Engineers (SOC 17–2000); Drafters, Engineering, and Mapping Technicians (SOC 17–3000); Life Scientists (SOC 19–1000); Physical Scientists (SOC 19–2000); Life, Physical, and Social Science Technicians (SOC 19–4000); Computer and Information Systems Managers (SOC 11–3020); Engineering Managers (SOC 11–9040); and Natural Sciences Managers (SOC 11–9120). A broader definition of occupations with STEM knowledge has been used to identify “advanced” industries by Muro et al. (2015). We use the traditional Hecker (2005) definition because it focuses on a smaller set of occupations that may better capture technology-oriented workers.
Then we can approximate the percent of total STEM jobs in each subcategory as follows:

\[ \text{STEM Jobs}_{\text{Subcategory}}^{\text{2013}} = \frac{\text{emp}_{\text{Subcategory}} \times \text{STEM Intensity}_{\text{Subcategory}}^{\text{Total}}}{\text{STEM Jobs}_{\text{Total}}} \]  

(3).

The STEM intensity and size of each of the SC and B2C subcategories is reported in Table 2.

5.2 STEM Occupations: The High Technology Intensity of the Supply Chain Economy

Where are the STEM occupations in the U.S. economy? Table 2 shows the STEM intensity and the percentage of the total STEM jobs across the industry subcategories in 2013. We estimate that the STEM intensity of the U.S. economy was only 5.6% in 2013, which corresponds to around 6.6 million STEM jobs (private employment, excluding self-employed). The STEM intensity of the U.S. has increased very slowly in the last decade: from 4.9% in 2002 (Hecker, 2005) to 5.6% in 2013.

Prior work suggests that suppliers play an important role in technological innovation (see e.g., Rosenberg, 1963; Carlsson and Jacobsson, 1991). Thus, we would expect STEM occupations to be particularly important for suppliers. Indeed, SC industries have a much larger intensity of STEM occupations than B2C industries (11.4% versus 2.1%); and they account for 76% of all the STEM jobs. The STEM intensity is also higher in SC Traded industries than in B2C Traded industries (17% versus 5.9%) and in SC Local industries than in B2C Local industries (2.8% versus 1.1%). These findings reinforce that the SC versus B2C categorization represents different labor pools and technology intensity.

What subcategory of the supply chain economy has the largest STEM intensity? The economic geography literature predicts that traded industries (i.e., those that exploit agglomeration economies) will be more innovative. This is consistent with our finding of significantly higher STEM intensity in traded versus local suppliers (17% compared to 2.8%). What is remarkable is that the STEM intensity is the highest in the SC Traded Services (19.3%), not in the SC Traded Manufacturing industries (11.7%). This finding is very robust, and strongly suggests that suppliers of traded services have high technology intensity and can play an important role in the innovation and growth of a country.25

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24 The STEM Jobs in the U.S. is computed by multiplying the U.S. employment (emp\text{Total}) by its STEM Intensity\text{Total}.  
25 The STEM intensity findings are robust to using 2009 occupation data; to excluding the STEM manager occupations (e.g., Natural Sciences Managers), which are slightly more prominent in services; to using an alternative definition
Besides having the greatest STEM intensity, suppliers of traded services account for more than 55% of all the STEM jobs in the U.S., followed by the SC Traded Manufacturing subcategory with 14% of STEM jobs. Because of this large presence of STEM jobs in the SC Traded Services, the innovation and growth debate should focus more on these services.

6. The Role of the Supply Chain Economy in Innovation

Where is innovation taking place in the U.S. economy? We have shown that an important innovation input, STEM jobs, is concentrated in the supply chain economy. In this section, we examine a traditional measure of innovation outcome: patenting. We ask, where is patenting in the U.S. economy happening?

