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Structural Change Within Versus Across Firms: Evidence from the United States

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PRELIMINARY

Abstract

US manufacturing's employment share fell from 27 to 9 percent between 1977 and 2016. A third of this reallocation is driven by a shift towards services – particularly professional services and retail – within continuing manufacturers. We show that firms with in-house professional service establishments are larger, grow faster, more likely to survive and more diversified than firms without such plants. These trends motivate a model of within-firm structural transformation in which non-manufacturing workers complement physical production, and where physical input price reductions induce firms to reallocate towards services. This mechanism is consistent with US firms' responses to growing trade with China.

JEL CLASSIFICATION: L11, L21, L25, L60

KEYWORDS: structural change, multi-product firms, globalization

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1 Introduction

The US economy has undergone substantial structural change over the past four decades, transitioning from a manufacturing employment share of 27 percent in 1977 to 9 percent in 2016, with about one-third of that occurring *within* surviving manufacturing firms. Over the same period, the United States experienced a considerable increase in the share of employment accounted for by older, larger firms (Decker, Haltiwanger, Jarmin, and Miranda (2014)), a rise in variable markups among publicly traded firms (De Loecker and Eeckhout (2017)), and declines in job reallocation rates (Decker, Haltiwanger, Jarmin, and Miranda (2016)), start-up rates (Pugsley and Sahin (2019)) and the labor share of GDP (Autor, Dorn, Katz, Patterson, and Reenan (2017)).

While controversial, one proposed explanation for these trends is the growing importance of high fixed-cost technologies in production, and the possibility that older, larger firms are better positioned to exploit them. Recent research in the industrial organization literature, for example, suggests that large firms alter their mix of marginal and fixed costs over time as they invest in quality, geographic location, and networks to improve product attributes and production methods (Berry, Gaynor, and Scott Morton (2019)). A canonical example of such a transition is Apple, a former manufacturer of computers that amassed expertise in an array of professional services, shed its manufacturing facilities, and now orchestrates the design, engineering, sourcing, marketing and distribution of consumer electronic devices rather than their physical production. Other examples of prominent manufacturing firms that have shifted towards services abound, including Boeing, IBM, and Pitney Bowes. More broadly, Fort, Pierce, and Schott (2018) report that three quarters of the decline in US manufacturing employment between 1977 and 2012 takes place within continuing manufacturing firms that exhibit more-than-offsetting increases in non-manufacturing employment, particularly in business services and retail.

In this paper we offer new facts, theory, and evidence highlighting a link between the rise of professional services and US structural change. First, using detailed microdata from the US Census Bureau, we construct a unique panel to analyze the relative growth of manufacturing and non-manufacturing sectors on a consistent industry basis for the past 40 years, from 1977 to 2016. This analysis reveals that Professional, Scientific, and Technical Services (NAICS 54), which includes activities that range from computer systems design to marketing, is an important contributor to the growth of the US service sector, increasing its share of overall US employment from 3 to 7 percent. Its rise in terms of overall US payroll is even more dramatic, from 4 to 11 percent. By comparison, Healthcare (NAICS 62) employment increased from 8 to 16 percent in terms of total US employment, and from 7 to 15 percent in terms of total US payroll.

A key distinction between the activities in NAICS 54, hereafter referred to as MPRO (for "management and professional services") and those of other fast-growing US service sectors, such as healthcare, is that the output of MPRO establishments is directed disproportionately to other firms rather than to final consumers. Furthermore, the majority of MPRO employment lies within establishments that do not sell their

output at arm's-length, but instead provide services to other establishments within multiple-establishment firms.[1] In a series of descriptive regressions, we find that firms with MPRO establishments are larger, more diversified, grow faster and are more likely to survive when these sales are directed in-house. Among manufacturing firms in particular, possession of an in-house oriented MPRO establishment is associated with a higher probability of opening establishments outside of manufacturing, e.g., in retail. These patterns suggest MPRO services may facilitate manufacturing firms' transition towards services. Though relatively unexplored in the macro literature, we find that this type of within-firm structural change is quantitatively important. Using the most conservative definition of a continuing firm available, we calculate that one third of the aggregate US transition from manufacturing to services occurs within firms that drop manufacturing employment even as they expand into services. In terms of payroll, the share is 40 percent.

Motivated by these facts, we develop a model in which firms can choose to operate in multiple sectors, and combine production workers and physical inputs as well as professional services workers to produce output within each sector. This production function differs from those typically assumed in IO and macro frameworks in that it includes professional services, which we model as being complementary to production inputs. Structural change occurs through the reallocation of economic activity between final demand sectors ("sectoral" structural change), and also via the reallocation of resources between production and professional services within sectors ("functional" structural change). A key implication of the model is that trade shocks that reduce the price of intermediate inputs induce firms to shift towards services, i.e., engage in within-firm functional structural change.

Firms also choose whether to outsource professional services or supply them in-house. In-house production requires an additional fixed cost, but allows a firm to exclude its competitors from the knowledge accumulated by these workers. Firms with in-house MPRO establishments thus build up intangible capital, e.g. "design expertise", which gives them a productivity advantage across all sectors and raises their ability to pivot from one sector to another. Though we focus on the design and manufacture of a physical product, the model is amenable to a number of extensions and reinterpretations. For example, Apple's "design" workers might also have expertise in building out a retail network, or in developing new or updated software products for its electronic devices. Both activities represent high fixed cost but low marginal cost complementary services that might raise the value of their existing products, e.g., the iPhone, as well as services for the iPhone sold by others, such as data providers. More broadly, outside manufacturing, retailers might combine "design" expertise from their supply chain management with "production workers" in their brick-and-mortar establishments to raise their competitive advantage.[2]

[1] For this reason, we also include headquarter establishments (NAICS 55), which are defined as those which oversee the activities of a multiple-unit firm by performing at least two NAICS 54 activities, in our definition of MPRO later in the paper. The Economic Census of Services does not record sales figures for MPRO services sold in-house, in contrast to the Economic Census of Manufacturers, which does track the value of shipments of physical goods sold between plants within the same firm. We are investigating whether and how the value of in-house MPRO employees is captured in aggregate data.

[2] Consider the comments of Target's Chief Information Officer, Mike McNamara as reported in FierceRetail (Alaimo (2019)):

> By keeping the intellectual property generated by the in-house software engineers, the company can preserve competitive advantage, McNamara told WSJ's CIO Journal. Target had been outsourcing significant parts of its

In the final section of the paper, we provide empirical support for the trade mechanism highlighted in the model by analyzing US manufacturing firms' responses to the "rise" of China. In this exercise we go beyond existing studies of US responses to China by considering potential opportunities as well as threats. That is, in addition to constructing a firm-level measure of exposure to China in terms of the goods a firm produces, we use detailed, firm-level information on the materials they use in their production processes to construct a measure of input exposure. In both cases, we follow Antràs, Fort, and Tintelnot (2017) in instrumenting industry changes in US import penetration with the growth in Chinese market share in Europe. This approach, similar in spirit to Autor, Dorn, and Hanson (2013), captures that part of US Chinese import growth attributable to China's gains in comparative advantage, due either to changes in US and Chinese trade policy (Pierce and Schott (2016), Handley and Limão (2017)) or productivity gains in China (Brandt, Van Biesebroeck, and Zhang (2012), Brandt, Van Biesebroeck, Wang, and Zhang (2017)).

Consistent with the literature, we find that firms with greater output vulnerability to China contract their employment, both in manufacturing and overall.[3] Increased Chinese import penetration in a firm's inputs, however, reorients firms towards services. We find that a 10 percentage point increase in a firm's input exposure is associated with a 4.1 percentage point decline in the firm's manufacturing employment share and a 2.8 percentage point increase in its MPRO employment share. Moreover, we find that these relationships hold in levels as well as shares. That is, a 1 percentage point change in a firm's input exposure, holding all else equal, is associated with a 5.7 percent decline in the firm's manufacturing employment, and a 15 percent increase in their MPRO employment. Examination of firms' trading behavior over this period provides further insight. Greater output exposure to China leads to a decline in export growth rates, the number of countries to which firms export, and the number of products they exports. Higher input exposure, on the other hand, coincides with increase along all three of these margins.

This paper contributes to three broad literatures. First, it relates to a large literature in macroeconomics on structural change, nicely summarized in Herrendorf, Rogerson, and Valentinyi (2014), and the substantial debate over whether its ultimate cause is non-homothetic demand (Comin, Lashkari, and Mestieri (2018)), asymmetric technological progress (Ngai and Pissarides (2007)), or both (Herrendorf, Rogerson, and Valentinyi (2013)). Here, our contribution is two-fold. First, we develop a model of structural change in response to globalization that captures the essence of both of these forces. That is, in response to greater access to lower-cost inputs from low-wage countries, US comparative disadvantage industries decline relative to comparative advantage industries (asymmetric demand shock) and US firms reallocate production towards services (asymmetric supply shock). Second, we assess the relative importance of these mech-

> application development and backend systems to India and domestic companies including Infosys and IBM. "We got to a stage where almost half the team is in third parties. It's unhealthy," he said. Target can boost its market advantage over competitors by making strategic use of technology, optimizing the supply chain, and cutting the time it takes to get products to customers. "If you can get advantage through shorter lead times, you don't want a third-party provider sending it to Retailer B down the road.

[3] Pierce and Schott (2016) find that manufacturing establishments with greater exposure to US trade liberalization with China are more likely to shrink and exit.

anisms among US manufacturing firms, focusing on how and why they might occur within rather than across firms. In this sense, the paper relates to recent work focusing on firms that transition from manufacturing into services (Bernard and Fort (2015), Bernard, Smeets, and Warzynski (2017), Bernard, Fort, Smeets, and Warzynski (2018), Breinlich, Soderbery, and Wright (2018), Fort, Pierce, and Schott (2018)) and on how differential entry rates across sectors can help explain the US transition (Dent, Karahan, Pugsley, and Sahin (2016), Pugsley and Sahin (2019)).