Table 2 reports the number of utility patents granted (column 3), the percentage of total patents (column 4), and the patent intensity (or patents per 1,000 jobs in column 5) across the subcategories in 2013. Consistent with prior work, we find that manufacturing has the majority of patents (86% of all patents in 2013),\(^{26}\) and a high patent intensity (9 patents per 1,000 jobs).

A new and important finding is that the number and intensity of patents is significantly higher in the SC industries (89% of patents and 2.4 intensity) than in the B2C industries (11% of patents and 0.2 intensity). In particular, the SC Traded Manufacturing subcategory has most of the patents (77%), and the largest patent intensity (11 patents per 1,000 jobs).\(^{27}\) Although there was a large decline in employment in SC Traded Manufacturing during 1998–2013 (Section 6), patenting remains highly concentrated in this subcategory (84% in 1998 versus 77% in 2013).

Another key finding is the size of the gap between the STEM content (innovation input) and the patenting (innovation output) of the suppliers of traded services. This subcategory has 55% of all STEM jobs and the highest STEM intensity (19%), but it only accounts for 10% of patents in 2013. There are several possible explanations of the STEM-patenting gap. First, a small part of

\(^{26}\) Similarly, Autor et al. (2016) estimate that manufacturing accounts for 71% of all corporate patents with U.S.-based inventors and an application year of 2007. The difference in the estimates may be due to several factors. First, we use U.S. utility patents granted to all organizations versus to Compustat firms. Second, the matching methods are different: from patent to firm name to industry in Autor et al. (2016) versus our patent-industry matching using a revised Silverman (2002) algorithm (Section 3). Our estimates offer a good approximation to the patent size of each subcategory, but they have some noise given the complexity in matching patent classes to industries.

\(^{27}\) These findings are very robust to using alternative definitions of SC industries.
the gap is because of the mismatch between patent technology classes and industry codes. In particular, the headquarter industry, which accounts for 7% of the STEM jobs, is assigned zero patents.\textsuperscript{28} Second, STEM talent may be attracted to high wage but low-patenting services (like investment banking) rather than to high-patenting manufacturing industries (like analytical laboratory instruments). Third, STEM jobs in traded services versus manufacturing may have lower skill intensity (e.g., fewer PhDs, lower grades in STEM education), and this could result in a lower ability to patent (Shu, 2016).

Finally, given the large size of the gap, a more plausible explanation is that services are difficult to patent (Helper and Kuan, 2016), and that their patents are more litigated in the existing Intellectual Property regime (see e.g., Allison et al. (2012) study of patents for new methods of doing business on the Internet). Hence, patenting activity will simply underestimate innovation in services (including in fin-tech, cloud computing services, logistic services, engineering services etc.) and, more broadly, in industries that do not rely on patents to protect their innovations (Cohen et al. 2000; von Hippel, 2005).

One important area for future research is to develop new measures of service innovation at the firm and industry levels that can map the process of creating and delivering new services (see e.g., Bitner et al. 2008). These new measures could take into account the technology intensity of service industries, and their linkages with other industries (input-output links, shared STEM occupations, etc.). To better measure innovation, new research could also explore how firms’ innovation practices respond strategically to changes in the IP regime that make new services more difficult to be patented.\textsuperscript{29}

\textsuperscript{28} The Silverman (2002) algorithm assigns zero patents to the Headquarter industry (NAICS code 551114), and instead assigns the patents to the set of industries whose goods and services are closer to the patent technology class.

\textsuperscript{29} For example, the Supreme Court’s June 2014 decision in Alice versus CLS Bank International could discourage software patents related to business method innovations.
7. The Role of the Supply Chain Economy in National Growth in Employment and Wages

In this section we compare the growth in employment and real wages of the SC and B2C subcategories. We seek to better understand the evolution of the U.S. economy from manufacturing into services. We study the overall growth during the 1998 to 2013 period (Sections 7.1 and 7.2).