This paper also adds to an extensive literature studying the impact of low-wage imports on worker, firm, and regional outcomes. A growing body of work documents relationships between low-wage import competition and firms' product mix (Bernard, Jensen, and Schott (2006), Bernard, Jensen, Redding, and Schott (2011)) and technological and quality upgrading (Khandelwal (2010), Bloom, Draca, and Van Reenen (2016). Other work emphasizes the impact of imported inputs and offshoring on firm productivity, employment levels and composition, and the firm-size distribution (Amiti and Konings (2007), Goldberg, Khandelwal, Pavcnik, and Topalova (2010), Halpern, Koren, and Szeidl (2015), Antràs, Fort, and Tintelnot (2017), Boehm, Flaaen, and Pandalai-Nayar (2017), Magyari (2017), Bloom, Handley, Kurmann, and Luck (2019)). Most recently, the negative impact of Chinese import competition on US manufacturing employment (Autor, Dorn, and Hanson (2013), Pierce and Schott (2016)) has received considerable attention. Here, our contribution is to differentiate the impact of rising low-wage country imports in firms' outputs versus inputs, and to show that separately identifying these channels provides a more complete understanding of the impact of international trade.

Finally, our analysis relates to the voluminous literature examining the boundaries of the firm. Existing theories focus on firms as vehicles for reducing transactions costs (Williamson (1981)) or resolving incomplete contracting problems (Grossman and Hart (1986), Hart and Moore (1990)).[4] Here, we emphasize firms' role in the accumulation and leveraging of intangible assets. In that sense, our approach is most closely related to Atalay, Hortacsu, and Syverson (2014), who argue that the transfer of intangibles across plants may be an important motive for integration, and Foster, Haltiwanger, and Syverson (2008), who document significant *revenue* productivity advantages of large, old firms relative to small, young firms, even though the latter tend to have higher physical productivity. Our contribution is to emphasize the role of intangibles in firm production in our model, and to show empirically that firm responses to integration with China are consistent with complementarities between these intangibles and manufacturing inputs.

The remainder of the paper proceeds as follows. Section 2 describes the data and provides a novel set of facts about the role of manufacturing firms in the US structural transformation, and the extent to which it has occurred within firms. In Section 4 we present a framework to rationalize in which firms have intangible assets that they can leverage across sectors, and which used in a complementary fashion with manufacturing inputs. We exploit the China shock in Section 5 to document the impact of specific demand and input shocks on structural change within the firm. The last section concludes.

[4] See Lafontaine and Slade (2007) and Hart (2011) for extensive reviews of this literature.

2 An Anatomy of US Structural Change, 1977 to 2016

This section offers an anatomy of US structural change over the last four decades. We describe the data used, the growing importance of management and professional (MPRO) services within the service sector, the attributes of firms that contain MPRO establishments, and the extent to which the US transition from manufacturing to services occurs within versus across firms.

2.1 Data and Definitions

Our principal source of data is the US Longitudinal Business Database (LBD), which tracks all private, non-farm employer establishments from 1977 to 2016 (Jarmin and Miranda (2002)).[5] "Establishments" are physical locations where business transactions take place and for which payroll and employment records are kept. The LBD also tracks "firms", which are organizational structures that can include one or more establishments. Each establishment is assigned a single industry code in each year based on its predominant activity.

2.1.1 Identifying Industries

In the LBD, as in official statistics such as those published by the Bureau of Labor Statistics, employees are classified into industries based on the industry code of the establishment at which they work. As a result, all employees in a manufacturing plant are allocated to the manufacturing industry code of that establishment, regardless of their occupation. A firm may span more than one industry if it has multiple establishments and these establishments have different industry codes.[6]

An important limitation of the LBD with respect to tracking economic activity across industries over time is the change in industry classification systems from SIC to NAICS in 1997, the middle of our sample period. We address this issue by using a re-mapping of plants to a unique (2012 version) NAICS industry code, even during the SIC era, developed by Fort and Klimek (2016). Use of these "FK" is superior to applying official SIC-NAICS concordances to plants' raw SIC codes during the SIC era because it minimizes the need for randomly assigning a NAICS code to an SIC code when the concordance is one-to-many, and because it exploits the longitudinal nature of the LBD.[7] Assigning NAICS codes at the establishment level during the SIC era is essential for producing proper aggregate time series because the scope of activities

[5] We drop records that are outside the scope of the LBD data, such as agriculture, and observations that are clearly erroneous, for example because of implausible payroll and employment numbers.

[6] Data available in the Censuses of Manufactures (CM), undertaken quinquennially in years ending in 2 and 7, provide detailed information about the vector of products produced by the plant in "product trailers" but do not provide information about how employment is allocated among to these products. See Bernard, Jensen, Redding, and Schott (2011). The CM also provides information about the vector of inputs used by each establishment in "materials trailers". As discussed further in Section 5, we use information from the product and materials trailers to gauge firms' exposure to greater trade with China. .

[7] For example, when an establishment is active in both the SIC (1977 to 2001) and NAICS (post 2001) eras, and the establishment's NAICS- and SIC-era codes are a match in terms of the official SIC-NAICS concordance, Fort and Klimek (2016) assign the NAICS-era code to the establishment during the SIC era. The authors outline a number of procedures to assign codes in more complicated cases, for example, when a plant exists only in the SIC era, or when plants switch industry codes over time within the two eras.

encompassed by sectors varies substantially across classification systems, even if the establishment's underlying activities do not. For example, in the transition from SIC to NAICS, many activities previously categorized as manufacturing are re-classified into other sectors. As a result, failure to concord at the establishment level can result in a spurious decline in manufacturing employment.

2.1.2 Identifying Firms

Census groups establishments into firms using information collected every five years in its quinquennial Economic Censuses and annual Company Organization Surveys. While the resulting firm identifiers (known as "firmids") can be used to track firms over time. A well-known issue with these identifiers, however, is that they break, by construction, when firms transition from a single-unit (SU) firm to a multi-unit (MU) firm, or vice-versa.[8] We address this issue in part by replacing SU firmids with their associated MU firmids in unambiguous movements between these states.[9]

2.2 US Employment and Payroll Growth by Sector, 1977 to 2016

In this section, we examine US employment and payroll growth across a consistent set of one- and two-digit NAICS sectors over the last four decades, with the 1977 and 2016 begin and end years dictated by the availability of the LBD. As noted above, our ability to analyze such a long time interval using a consistent set of NAICS industries is feasible due to the Fort and Klimek (2016) assignment of a unique NAICS code to all establishments in all years of the LBD, even the SIC years.

Figure 1 reports US employment (left panel) and payroll (right panel) by one- or two-digit NAICS sectors from 1977 to 2016. The starkest trend in the figure is the steady movement of US employment away from Manufacturing (NAICS 3) and towards services, which we define to be all sectors except manufacturing. Indeed, manufacturing employment falls 35 percent between 1977 and 2016, from 17.8 to 11.5 million. By contrast, the two service sectors with the largest employment growth are Business Services (NAICS 5X) – defined in more detail below – and Healthcare (NAICS 62). Employment in these two sectors grows by 21.3 and 14.1 million, or 165 and 265 percent, respectively. Overall, the share of US employment devoted to manufacturing declines from 26 percent in 1977 to 9 percent in 2016.

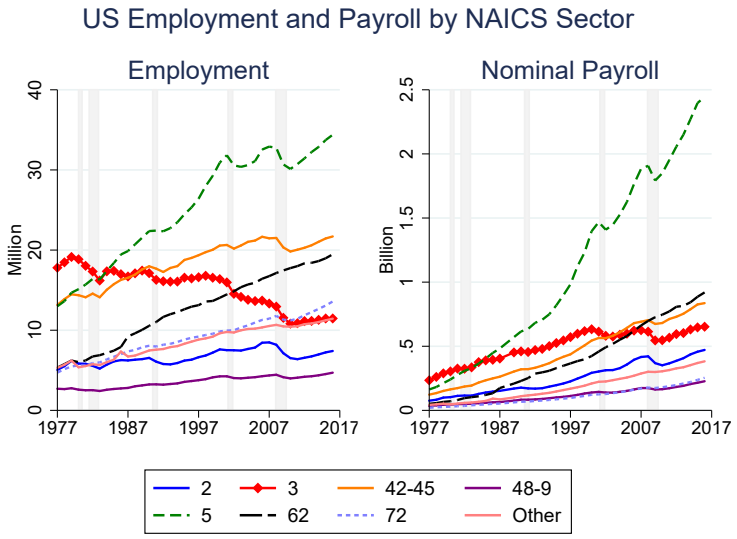
The right panel of Figure 1 provides an analogous decomposition with respect to nominal payroll, i.e., wages times employment.[10] The relative decline in manufacturing is similar: from 31 to 11 percent for payroll versus 26 to 9 percent for employment. The rise of Business Services (NAICS 5) payroll, by contrast, is starker: its share of overall payroll almost doubles, from 22 to 39 percent, versus the increase

[8] For this reason they typically are not used to decompose changes in employment driven by entry and exit versus incumbents. See, for example, Haltiwanger, Jarmin, and Miranda (2013).

[9] The two case we address are: (1) where SUs transition to MUs and all additional plants joining the original SU are new to the LBD; and (2) where MUs transition to SUs and all of the units that don't make the transition exit the LBD permanently. Our code for these fixes, for use within the Census Bureau's research labs, is available upon request.

[10] Unfortunately, sales information is not currently available in the LBD. We plan to analyze sales in a future draft using an updated version of the LBD that includes this information (the mythical RLBD).

Figure 1: US Employment and Payroll by Sector



Source: Longitudinal Business Database and authors' calculations. Figure displays US employment (left panel) and wagebill (right panel) by broad NAICS sector from 1977 to 2016. Sector descriptions are as follows: Mining, Utilities and Construction (2), Manufacturing (3), Wholesale and Retail Trade (42-45), Transportation and Warehousing (48-49), Information Services, Finance, Insurance, Real Estate Services, Professional, Scientific and Technical Services, Management Services, and Administrative Services (5), Healthcare (62), Accommodation and Food Services (72), and Other, which includes Educational Services, the Arts and Public Administration. Payroll data for 1988 are missing.

in its employment share from 19 to 28 percent.