7.1 Employment Growth, 1998–2013

Table 3 (columns 1-6) displays the employment size and the growth (natural-log changes) over the 1998–2013 period for each industry category and subcategory. The manufacturing category shows the largest decline in the share of total employment during the period (from 16% in 1998 to 10% in 2013) and the lowest growth (-41% versus 10% for the total U.S. economy); and services had the highest growth (17%). The SC category registered a low growth rate of 4% and reduced its share of total employment by 2 percentage points (from 39% in 1998 to 37% in 2013). In contrast, the B2C category experienced a high growth (13%).

To explain these different growth trends across categories, we examined each industry subcategory in detail. Employment within the SC Traded subcategory has evolved away from manufacturing and towards services continuously during the 16 years examined (see Figure 5a for the annual growth trends). SC Traded Manufacturing registered the lowest growth (-44%) in the economy. In contrast, SC Traded Services registered the strongest growth across all of the subcategories (33%), and had the largest increase in the share of total employment (from 13% in 1998 to 16% in 2013). Within the B2C Traded subcategory, manufacturing employment also registered a significant decline (-37%), but this was accompanied by a more moderate increase in B2C Traded Services (11%).

Among local services, the SC Local subcategory experienced low growth in employment from 1998–2013 (6%), but the B2C Local subcategories showed high growth: Main Street (14%) and Healthcare (25%). In fact, Healthcare is the only subcategory growing every year, including the recession years (see Figure 5b).

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30 The growth trends findings across the SC and B2C subcategories presented in this section hold when we use the three alternative definitions of SC versus B2C industries.
31 If we exclude non-manufactured goods from the SC Traded Services subcategory, employment growth is slightly higher (36% versus 33%).
Overall, our analysis suggests that the employment composition of the supply chain economy has changed significantly in the last 16 years. It lost many manufacturing jobs in this period (4.4 million), but it was not decimated. Instead, it has evolved towards high-wage suppliers of traded services that leverage a STEM labor force. Industries in consulting, design, software, and other supply chain traded services have created many jobs (5.3 million). At the same time, the B2C economy employment has also evolved from manufacturing towards services, but primarily into local services (Main Street and Healthcare). Although beyond the scope of this paper, identifying which industry subcategories employed the workers who lost their jobs in manufacturing would be an important next step in understanding this evolution of the U.S. economy.

### 7.2 Wage Growth, 1998–2013

Table 3 (columns 7 to 9) reports the growth in real wages (2013 USD) for each industry category. In 1998–2013, the manufacturing category experienced low growth in wages (6% versus 9% for the US economy) as well as the large decline in employment. This low wage growth occurred in both the SC and B2C manufacturing subcategories. In contrast, services experienced high growth in wages (11%) and employment. What types of services drove this high wage growth? We use our SC and B2C categorization to answer this question.

The supply chain economy registered high wage growth (13%). This is due to the SC Traded Services subcategory, which experienced high growth in real wages (12%) as well as the largest growth in employment in the economy (33%).\(^{32}\) It was also the part of the economy with the largest initial wages ($71,400 in 1998). These findings show that the SC Traded Services subcategory disproportionately was creating high-paying jobs; as a result, it became the largest contributor to total income in the U.S. (with 27% of total payroll by 2013). This superior growth of the SC Traded Services is consistent with their high intensity of STEM jobs. Indeed, the presence of high-technology jobs in firms and regions has been associated with higher innovation and growth (Leiponen, 2005; Moretti, 2010, 2012). Another potential explanation for their strong growth is that these services involve knowledge-intensive tasks that may not be easily replaced by automation (Autor, 2015). Further research is needed to explain the strong growth in these

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\(^{32}\) The SC Traded Service industries wage growth was 11% if we exclude non-manufactured goods.
supply chain services, and their potential multiplier effect in jobs and wages in the rest of the economy.

The B2C category registered a low wage growth but high employment growth. The B2C Traded Services and Healthcare subcategories, however, experienced high growth in both wages (14% and 12%) and employment. In contrast, B2C Main Street, which had the lowest initial wages ($29,100 in 1998), experienced a decline in real wages during the period (with a growth rate of -1%) accompanied by high employment growth. It created many low-paid jobs. This finding is amplified when we focus on Main Street industries with higher value sold to personal consumption, like retail stores and restaurants. Our results shed light on recent studies that find an increase in low-skill service jobs which require “manual” tasks that are difficult to automate (Autor and Dorn, 2013; Autor, 2015).

In sum, the supply chain versus B2C framework helps explain the job polarization in services identified in prior work (Autor and Dorn, 2013; Autor, 2015). The two services subcategories that have created more jobs during 1998–2013 are supply chain traded services (with the highest STEM intensity and wages) and Main Street services (with the lowest STEM intensity and wages). Both subcategories generated a similar number of jobs during the period (5.3 million each), but with very different skills and wages.

8. Conclusion

We offer a new innovation framework that focuses on the suppliers of goods and services to businesses and the government. We provide an industry categorization that quantifies the supply chain economy in the U.S. and sheds light on the role of suppliers in national innovation and economic performance. We find that the supply chain economy is large, includes manufacturers but primarily service providers, and offers relatively high-paying jobs. The supply chain economy is also important for innovation as it has the majority of STEM occupations and patents.

Our industry categorization helps to better diagnose and understand the innovation and production capacity of the economy. It complements the Manufacturing versus Services categorization. In the past, the study of the supply chain economy often has been limited to manufacturing. We find instead that a significant portion of suppliers are in high-tech services.
Our categorization also complements the Traded versus Local industry classification (Porter, 1998, 2003). By identifying suppliers within the local and traded economies, we are able to focus on those industries that provide the inputs to grow the economy and pay higher wages. Traded suppliers are particularly important for U.S. innovative activity: they represent the majority of STEM occupations (innovation input) and account for the majority of patents (innovation outcome).

By separating traded suppliers into manufacturing and services, we find that the subcategory of supply chain traded services (e.g., financial, engineering, and data processing services) is very large and has the highest wages. This subcategory has the largest presence of STEM occupations, but other occupations (e.g., accounting, managerial, and logistics occupations) are also important. While suppliers of traded services have the largest presence of STEM jobs, they barely patent at all. Instead, most patents are concentrated among the manufacturing suppliers. This finding calls into question the usefulness of patent-based indicators for examining innovation in the increasingly important services sector.

In terms of growth dynamics, we find that employment in the supply chain economy has been evolving away from manufacturing and towards services. Suppliers of traded services have experienced high growth in employment and wages. But while the supply chain economy seems to foster innovative activity and growth in the economy, it is particularly vulnerable to economic crises.

The new categorization of the U.S. economy described in this paper has important implications for policy. The supply chain has long been a focus of the federal government, manifested primarily through its procurement activities (in areas like defense and energy) and its efforts to upgrade the supply chain of manufactured goods. The ability to define and measure the total category of suppliers in the economy and to evaluate the dynamics of its sub-segments—in particular the suppliers of traded services—can improve the ability of policymakers to create and assess new programs related to innovation, economic growth and the labor force.

Economic development policies should recognize the evolution of the supply chain economy from manufacturing towards services. For example, skills training initiatives should take into account the broad range of STEM and other labor occupations in the growing supply chain
traded services segment. Innovation policies potentially could be analyzed in terms of their impact on the supply chain economy. In the private sector, policies that encourage large firms to create partnerships with and invest in their domestic supply chains also have the potential to bolster growth and resilience in this critical part of the economy (Helper and Henderson, 2014). The SupplierPay initiative, which encourages private firms to reduce the working capital costs of their small suppliers, is one example of this type of policy (Helper, Nicholson, and Noonan, 2015).