Further comparison of the two panels reveals several interesting *implict* trends with respect to wages. The relatively high payroll shares for manufacturing and business services compared to their employment shares reveals their relatively high wages compared to other sectors. Wage growth in business services has been particularly rapid: over the entire 1977 to 2016 interval, the average annual increase in the business services wage is 12 percent, versus an average of 7 percent across all other sectors. After 2000, this relative increase subsides somewhat, as business services wage growth averages 3.6 percent versus 2.8 percent for all other sectors. A final notable difference between the left and right panels of Figure 1 is the large gap between the employment and payroll shares for Accommodation and Food Services' (NAICS 72). In 2016, for example, they are 4 and 11 percent, respectively, an indication of that sector's relatively low wages.

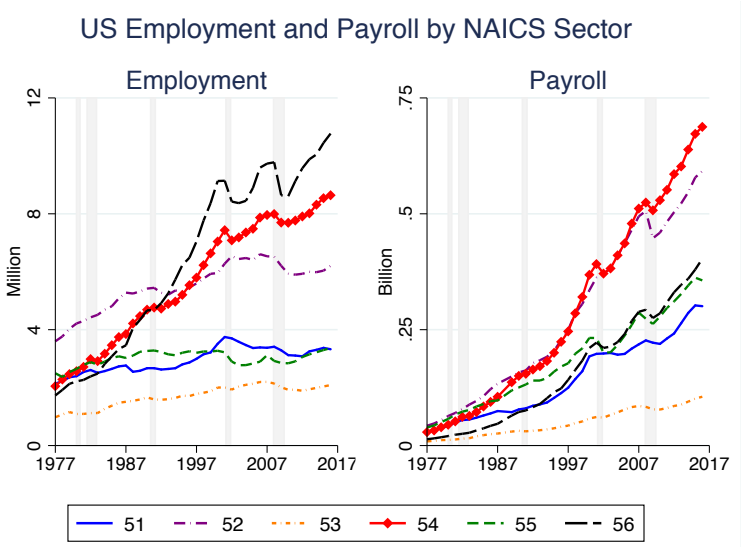
Business services encompasses Information (NAICS 51), Finance, Insurance and Real Estate (NAICS 52-3), Professional, Scientific and Technical Services (NAICS 54), Management Services (NAICS 55) and Administration Services (NAICS 56). Employment and payroll across the two-digit NAICS codes are reported in Figure 2. As indicated in the figure, Administrative Services (NAICS 56) and Professional Services (NAICS 54) account for most of the growth in NAICS 5 overall. In terms of employment, Administrative Services (NAICS 56), which includes temp agencies and janitorial service providers, grows from 1.7 million in 1977 to 10.8 million in 2016, or from 2.6 to 8.7 percent of overall US employment.[11] Employment in NAICS 54, which consists of a host of technical fields ranging from scientific research to computer design to marketing, increases from 2 million in 1977 to 8.7 million in 2016, or from 3 to 7 percent of overall US employment. Its rise in terms of payroll, from 4 to 11 percent of the US total, is even more dramatic, and dominates all other two-digit NAICS sectors.

Management Services (NAICS 55) establishments are more commonly referred to as "headquarters", that is, plants whose primary purpose is to oversee the other establishments of a multi-plant firm (U.S. Census Bureau (1998)). This supervisory role includes a range of core services, including planning, marketing, accounting, legal services, human resources, and financial management. Plants performing at least two of these activities are classified as NAICS 55. If they perform just one, their NAICS code corresponds to that single activity, e.g., Marketing (NAICS 541613). Thus NAICS 55 establishments can loosely be thought of as plants that perform at least two Professional, Scientific and Technical Services (NAICS 54) activities, a primary reason why we bundle them together under the moniker "MPRO" in our regression analysis below. As indicated in Figure 2, Management Services (NAICS 55) employment and payroll account for approximately 3 and 5 percent of the US totals during the 1977 to 2016 sample period.

Finally, Figure 3 decomposes NAICS 54 into its four-digit NAICS components: Legal Services (5411), Accounting (5412), Engineering and Architecture (5413), Computer System Design (5415), Management and Technical Consulting (5416), Research and Development (5417) and Other (5419), within which we include Specialized Design (5414) and Advertising and Marketing (5418). As indicated in the figure, Com-

[11] See Dey, Houseman, and Polivka (2012) for an examination of the growing use of staffing services among manufacturers.

Figure 2: US Employment and Wagebill in Business Services



Source: Longitudinal Business Database and authors' calculations. Figure displays US Business Services (NAICS 5X) employment (left panel) and wagebill (right panel) by two-digit NAICS sectors from 1977 to 2016. Sector descriptions are as follows: Information (51), Finance and Insurance (52), Real Estate (53), Professional Services (54), Headquarters Services (55) and Administration Services (56). Payroll data for 1988 are missing.

puter Systems Design (NAICS 5415) exhibits the largest growth over the sample period, with employment well below100 thousand workers until 1988, at which point it begins rising sharply, presumably in line with the rise of personal computers. Its employment increases to 1.7 million in 2016, or from 0.002 to 1.4 percent of overall US employment, while its share of overall US payroll increases from 0.003 to 2.6 percent.[12]

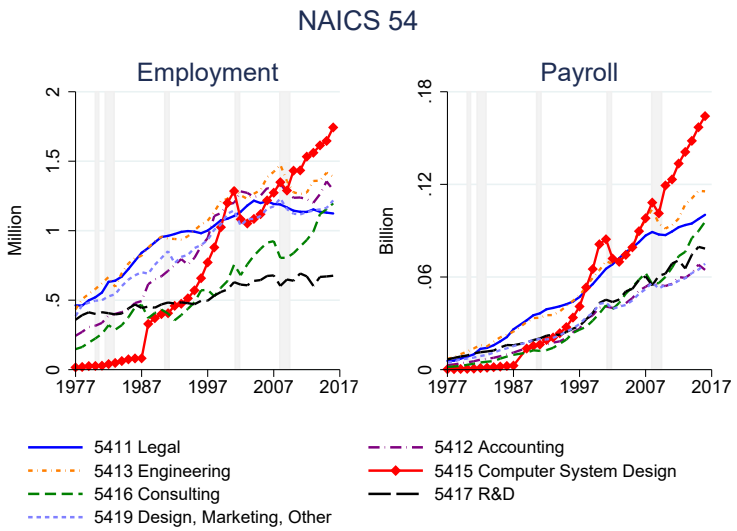
2.3 Services as Intermediate Inputs

Non-homothetic demand and rising income is a well-understood source of sectoral structural change, and a likely factor, along with the aging of the US population, of the growing demand for medical services and associated increase in US healthcare employment and payroll displayed above. Demand seems less obvious as an explanation for the growth of Management (NAICS 55) and Professional Services (NAICS 54), however, given that these services are used mostly as an input into the production of other goods. This difference between healthcare and MPRO is illustrated in the left panel of Figure 4, which uses data from the 1997 US supply-use input output table to report the share of output *not* sold to final consumers across two-digit NAICS sectors.[13] In the figure, Wholesale (NAICS 42), Management Services (NAICS 55)

[12]Establishments providing these services are far more difficult to measure and analyze using SIC codes because under that industry classification system they are coded according to the industry they serve. An auto firm's R&D facility, for example, would be classified as an automobile establishment. We are able to track these establishment during both the SIC and NAICS eras here using the Fort and Klimek (2016) NAICS codes discussed above.

[13]Output sold to final consumers is identified via BEA output sector F01000. The patterns displayed in Figure 4 are similar in subsequent years. We use 1997 because it is halfway through our sample period, and the earliest input-output table using NAICS

Figure 3: US Employment and Wagebill in Professional, Scientific and Technical Services



Source: Longitudinal Business Database and authors' calculations. Figure US Professional Services (NAICS 54) employment and payroll by four-digit NAICS code. Sector descriptions are: Legal Services (5411), Accounting (5412), Engineering and Architecture (5413), Computer System Design (5415), Management and Technical Consulting (5416), Research and Development (5417) and Other (5419). We include Design (5414) and Advertising and Marketing (5418) in Other.. Payroll data for 1988 are missing.

and Professional Services (NAICS 54) have the highest shares, while, Healthcare (NAICS 62), Education (NAICS 61) and Retail (NAICS 44-45) have the lowest. The relatively low shares for MPRO industries seems to rule out demand as an explanation for their growth, unless that demand is indirect in the sense that MPRO services are increasingly valued as attributes bundled into final goods, e.g., as a heightened taste for aesthetically pleasing cell phones as US incomes rise.

The right panel of Figure 4 reports the same information for the four-digit sectors in NAICS 54. As indicated in this panel, these shares are close to 100 percent for the two four-digit sectors – Computer Systems Design (NAICS 5415) and Research and Development (NAICS 5417) that report the largest employment and payroll growth above.[14]

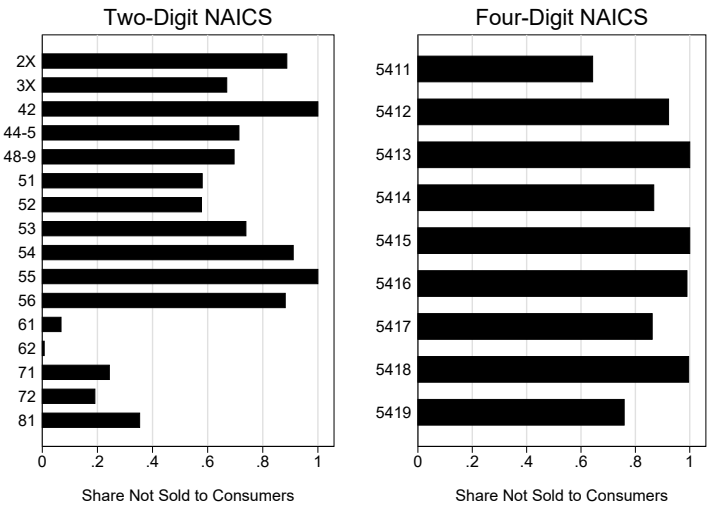
2.4 MPRO and Manufacturing

In this section we examine the attributes of firms with MPRO (i.e., NAICS 54 and 55) establishments, and the connection between MPRO and manufacturing. We focus on MPRO establishments for three reasons. First, as highlighted in Figure 2, employment in NAICS 54 accounts for a substantial share of the growth

industries.