Our analysis offers many directions for future research aimed at informing policies to foster the innovation and production capacity of a country and its regions. First, future research could further characterize the SC and B2C industries (and services in particular) based on other relevant indicators such as capital intensity, entrepreneurship activity, productivity, and exports-imports. These analyses could help to identify the underlying causes of the evolution of the economy from manufacturing towards suppliers of traded services. Manufacturing has experienced a large decline in employment that has been attributed to import competition (Acemoglu et al., 2016). In contrast, the high growth of the traded service suppliers may reflect lower import competition faced by these high-technology services.

Second, building on our analysis of the particular occupations that support the supply chain economy, one could investigate the evolution of the labor occupation and skill composition within the supply chain economy. For example, we could examine the changing importance of STEM occupations and skills among suppliers of services versus goods over time. That research would have implications for education and labor policies (Autor, 2015).

Third, future research might assess the attributes of locations that foster the growth of the supply chain economy. For instance, suppliers could benefit especially from co-locating with their business customers within regional clusters of related industries (Delgado and Porter, 2016). Further, what is the role of the supply chain economy in regional performance? We suspect that the presence of supply chain industries (in particular services) within regional clusters could increase a region’s growth.

This paper has defined firms whose primary industry was part of the supply chain economy as suppliers. However, some firms can operate in multiple industries. Future work should map supply chain firms and their networks of suppliers and buyers (Helper and Kuan,
Using longitudinal establishment level data, we could also examine whether and how firms have been transforming over time from manufacturing into suppliers of high-tech services (e.g., Intel, Dell Technologies, and General Electric). We could then see how different types of suppliers (manufacturing versus services, small versus large, young versus old) affect the innovation and growth of a region and its firms.

At the firm level, another fruitful area for future research is understanding the implications for strategy and performance of being a supply chain firm. Organizational and marketing practices and their impact on performance can vary for SC versus B2C firms. For example, prior studies find that the adoption of electronic selling (McElheran, 2015) and the extent of stakeholder orientation (Flammer and Kacperczyk, 2016) are greater for firms in B2C industries. Location choices also can be different for suppliers because their potential customers are more geographically concentrated than consumers. Overall, we know very little about how the innovation practices of SC and B2C firms differ (e.g., access to skilled labor, types of inter-firm collaborations, and practices for appropriating returns to innovation).

Finally, the high STEM intensity but low patenting of the suppliers of traded services raises an old but relevant question: how can we better measure innovation for all economic activities, including those with low patenting? Surveys that measure firm introductions’ of new goods and services and describe the nature of the innovation process would be most useful for capturing innovativeness (e.g., von Hippel, 2005; Bitner et al. 2008; Arora, Cohen, and Walsh, 2014). Another way to measure the innovation potential of services is through inputs (like the presence and skill-level of STEM jobs). Also, new measures of innovation for a particular service industry could take into account its linkages with other industries. More broadly, the development of new tools for assessing the innovation potential of any firm is an important area for research (Guzman and Stern, 2015).
9. References


Figure 1. Industry Categorizations of the U.S. Economy, 2012

<table>
<thead>
<tr>
<th>All Industries, 2012</th>
<th>All Industries, 2012</th>
<th>All Industries, 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Wage $46,800</td>
<td>Employment 115,931K</td>
<td>No. of Firms 5,845K</td>
</tr>
<tr>
<td>Employment 115,931K</td>
<td>No. of Firms 5,845K</td>
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<td>No. of Firms 5,845K</td>
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</table>

<table>
<thead>
<tr>
<th>Manufacturing</th>
<th>Services</th>
<th>Traded</th>
<th>Local</th>
<th>Supply Chain</th>
<th>B2C (Business-to-Consumer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Wage $53,500</td>
<td>Average Wage $46,100</td>
<td>Average Wage $65,900</td>
<td>Average Wage $36,000</td>
<td>Average Wage $60,800</td>
<td>Average Wage $38,400</td>
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<tr>
<td>No. of Firms 267K</td>
<td>No. of Firms 5,578K</td>
<td>No. of Firms 14,84K</td>
<td>No. of Firms 4,362K</td>
<td>No. of Firms 2,511K</td>
<td>No. of Firms 3,334K</td>
</tr>
</tbody>
</table>

Note: Private Employment (excluding self-employed). Employment (in 000s) and wages are sourced from CBP data, and the number of firms (in 000s) is sourced from the 2012 Economic Census (available at 5-year intervals). The Services category includes non-manufactured goods (Agriculture, Forestry, Fishing and Hunting; Mining; and Construction).

Figure 2. The Supply Chain versus B2C Categorization: Employment and Number of Firms, 2012

<table>
<thead>
<tr>
<th>All Industries, 2012</th>
<th>B2C (Business-to-Consumer)</th>
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<tbody>
<tr>
<td>Employment 115,931K</td>
<td>Employment 72,832K</td>
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<td>No. of Firms 5,845K</td>
<td>No. of Firms 3,334K</td>
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<tr>
<th>Supply Chain</th>
<th>B2C Traded</th>
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<tr>
<td>Employment 43,099K</td>
<td>Employment 15,550K</td>
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<td>No. of Firms 545K</td>
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<table>
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<tr>
<th>Supply Chain Local</th>
<th>B2C Local (Main St., Healthcare)</th>
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<tr>
<td>Employment 17,099K</td>
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<th>Supply Chain Traded Services</th>
<th>Supply Chain Traded Mfg</th>
<th>B2C Traded Services</th>
<th>B2C Traded Mfg</th>
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<td>Employment 13,167K</td>
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<td>No. of Firms 496K</td>
<td>No. of Firms 49K</td>
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</tbody>
</table>

Note: The B2C Local subcategory is divided into B2C Main Street (with 40,937K employment and 2,223K firms) and B2C Healthcare (with 16,345K employment and 567K firms). We use 2012 data because the Number of Firms is sourced from the Economic Census (available at 5-year intervals). See Note in Figure 1.
Table 1. Examples of SC and B2C Industries

<table>
<thead>
<tr>
<th>Industry Name</th>
<th>Traded Manufacturing</th>
<th>Traded Services</th>
<th>Local</th>
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<td>SC B2C</td>
<td>SC B2C</td>
<td></td>
</tr>
<tr>
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<td>325414</td>
<td>541330</td>
<td>561320</td>
<td>0%</td>
</tr>
<tr>
<td>Breakfast Cereal</td>
<td>311230</td>
<td>611420</td>
<td>722511</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0.50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90%</td>
<td>86%</td>
<td>79%</td>
<td></td>
</tr>
</tbody>
</table>

Note: PCE is Personal Consumption Expenditure.

Figure 3. Where are the Good Jobs?: Average Wages, 2013

Note: Wages in 2013 USD. The %s in parentheses represent percent of total private employment in 2013.

Figure 4. Wage Distribution Across SC Traded Service Industries, 2013

Percentile values of average wages across 159 SC Traded Service industries, 2013

$314,500, $113,100, $92,900, $81,900, $73,500, $63,400, $56,000, $50,900, $45,100, $38,400, $22,300.
Table 2. STEM Occupations and Utility Patents across Subcategories