[14] Additional analysis of the 1997 to 2012 US input-output tables reveals that large shares of the output of these sectors, as well as Engineering (NAICS 5413), contribute to the accumulation of non-residential private fixed investment (i.e., BEA codes with "F02"). A link between professional services employment and the development of intangible capital is an explicit feature of the model presented below.

Figure 4: Share of Sector Sold to Other Firms in 1997



Source: Bureau of Economic Analysis and authors' calculations. Figure displays the share of each sector's value not sold to consumers, i.e., share of output sold as intermediates to firms as well as to the government. Data are from the detailed 1997 US Supply-Use Table published on the BEA website. The activities encompassed by the various two- and four-digit NAICS sectors are listed in Figures 1, 2 and 3.

in US employment between 1977 and 2016. Second, as illustrated in Figure 4, the output of these sectors is used primarily as inputs for other industries. Third, unlike Administrative Services (NAICS 56), whose employment also has grown substantially but which consists primarily of temporary employment agencies and building services, these sectors tend to employ the more educated, more highly paid workers that define US comparative advantage. Their skill may be especially important in facilitating firms' transition from one sector to another in response to shocks.

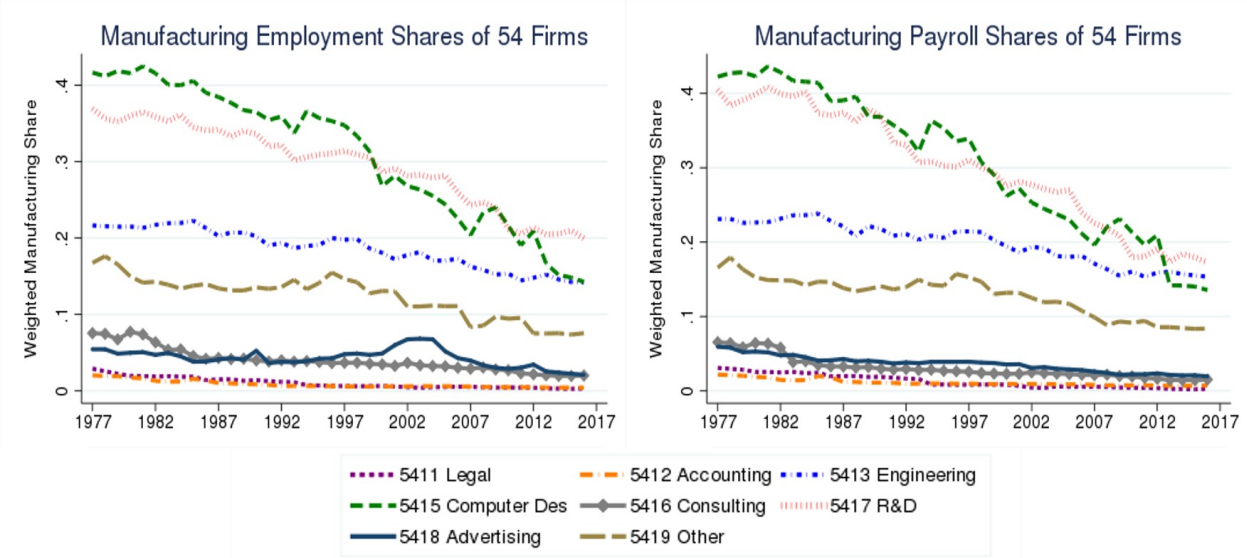
While the vast majority of firms with MPRO establishments do not have establishments in any other sector, diversified MPRO firms, that is, firms that produce MPRO in conjunction with industries outside NAICS 54 and 55, account for the virtually all of MPRO employment. In 1997, mid way through our sample, the 5 percent of MPRO firms that are diversified account for 90 percent of US MPRO employment. Moreover, MPRO establishments in diversified firms are more likely to be oriented in-house: in 1997, half of diversified MPRO firms' MPRO establishments primarily serve their firm's other establishments, versus less than 1 percent for undiversified MPRO firms.

Further insight into the relationship between professional services and manufacturing comes from Figure 5, which displays the prior production history of firms that have NAICS 54 employment in 2016. To focus on potential within-firm structural change, we restrict this analysis to Census firmids that survive for the entire sample period.[15] For each four-digit code in NAICS 54, the left panel of the figure plots the

[15]Census firmids that survive from 1977 to 2016 account for XXX percent of the growth in NAICS 54 employment over that

average manufacturing employment share of firms with 2016 employment in that four-digit code, for each year from 1977 to 2016, using firms' 2016 employment in those codes as weights. The right panel displays similar information with respect to payroll, i.e., the weighted average manufacturing payroll share of firms with employment in each four-digit code in 2016.

Figure 5: Average Manufacturing Share 2016 NAICS 54 Producers



Source: Longitudinal Business Database and authors' calculations. Figure plots the weighted average manuafacturing share of firms producing the noted four-digit NAICS sectors in 2016, using their 2016 employment in those sectors as weights.

This figure conveys two interesting messages. First, it reveals that firms with employment in Computer Systems Design (NAICS 5415), Research and Development (NAICS 5417) and Engineering (NAICS 5413) in 2016 have substantially larger manufacturing employment shares compared to firms with employment in other professional services, such as Accounting (5412) and Legal Services (5411), i.e., 15 to 20 percent versus close to zero. This variation hints at a potential benefit associated with the co-location of NAICS 5413, 5415 and 5417 and physical production within the same firm. Research and development at Boeing, for example, might be more effective if done in-house rather than via arm's-length contractors for a number of reasons, including internal researchers' possession of a greater understanding of the firm's overall product range, engineering capabilities, and design philosophy. Boeing may also favor in-house research and development to prevent its technological innovations from being appropriated by its competitors.[16]

The second message conveyed by Figure 5 is that continuing firms with employment in NAICS 54 in 2016 exhibit falling manufacturing employment shares over time. We provide evidence below (in Section 2.5) that these declines are driven in part by simultaneous reductions in manufacturing employment and increases in non-manufacturing employment. We interpret this trend as capturing within-manufacturing-

period. The remainder is due to net entry.

[16]During a January 3, 2019 visit to Boeing's propulsion plant in South Carolina, Charlie Hix, the plant manager, told the authors (Fort and Schott) that Boeing recently decided to bring nacelle production back within the boundaries of the firm because, after developing a nacelle jointly with an arm's-length contractor, Boeing observed a similar nacelle being used by Airbus.

firm pivoting towards services that contributes to both functional and sectoral structural change. Apple's trajectory, for example, highlights functional structural change. Founded in 1977, it operated several manufacturing facilities in the United States, Ireland and Singapore until the mid 1990s, at which point it began selling them to contract manufacturers and outsourcing production (Prince and Plank (2012)). It shuttered its last US manufacturing plant in 2004, and since then has focused on the design and distribution of consumer electronics devices rather than their physical assembly. IBM's evolution, by contrast, suggests sectoral structural change. It transitioned from a producer of mainframe and then personal computers to a purveyor of productivity software and consulting services, building on – and extending – the technical capabilities and customer base it had developed as a hardware manufacturer.

The growth of MPRO employment within manufacturing firms depicted in Figure 5 may provide an explanation for the divergence of real and nominal manufacturing value added since 1977, displayed as shares of nominal and real GDP in Figure 6. While the nominal share declines steadily, the real share is more-or-less constant, indicating a relative decline in manufacturing prices. As discussed in detail in Houseman, Bartik, and Sturgeon (2018), the relative increase in real manufacturing value added is driven almost exclusive by rising product quality in just two industries: Semiconductors (NAICS 334413) and Electronic Computer Manufacturing (NAICS 334111). It's possible that that this growth is the result of greater contributions from MPRO workers. Moreover, to the extent that expertise MPRO skill is built up via high fixed costs – e.g., adding an in-house oriented MPRO establishment – these contributions may manifest as higher variable markups (e.g., De Loecker and Eeckhout (2017)), especially if these innovation-related workers are not included in the production functions from which these markups are estimated. The rise of MPRO workers may also be influential in other industries, e.g., the rising concentration among US wholesalers documented in Ganapati et al. (2016)).

We find that possession of an MPRO establishment is correlated with firm size and survival. Each column in Table 1 reports the results of a separate cross-sectional OLS regression of a firm attribute on a dummy variable indicating whether the firm contains an MPRO establishment. Data are for 1997, and firms are identified in terms of their Census firmids for the reasons noted in Section 2.5. The top panel of Table 1 includes only the indicator variable just noted. The bottom panel includes this indicator variable as well as its interaction with another indicator, "in-house", for whether the MPRO establishment primarily serves its own firm.

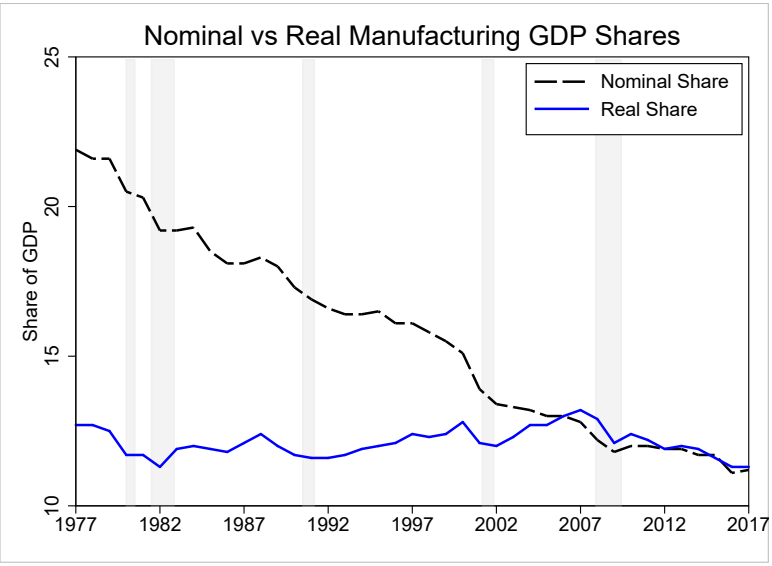
We focus on results in the second panel. The first column of this panel reveals that firms whose MPRO establishments are primarily oriented in-house are larger by 0.89 log points compared to firms where that is not the case. The linear probability models in the second and third columns of this panel reveal that firms with in-house MPRO establishments also are about 4 percent more likely to survive until 2016 compared to firms with MPRO establishments that are not in-house oriented. These columns control for firm employment (coefficient estimates not shown) and use two different definitions of survival: in terms of the firm's Census firmid persisting until that year (column 2,) or as part of an indirectly linked (IL) legacy