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intensity (%)</td>
<td>Jobs (%)</td>
<td>Count (000s)</td>
</tr>
<tr>
<td>Total</td>
<td>5.6%</td>
<td>100%</td>
<td>120.0</td>
</tr>
<tr>
<td>Manufacturing (Mfg)</td>
<td>9.5%</td>
<td>16%</td>
<td>103.4</td>
</tr>
<tr>
<td>Services (Svc)</td>
<td>5.2%</td>
<td>84%</td>
<td>16.6</td>
</tr>
<tr>
<td>Traded</td>
<td>12.9%</td>
<td>83%</td>
<td>116.8</td>
</tr>
<tr>
<td>Local</td>
<td>1.5%</td>
<td>17%</td>
<td>3.2</td>
</tr>
<tr>
<td>Supply Chain (SC)</td>
<td>11.4%</td>
<td>76%</td>
<td>106.3</td>
</tr>
<tr>
<td>B2C</td>
<td>2.1%</td>
<td>24%</td>
<td>13.7</td>
</tr>
<tr>
<td>SC Local</td>
<td>2.8%</td>
<td>7%</td>
<td>1.9</td>
</tr>
<tr>
<td>B2C Local</td>
<td>1.1%</td>
<td>9%</td>
<td>1.3</td>
</tr>
<tr>
<td>B2C Main Street</td>
<td>1.1%</td>
<td>7%</td>
<td>1.1</td>
</tr>
<tr>
<td>B2C Healthcare</td>
<td>1.0%</td>
<td>3%</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Note: STEM Intensity is the % of the subcategory jobs that are in STEM; and STEM Jobs is the % of Total STEM jobs in the subcategory. Patent Intensity is the no. of patents per 1,000 jobs. Patent Growth is Ln(Patents2013/Patents1998).

Table 3. Employment and Wage Trends across Subcategories, 1998–2013

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mill</td>
<td>% Total</td>
<td>Mill</td>
</tr>
<tr>
<td>Total</td>
<td>107.1</td>
<td>100%</td>
<td>118.3</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>16.9</td>
<td>16%</td>
<td>11.3</td>
</tr>
<tr>
<td>Services</td>
<td>90.2</td>
<td>84%</td>
<td>107.0</td>
</tr>
<tr>
<td>Traded</td>
<td>41.4</td>
<td>39%</td>
<td>42.6</td>
</tr>
<tr>
<td>Local</td>
<td>65.7</td>
<td>61%</td>
<td>75.7</td>
</tr>
<tr>
<td>SC</td>
<td>42.3</td>
<td>39%</td>
<td>44.2</td>
</tr>
<tr>
<td>B2C</td>
<td>64.8</td>
<td>61%</td>
<td>74.1</td>
</tr>
<tr>
<td>SC Traded</td>
<td>25.9</td>
<td>24%</td>
<td>26.8</td>
</tr>
<tr>
<td>B2C Traded</td>
<td>15.5</td>
<td>14%</td>
<td>15.8</td>
</tr>
<tr>
<td>SC Traded Mfg</td>
<td>12.5</td>
<td>12%</td>
<td>8.1</td>
</tr>
<tr>
<td>SC Traded Svc</td>
<td>13.4</td>
<td>13%</td>
<td>18.7</td>
</tr>
<tr>
<td>B2C Traded Mfg</td>
<td>3.5</td>
<td>3%</td>
<td>2.4</td>
</tr>
<tr>
<td>B2C Traded Svc</td>
<td>12.0</td>
<td>11%</td>
<td>13.4</td>
</tr>
<tr>
<td>SC Local</td>
<td>16.4</td>
<td>15%</td>
<td>17.4</td>
</tr>
<tr>
<td>B2C Local</td>
<td>49.3</td>
<td>46%</td>
<td>58.3</td>
</tr>
<tr>
<td>B2C Main Street</td>
<td>36.4</td>
<td>34%</td>
<td>41.8</td>
</tr>
<tr>
<td>B2C Healthcare</td>
<td>12.9</td>
<td>12%</td>
<td>16.5</td>
</tr>
</tbody>
</table>

Note: Growth rate in X (employment or wages) is computed as Ln(X1998/X1998). We use real wages in 2013 US Dollars. The wages are adjusted using CPI-U (All Urban Consumers; BLS).
Figure 5. Annual Employment by Industry Category (indexed to 1998 level), 1998–2013

Fig. 5a. Employment Trends: Traded Economy Subcategories

Fig. 5b. Employment Trends: Local Economy Subcategories