Table 1: Correlates of Having an MPRO Establishment in 1997

	Panel A				
	ln(Emp)	**Persistent**	**Legacy**	**Sectors**	**Sectors**
MPRO	4.371	0.040	0.368	0.869	0.785
	0.009	0.002	0.002	0.001	0.004
Obs (Mill)	4.74	4.74	4.74	4.74	0.30
Sample	All	All	All	All	Manufacturers
	Panel B				
	ln(Emp)	**Persistent**	**Legacy**	**Sectors**	**Sectors**
MPRO	3.851	0.013	0.343	0.703	0.331
	0.011	0.002	0.003	0.001	0.005
MPRO x In-house	0.888	0.046	0.043	0.287	0.831
	0.011	0.002	0.003	0.001	0.006
Obs (Mill)	4.74	4.74	4.74	4.74	0.30
Sample	All	All	All	All	Manufacturers

Source: Longitudinal Business Database and authors' calculations. Table reports a series of firm-level OLS regressions of 1997 firm attributes on a dummy variable indicating whether the firm has a Management or Professional Services (i.e., "MPRO") establishment. Bottom panel includes an additional covariate, In-house, an indicator for whether any of the firms' MPRO establishment primarily provide services for the firm, as opposed to outside customers. Dependent variables are log firm employment, an indicator for whether the firmid persists over the entire 1977 to 2016 sample period, whether the firm is a legacy, the number of sectors in which the firm produces. Final column in both panels is restricted to manuafacturing firms. All regressions except for those in the first column of each panel also include log employment. All regressions include a series of covariates indicating the share of firm employment in each two-digit NAICS sector. Standard errors are noted below coefficients. Observations are rounded for disclosure avoidance.

Figure 6: US Manufacturing and Service Employment, 1977-2012



Source: Longitudinal Business Database, US Bureau of Economic Analysis and authors' calculations. Figure displays manufacturing employment as a share of total employment, as well as manufacturing GDP as a share of overall GDP, in both real and nominal terms.

firm (column 3).[17] The final two columns in the last panel of Table 1 examine the diversification of all firms (column 4) and manufacturing firms in particular (column 5). For the former, having an in-house MPRO establishment is associated with production of 0.3 additional two-digit NAICS sectors. For manufacturers, the magnitude is is larger, at 0.8 additional two-digit NAICS sectors.[18]

We assess the relationship between in-house use of MPRO services and the likelihood that manufacturing firms further diversify into additional two-digit NAICS sectors in Table 2. This table report results from a series of linear probability models estimating whether firms with manufacturing establishments in 1997 have a new establishment by 2007 in Wholesale (NAICS 42), Retail (NAICS 44-5), Transportation and Warehousing (NAICS 48-9), Educational Services or Healthcare (NAICS 61-2), and Arts, Entertainment, and Recreation or Accommodation and Food Services (NAICS 71-2). All regressions include controls for the log of firm employment in 1997, and for firms' share of employment across broad, two-digit sectors in 1997. We focus here, too, on the in-house indicator, which is positive for firms with an MPRO establishment that primarily serve other establishments of the firm.

Results indicate that firms with in-house MPRO establishments are more likely to open new plants outside of manufacturing, and that this relationship is strongest for further diversification into wholesale,

[17] As discussed in detail in Section 2.1.2, surviving as an indirect legacy means that at least one of the plants in the firmid in 1997 is alive in both 1977 and 2016, or that it is was and will be associated with such plants at some point, up to any degree of separation.

[18] These two regressions also control for firm employment (coefficient estimates not shown). We do not log the dependent variables in the final two columns in order to include zeros. Results are quantitatively similar if the zeros are dropped and the dependent variable is logged.

Table 2: Probability that Manufacturing Firms Expand into Non-Manufacturing Sectors

	Wholesale	Retail	Transportation & Warehousing	Health & Education	Accomodation & Food Services
MPRO	0.134***	0.027***	0.048***	0.005***	0.010***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
MPRO x In-house	0.047***	0.056***	0.079***	0.011***	0.019***
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)
Adj. R-Squared	0.06	0.02	0.07	0.01	0.01
Obs (Thous)	298	298	298	298	298

Source: Longitudinal Business Database and authors' calculations. Table reports a series of firm-level linear probability regressions of the probability that firms with Manufacturing employment in 1997 will open an establishment in the sector indicated in the column header on a dummy variable indicating whether the firm has a Management or Professional Services (i.e., "MPRO") establishment, and an indicator for whether any of the firms' MPRO establishment primarily provide services Inhouse for the firm, as opposed to outside customers. All regressionsinclude log employment in 1997 as an additional control, as well as a series of covariates indicating the share of firm employment in each two-digit NAICS sector. Standard errors are noted below coefficients. Observations are rounded for disclosure avoidance.

retail, and transportation and warehousing. Having an MPRO establishment that is primarily engaged in support services for the firm is associated with 4.7 percentage point increase in the probability of opening a new wholesale establishment, a 5.6 point increase in the probability of opening retail establishment, and a 7.9 point increase in the probability of a new transportation and warehousing establishment. We view these results as broadly consistent with the premise that in-house MPRO establishments facilitate within-firm structural change across sectors, though we acknowledge that they do not provide causal evidence of this relationship. Further work is needed to identify an exogenous change in firms' MPRO establishments, and in particular on their use of these establishments for in-house activities.

2.5 Quantifying Within-Firm Structural Change

Results in previous sections suggest manufacturing firms may pivot towards services, either to enhance the products they already make or to broaden their product range. In this section, we examine the extent to which declines in manufacturing employment and increases in non-manufacturing employment occur *within the same firm.* To be conservative we use the most restrictive definition of firm available, Census firmids.[19] We define manufacturing firms to be Census firmids that contain a manufacturing establishment during at least one year between 1977 to 2016. The nine cells in each panel of Table 3 report changes across firms taking one of three actions each with respect to their manufacturing (M) and non-manufacturing (NM) employment between 1977 and 2016: decrease it, leave it unchanged, or increase it. The top panel reports changes in M employment, while the bottom panel focuses on changes in NM employment.

[19] As discussed in Section 2.1.2, this definition uses the longitudinal firmids constructed by the Census Bureau. It is conservative because these firmids might break do to changes in ownership that do not alter fundamental attributes of the firm, and because they incorporate less merger and acquisition activity than might be warranted for studying pivoting.

Table 3: Employment Growth Among Continuing Manufacturers

Continuing M Firms
M Employment Change

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	-2.7	-0.2	-1.4	-4.3
$\Delta Emp^{M} = 0$	0.0	0.0	0.0	0.0
$\Delta Emp^{M} > 0$	0.3	0.4	1.6	2.3
Total	-2.4	0.2	0.2	-2.0

Continuing M Firms
NM Employment Change

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	-1.7	0.0	3.3	1.6
$\Delta Emp^{M} = 0$	-0.3	0.0	3.4	3.1
$\Delta Emp^{M} > 0$	-0.3	0.0	5.7	5.4
Total	-2.3	0.0	12.4	10.1

Source: Longitudinal Business Database and authors' calculations. Table reports the change in manufacturing (M) and non-manufacturing (NM) employment, in millions of workers, across manufacturing firms that survive (i.e., continue) from 1977 to 2016 and engage in one of nine mutually exclusive activities: dropping, maintaining or increasing their M employment (i.e., $\Delta Emp^{M} < 0$, $\Delta Emp^{M} = 0$, and $\Delta Emp^{M} > 0$), and dropping, maintaining and increasing their NM employment (i.e., $\Delta Emp^{NM} < 0$, $\Delta Emp^{NM} = 0$, and $\Delta Emp^{NM} > 0$). Top panel reports changes in M employment while bottom panel reports changes in NM employment. Firms are defined according to Census firmids, as outlined in Section 2.1.2. Manufacturing firms are defined as firms that have manufacturing employment in at least one year of the 1977 to 2016 sample period.

As indicated in the top panel, continuing M firms drop 2 million manufacturing workers between 1977 and 2016, which is 30 percent of the aggregate decline in M over that period.[20] The subset of continuing M firms that shrink their M employment (top panel, first row), however, lose 4.3 million manufacturing workers, representing 80 percent of their initial, 1977 M employment of 5.6 million (not shown in table). This large decline is offset by the 2.3 million increase in M employment among continuing M firms that add M employment.

The bottom panel of Table 3 reveals that although continuing M firms experience significant M employment declines, they add 10 million NM workers, or 16 percent of the aggregate growth in US NM employment over this period. This panel highlights two forms of M firms pivoting towards services. First, there is the "extreme" pivoting by the subset of continuing M firms that drop M workers while adding NM employment. These firms increase NM employment by 1.6 million. Second, there is the milder pivoting of continuing M firms that weakly increase both forms of employment, but add considerably more NM workers than M workers, 8.5 million versus 2.3 million.[21]

Tables A.1 and A.2 in the online appendix display similar information for M firm births and deaths, and for NM firms. M firm births and deaths account for the loss of more than twice as many M workers as continuing M firms, -4.5 million versus -2 million, and far less growth among NM workers, 0.7 versus 10.1 million. The message of Table A.1 is that adding NM workers by M firms is primarily accomplished by continuing M firms rather than net M firm birth. Continuing NM firms (Table A.2) grow their NM employment by 12 million, surprisingly similar in levels to the overall NM employment growth observed for continuing M firms. The bulk of NM employment growth, 76 percent, however, is due to net NM firm birth.

We use the information in Tables 3, A.1, and A.2, and analogous, unreported tables for payroll[22], to provide a simple decomposition of US structural change in employment and payroll terms. These decompositions are reported in the two panels of Table 4. The first and last rows of each panel report M, NM and total employment and payroll in 1977 and 2016, as well as manufacturing's share of total employment and payroll in those years. The remaining rows of each panel decompose the cumulative changes in M and NM employment and payroll by type of firm and margin of adjustment.

As indicated in the top panel, the M share of total employment fell from 27 to 9 percent between 1977

[20] Fort, Pierce, and Schott (2018) find that 75 percent of the net decline in US manufacturing employment from 1977 to 2012 occurs within continuing firms, as they shed 6 million manufacturing workers while adding 10 million non-manufacturing workers, with one-third of the latter in Business Services (NAICS 5). Although the time period examined here is longer, the main reason for the difference in the intensive margin share of the manufacturing worker decline (75 versus 30 percent) is our use of a far more restrictive definition of a firm, i.e., Census' longitudinal firmids versus their DL firms. As discussed in the previous paragraph and in more detail in Section 2.1.2, Census's longitudinal firmids break for a number of reasons orthogonal to our research interest, thereby understating the extent of within-firm structural change to a substantial degree. We use them here, however, because the broader DL and IL definitions of a firm are not as amenable to examining outcomes within firms over time.

[21] Row 2 of the bottom panel of Table 3 includes firms that have no M employment in either 1977 or 2016, but do have M employment for at least one year in between.

[22] Table A.3 in the online appendix reports the changes in M and NM payroll across continuing M firms that engage in the nine activities discussed above. Analogous tables for M firm entrants and exiters,and NM firms, are available upon request.

Table 4: Decomposition of US Structural Change (preliminary)

	Employment			
	M Emp	NM Emp	Total	M Share
1977 Employment	17.9	49.2	67.1	0.27
+ Changes in Continuing M Firms	15.9	59.3	75.2	0.21
+ Changes in M Firm Birth/Death	11.4	60.0	71.4	0.16
+ Changes in Continuing NM Firms	11.4	72.7	84.1	0.14
+ Changes in NM Firm Birth/Death	11.4	112.8	124.2	0.09
2016 Employment	11.4	112.8	124.2	0.09

	Payroll			
	M Pay	NM Pay	Total	M Share
1977 Payroll	0.23	0.51	0.75	0.31
+ Changes in Continuing M Firms	0.42	1.39	1.82	0.23
+ Changes in M Firm Birth/Death	0.65	1.82	2.47	0.26
+ Changes in Continuing NM Firms	0.65	2.75	3.41	0.19
+ Changes in NM Firm Birth/Death	0.65	5.54	6.19	0.11
2016 Payroll	0.65	5.54	6.19	0.11

Source: Longitudinal Business Database and authors' calculations. The first and last rows of each panel report US manufacturing (column 1), non-manufacturing (column 2) and total (column 3) employment or (nominal) payroll in 1977 and 2016, as well as the manufacturing share of total employment or payroll (column 4) in each year. Remaining rows decompose the change in each type of employment or payroll, as well as the manufacturing share, according to whether they are due to continuing M and NM firms (rows 2 and 4) or as a result of M and NM firm birth and death (rows 3 and 5). Manufacturing firms are defined as firms that have manufacturing employment in at least one year of the 1977 to 2016 sample period. Firms are defined according to Census firmids, as described in Section 2.1.2.

and 2016. Thirty-two percent of that decline (i.e., 6/18) is driven by continuing M firms that shed 2 million M workers while adding 10 million workers outside manufacturing (row 2). An additional 14 percent of that decline (2/18) is due to continuing NM firms, who add 13 million workers (row 4). Thus, in total, 44 percent of the US shift from manufacturing to services employment from 1977 to 2016 takes place within firms engaged in the extreme and milder forms of pivoting described above. The remaining adjustment is due to M and NM firm birth and death, which account for 30 and 25 percent of the overall shift towards services, respectively.

Expressed in terms of payroll, the share of structural change occurring within continuing M firms is larger, at 39 percent (8/20) in the bottom panel of Table 4 versus 32 percent in the upper panel. Continuing NM firms make a larger contribution, at 35 (7/20) versus 14 percent in the top panel. Combined, continuing firms account for 67 percent of the shift towards services when expressed in terms of payroll.

3 Legacies and Superstars

Results thus far indicate that firms that survive from 1977 to 2016 play an important role in US structural transformation from manufacturing to services. At the same time, recent research at the intersection of industrial organization, labor and macroeconomics has called attention to the potentially growing influence of old, large (i.e., "superstar") firms (Decker, Haltiwanger, Jarmin, and Miranda (2014)) and the role they might play in rising markups (De Loecker and Eeckhout (2017)). declining job reallocation rates (Decker, Haltiwanger, Jarmin, and Miranda (2016)), falling start-up rates (Pugsley and Sahin (2019)) and decreasing labor share of GDP (Autor, Dorn, Katz, Patterson, and Reenan (2017)).

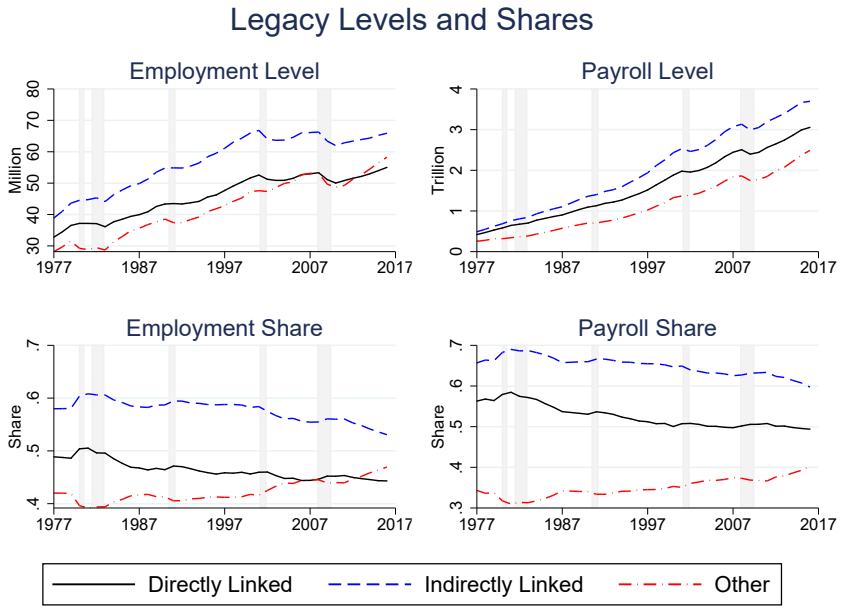
Given these trends, in this section we examine the dominance of firms which span the 1977 to 2016 sample period. To account for the possibility that intangible capital built up in long-lived establishments might be passed on to firms which acquire them, we consider two types of "long-lived" firms, both of which are broader than the longitudinal firmids provided by Census. First, we identify "directly linked" (DL) long-lived firms in year t as Census firmids that contain an establishment that survives from 1977 to 2016. Second, we define "indirectly linked" (IL) long-lived firms in year t as the even broader set of Census firmids in that year that include at least one plant that is ever associated (from 1977 to 2016) within a Census firmid with plants that were alive in b and will be alive in e, up to any degree of separation. IL long-lived firms capture the idea that intangible capital might be given to firms in chains as establishments are passed around via mergers and acquisitions. Note that all DL firms are also IL, that the number of DL firms in a given year weakly exceeds the number of Census firmids, and that the number of IL firms in a given year weakly exceeds the number of DL firms.[23] Firms that are not IL fall into two groups: those that are born after 1977 and die before 2016, and those that are born after 1977 but survive until 2016.

Figure 7 plots the overall employment (top panel) and payroll (bottom panel) of DL, IL and other . This figure displays three noteworthy trends. First, as expected, the share of employment and payroll accounted

[23] We provide a more complete discussion of these two conceptualizations of firms in online appendix Section A.

for by IL firms is larger than that due to DL firms. Second, the share of employment accounted for by DL and IL firms is smaller than the share of payroll accounted for by these firms, indicating that long-lived firms pay relatively higher wages than other firms. Third, the share of overall US employment and payroll contained in these firms is declining over time.

Figure 7: Legacy Firms' Employment and Payroll over Time



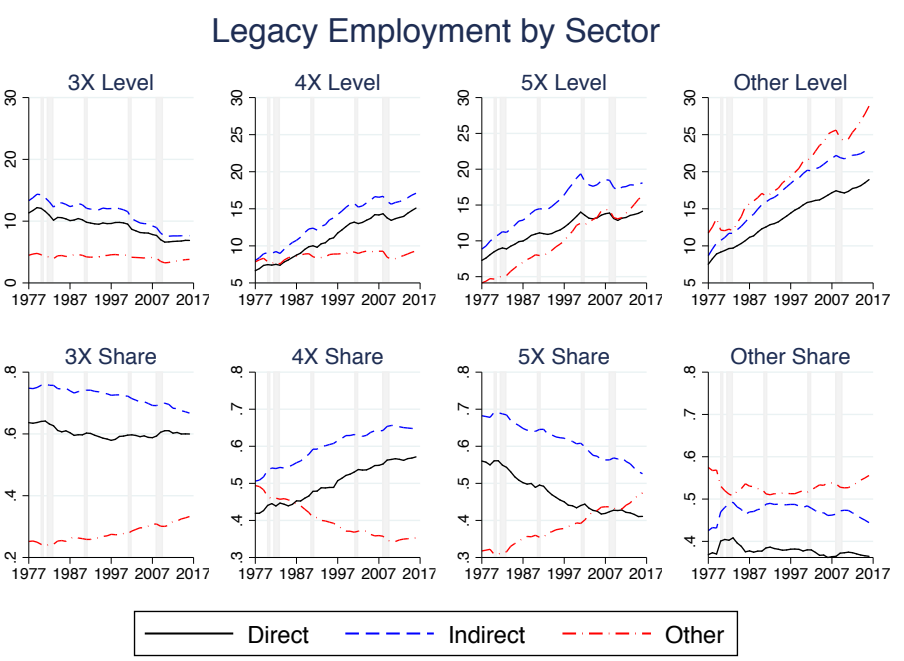
Source: Longitudinal Business Database and authors' calculations. Panels report the total employment and employment share (left panels) and total payroll and payroll share (right panels) of direclty and indirectly linked legacy firms from 1977 to 2016. A firm in year t is a directly linked long-lived firm if it encompasses a plant that survives from 1977 to 2016. A firm in year t is an indirectly linked long-lived firm if it includes a plant that is ever associated within a firm with plants that are present in 1977 and 2016, up to any degree of separation. These definitions are nested, as all directly linked plants are indirectly linked.

The latter trend, however, is not true across all sectors of employment and payroll. Figure 8 and 9 provide similar information, but across broad sectors: Manufacturing (NAICS3), Wholesale, Retail, Transportation and Warehousing (NAICS 4), Business Services (NAICS 5) and everything else. The relative growth of long-lived firms in NAICS 4 stands out.

4 Model

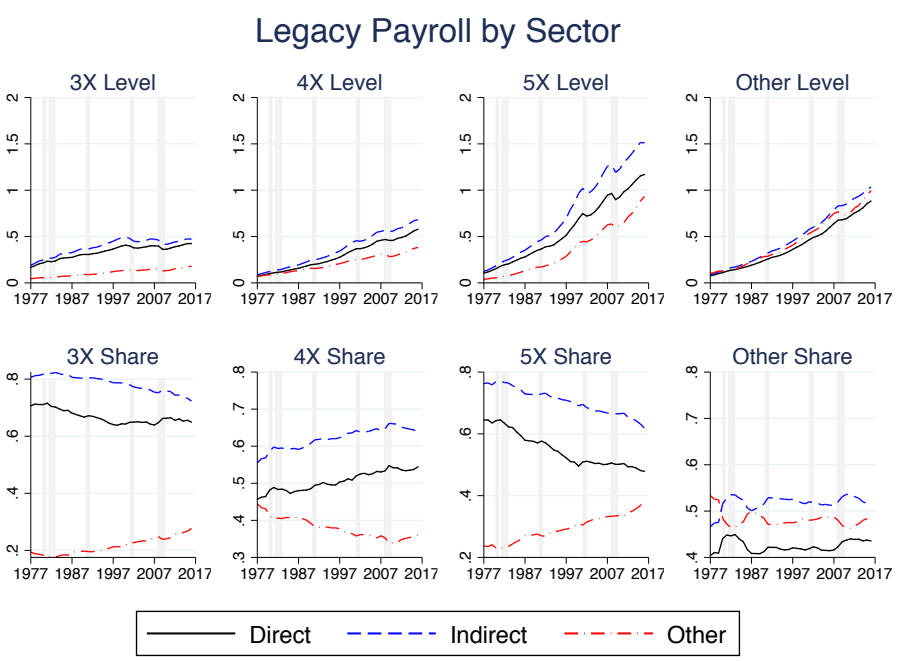
The facts presented in the previous section highlight the reallocation of economic activity from manufacturing to services, the growing importance of managerial and professional (MPRO) services within the service sector, heterogeneity between firms that operate MPRO establishments and those that do not, and the substantial role played by within-firm reallocations of economic activity from manufacturing to services.

Figure 8: Legacy Firms' Employment by Sector



Longitudinal Business Database and authors' calculations. Panels report the total employment (top panels) and employment shares (bottom panels) of direclty and indirectly linked legacy firms from 1977 to 2016, by sector. A firm in year t is a directly linked long-lived firm if it encompasses a plant that survives from 1977 to 2016. A firm in year t is an indirectly linked long-lived firm if it includes a plant that is ever associated within a firm with plants that are present in 1977 and 2016, up to any degree of separation. These definitions are nested, as all directly linked plants are indirectly linked.

Figure 9: Legacy Firms' Employment by Sector



Source: Longitudinal Business Database and authors' calculations. Panels report the total payroll (top panels) and payroll shares (bottom panels) of direclty and indirectly linked legacy firms from 1977 to 2016, by sector. A firm in year t is a directly linked legacy firm if it encompasses a plant that survives from 1977 2016. A firm in year t is an indirectly linked legacy firm if it includes a plant in year t that has ever (i.e., from 1977 to 2016), been associated with a plant that is alive in 1977 as well as a plant that is alive in 2016, up to any degree of separation. These definitions are nested, as all directly linked plants are indirectly linked.

In this section, we outline a theoretical framework to interpret these facts and derive additional empirical predictions that we examine below. The model allows firms to operate across multiple final demand sectors (including manufacturing and services). Within each sector, output is generated by the performance of professional services and production services, which are complements to one another. Each firm can either outsource professional services to a standalone supplier or undertake them in-house by incurring an additional fixed cost. Each firm also chooses how much to invest in the accumulation of intangible knowledge. We assume that these intangible knowledge investments are only excludable if all economic activity (including professional services) is undertaken within the boundaries of the firm, so that only firms that incur the fixed cost of in-house MPRO activities accumulate intangible knowledge that gives them an advantage relative to other firms.

The key predictions of the theoretical model are as follows. First, there is self-selection of more productive firms into performing professional services in-house, because of the fixed costs to undertaking these activities within the boundaries of the firm. Second, firms that undertake professional services in-house invest in the accumulation of intangible knowledge capital that increases the number of final demand sectors in which the firm operates. Third, structural change occurs through reallocations of economic activity between final demand sectors and also through reallocations of resources between production and professional services within sectors. Fourth, each of these dimensions of structural change occurs both between and within firms. Fifth, increases in productivity and reductions in trade costs induce reallocations of economic activity away from production services and towards professional services.

4.1 Preferences

We consider a world of N countries indexed by $n, i \in N$.[24] The representative consumer's preferences in country n are defined over consumption indexes (C_{nj}) of a set of final demand sectors indexed by $j \in J$:

$$U_n = \left[\sum_{j \in J} \left(\frac{C_{nj}}{\eta_{nj}^U} \right)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}, \tag{1}$$

where ν is the elasticity of substitution across sectors and η_{nj}^U captures the representative consumer's relative preferences across sectors. The consumption index for each sector j in destination country n (C_{nj}) is defined over consumption (c_{njf}) of horizontally-differentiated varieties supplied by a firms $f \in F_{ij}$ from each origin country i:

$$C_{nj} = \left[\sum_{i \in N} \sum_{f \in F_{ij}} c_{nijf}^{\frac{\sigma_j - 1}{\sigma_j}} \right]^{\frac{\sigma_j}{\sigma_j - 1}}, \tag{2}$$

where σ_j is the elasticity of substitution across varieties within sectors. Given this nested constant elasticity of substitution (CES) demand structure, sales for firm f from origin country i in destination country n and

[24] To simplify the exposition, we typically use n to indicate countries of consumption (destinations) and i to denote countries of production (origins), except where otherwise indicated.

in sector j (x_{nijf}) are:

$$x_{nijf} = p_{nijf}^{1-\sigma_j} X_{nj} P_{nj}^{\sigma_j - 1}, \tag{3}$$

where X_{nj} is expenditure on sector j in destination country n; P_{nj} is the price index for sector j in destination country n (dual to equation (2)). Total firm sales (x_{if}) are the sum of sales across all sectors within each destination country and across all destination countries served by the firm:

$$x_{if} = \sum_{n \in N_{if}} \sum_{j \in J_{nif}} x_{nijf} = \sum_{n \in N_{if}} \sum_{j \in J_{nif}} p_{nijf}^{1-\sigma_j} X_{nj} P_{nj}^{\sigma_j - 1}, \tag{4}$$

where N_{if} is the set of destination countries served by firm f from origin country i and J_{nif} denotes the set of sectors in which firm f from origin country i serves destination country n.

4.2 Final Goods Production

Each country i is endowed with inelastic supplies of production workers ($\bar{L}_i^P$) and professional service or non-production workers ($\bar{L}_i^S$). In order to enter, a final goods firm must incur an upfront entry cost of f_e units of professional service workers. Incurring this sunk entry cost creates a horizontally-differentiated brand, which can be used to supply one variety in each sector, and reveals the firm's productivities in each sector (φ_{fj}). If the firm chooses to serve a country n in sector j, it must incur an additional fixed market entry cost of F_{nj}^N units of professional service workers for that country and sector. After incurring this additional market entry cost, the firm can supply its variety in sector j to country n at a constant unit cost that depends on its productivity in that sector (φ_{fj}). Additionally, the firm faces iceberg variable trade costs, such that $\tau_{nij} \geq 1$ units of a variety must be shipped from origin country i in sector j in order for one unit to arrive in destination country n, where $\tau_{nij} > 1$ for $n \neq i$ and $\tau_{nnj} = 1$.

Unit costs for firm f in sector j in origin country i depend on the cost of performing professional services (e.g. marketing, advertising, managing, accounting) and production services (e.g. assembling, machining, stamping). We assume that professional and production services are combined according to the following CES unit cost function:

$$\frac{1}{\theta_f}\gamma_{ifj} = \frac{1}{\theta_f}\left[\left(q_{if}^S\right)^{1-\mu_j} + \left(\frac{\left(w_i^P\right)^{\beta_j}\left(Q_{ij}\right)^{1-\beta_j}}{\varphi_{fj}}\right)^{1-\mu_j}\right]^{\frac{1}{1-\mu_j}}, \qquad \begin{matrix} 0 < \mu_j < 1 \\ 0 < \beta_j < 1 \end{matrix}, \tag{5}$$

where $\theta_f \geq 1$ is a Hicks-neutral productivity shifter that depends on firm investments in intangible knowledge; q_{if}^S is the cost of professional services; w_i^P is the wage of production workers; Q_{ij} is the cost of intermediate inputs in sector j in country i; μ_j is the elasticity of substitution between professional and production services in sector j; and β_j controls the intensity with which production in sector j involves the use of production workers and intermediate inputs.

We model intermediate inputs using roundabout production, in which each sector uses all sectors as intermediate inputs with the same elasticity of substitution between sectors as for final demand. The

cost of intermediate inputs for each sector (Q_{ij}) takes the same form as the price index dual to the utility function (1):

$$Q_{ij} = \left[\sum_{k \in J} \left(\frac{P_{ik}}{\eta^P_{ijk}} \right)^{1-\nu} \right]^{\frac{1}{1-\nu}}, \tag{6}$$

where η^P_{ijk} controls the relative intensity with which each sector k is used as an input for sector j, which can differ from the relative preferences for each sector k in consumption ($\eta^U_{nk} \neq \eta^P_{ijk}$).

Two aspects of this production technology are worthy of remark. First, we assume that professional services and production services are complements ($0 < \mu_j < 1$), which is in line with the assumption in the macroeconomics literature of that services and goods are complements, although here we make the assumption about the production technology rather than final demand. Second, we assume that the cost of professional services for each firm is the same across all sectors in which it operates ($q^S_{ifj} = q^S_{if}$ for all j), although we show below that the relative shares of professional and production services in unit cost vary across sectors with the firm's productivity in each sector (φ_{fj}). We now turn to examine the determination of this cost of professional services (q^S_{if}).

4.3 Professional Services

Each final goods firm faces the choice between outsourcing professional services to a standalone supplier or incurring a fixed cost of F^S units of professional service workers to undertake them in-house. Each firm also chooses how much to invest in intangible knowledge capital accumulation to reduce unit costs. We assume that a firm can obtain a stock of $\theta_f > 1$ of intangible knowledge capital by employing $\psi \left(\theta_f^{\zeta} - 1 \right)$ professional service workers in research.[25] The parameter ψ governs the productivity of these investments, while the parameter ζ controls the convexity of research costs with respect to these investments. We assume that investments in intangible knowledge capital are only excludable if all economic activity (including professional services) is undertaken within the boundaries of the firm.[26] Therefore, if a final goods firm incurs the fixed cost of vertically integrating professional services in-house, only it retains access to its intangible knowledge. In contrast, if the final goods firm outsources professional services to a standalone supplier, its intangible knowledge diffuses freely to all firms in the economy.

Under these assumptions, the vertical integration and intangible investment decisions become closely connected to one another. If a firm incurs the fixed cost of vertically integrating professional services in-house and invests in intangible knowledge capital, its exclusive access to this intangible knowledge raises its share of revenue within each sector. In contrast, if a firm outsources professional services, any investment in intangible knowledge capital diffuses freely to all firms, and leaves the firm's share of revenue

[25] This formulation of research costs ensures that a firm that makes no investment in intangible knowledge ($\theta_f = 1$) incurs zero cost since $\psi \left(1^{\zeta} - 1 \right) = 0$.

[26] For a discussion of the broader literature on knowledge-based approaches to the boundaries of the firm, see Demsetz (1988).

within each sector unchanged. Assuming that each firm is sufficiently small that its investments in intangible knowledge have a negligible effect on the sector price index and total sector expenditure, it follows that no firm that outsources professional services has any incentive to undertake costly investments in intangible knowledge capital ($\theta_f = 1$). In contrast, firms that vertically integrate professional services in-house in general undertake positive investments in intangible knowledge capital ($\theta_f > 1$), as determined further below.

We assume that professional services are produced using professional service workers according to the following unit cost function:

$$\delta_{if}^S = w_i^S, \tag{7}$$

where δ_{if}^S denotes the unit cost of professional services for firm f in origin country i.

We assume that this production technology for professional services is freely available to all firms. If professional services are outsourced, they are produced by a standalone supplier using this technology under conditions of perfect competition. Therefore, zero profits implies that the price of professional services equals unit cost, which is equal to the wage of professional service workers (w_i^S). If professional services are vertically integrated in-house, they are produced by the final goods firm using this same technology, which implies that unit cost is again equal to the wage of professional service workers (w_i^S). Therefore, in either case, the final goods firm's unit cost function (5) can be re-written as follows:

$$\frac{1}{\theta_f}\gamma_{ifj} = \frac{1}{\theta_f}\left[\left(w_i^S\right)^{1-\mu_j} + \left(\frac{\left(w_i^P\right)^{\beta_j}\left(Q_{ij}^P\right)^{1-\beta_j}}{\varphi_{fj}}\right)^{1-\mu_j}\right]^{\frac{1}{1-\mu_j}}. \tag{8}$$

Under our assumptions, there are only two differences between vertical integration and outsourcing. First, vertical integration requires an additional fixed cost (F^S) to be incurred. Second, only final goods firms that vertically integrate professional services have an incentive to invest in intangible knowledge ($\theta_f > 1$). In contrast, final goods firms that outsource professional services make zero investments in intangible knowledge ($\theta_f = 1$).

4.4 Firm Problem

We assume that final goods firms compete under conditions of monopolistic competition within each sector. Each firm chooses the number of countries to serve, the number of sectors in which to serve each country, whether to outsource professional services or undertake them in-house, its investment in intangible knowledge capital, the price to charge for each variety, and inputs of professional services, production workers and intermediate inputs to maximize its profits. Using the unit cost function (8), the

firm problem can be written as follows:

$$\max_{\left\{\{p_{nijf}\},N_{if},J_{nif},\mathbb{I}^S_{if},\theta_f\right\}} \left\{ \begin{array}{l} \sum\limits_{n\in N_{if}} \sum\limits_{j\in J_{nif}} p_{nijf} y_{nijf}\left(p_{nijf}\right) - \frac{1}{\theta_f}\gamma_{ifj} y_{nijf}\left(p_{nijf}\right) \\ - \sum\limits_{n\in N_{if}} \sum\limits_{j\in J_{nif}} w_i^S F_{nj}^N - \mathbb{I}^S_{if} w_i^S F^S - w_i^S \psi\left(\theta_f^{\zeta} - 1\right) \end{array} \right\}, \tag{9}$$

where $y_{nijf}\left(p_{nijf}\right)$ is output of firm f from origin country i in each sector j and destination country n, which is a function of the price chosen for its variety (p_{nijf}; and $\mathbb{I}^S_{if}$ is an indicator variable that equals one if firm f in origin country i chooses to undertake professional services in-house and zero otherwise.

We characterize the solution to the firm's problem as follows. First, we solve for the equilibrium price for the firm's variety in each country and sector conditional on its choice of the sets of countries and sectors to serve, its decision whether to organize professional services in-house, and its investment in intangible knowledge. Second, we determine a firm's usage of factor inputs conditional on its market entry, vertical integration and intangible investment decisions. Third, we characterize the firm's choice of the set of countries and sectors to serve conditional on its vertical integration and intangible investment decisions. Fourth, we analyze the firm's vertical integration and intangible investment decisions.

4.5 Equilibrium Prices

Beginning with the equilibrium pricing rule, profit maximization under CES demand and monopolistic competition implies that the equilibrium price for each firm variety is a markup over marginal cost:

$$p_{nijf} = \frac{\sigma_j}{\sigma_j - 1}\tau_{nij}\frac{1}{\theta_f}\gamma_{ifj}, \tag{10}$$

where the markup depends on the constant elasticity of substitution (σ_j); and marginal costs include both the unit production cost (γ_{ifj}/θ_f) and the iceberg variable trade cost (τ_{nij}).

Using this equilibrium pricing rule in the revenue function (3), firm revenue in a given sector and market is a power function of firm unit costs:

$$x_{nijf} = \left(\frac{\sigma_j}{\sigma_j - 1}\tau_{nij}\frac{1}{\theta_f}\gamma_{ifj}\right)^{1-\sigma_j} X_{nj} P_{nj}^{\sigma_j - 1}. \tag{11}$$

Therefore, the relative revenues of any two firms within the same sector and destination market depend solely on their relative unit costs:

$$\frac{x_{nfj}}{x_{n\ell j}} = \left(\frac{\gamma_{ifj}/\theta_f}{\gamma_{i\ell j}/\theta_\ell}\right)^{1-\sigma_j}. \tag{12}$$

From equation (11), although we have interpreted intangible knowledge investments as reducing unit costs, an isomorphic interpretation for equilibrium firm revenue is that they increase product quality.

4.6 Final Goods Costs

Turning now to the firm's optimal choice of factor inputs, we establish a number of predictions that we provide empirical evidence on below. Using cost minimization, the share of professional services in the

unit costs of final goods firm f in origin country i in sector j (ξ^S_{ifj}) depends on the prices of professional service and production workers in that country (w^S_i, w^P_i), the cost of intermediate inputs in that sector and country (Q_{ij}), and firm productivity (φ_{fj}):

$$\xi^S_{ifj} = \frac{\left(w^S_i\right)^{1-\mu_j}}{\left(w^S_i\right)^{1-\mu_j} + \left(\frac{\left(w^P_i\right)^{\beta_j}\left(Q_{ij}\right)^{1-\beta_j}}{\varphi_{fj}}\right)^{1-\mu_j}}. \tag{13}$$

We now establish some properties of this final goods cost share with respect to shocks to technology and international trade. Totally differentiating this cost share (13), the log change in the share of professional services in firm costs can be linearly decomposed into log changes in factor prices and log changes in productivity:

$$\mathrm{d}\ln \xi^S_{ifj} = \left(1-\mu_j\right)\left(1-\xi^S_{ifj}\right)\left[\ \mathrm{d}\ln w^S_i - \beta_j \mathrm{d}\ln w^P_i - \left(1-\beta_j\right)\mathrm{d}\ln Q_{ij} + \mathrm{d}\ln \varphi_{fj}\ \right]. \tag{14}$$

Using our assumption that professional services and production services are complements ($0 < \mu_j < 1$), and holding constant factor prices ($\mathrm{d}\ln w^S_i = 0$ and $\mathrm{d}\ln w^P_i = 0$), equation (14) implies that both productivity growth ($\mathrm{d}\ln \varphi_{fj} > 0$) and lower prices of intermediate inputs as a result of lower trade costs ($\mathrm{d}\ln Q_{ij} < 0$) induce structural transformation in the form of a higher share of professional services in unit costs ($\mathrm{d}\ln \xi^S_{ifj} > 0$).[27] The mechanism underlying this structural transformation is the same as that in the macroeconomics literature emphasizing unbalanced productivity growth and complementary demand following Baumol (1965). Whereas the structural transformation in the macroeconomics literature occurs between final demand sectors, here it occurs between functions (professional versus production services) within firms and sectors, in line with our stylized facts above.

We now connect this result for the share of professional services in overall firm unit costs to the share of professional services in labor costs and employment, which are more readily observable in the data. We start with the share of professional services in labor costs:

$$\vartheta^S_{ifj} = \frac{w^S_i L^S_{ifj}}{w^S_i L^S_{ifj} + w^P_i L^P_{ifj}}. \tag{15}$$

Totally differentiating this share of professional services in labor costs, we have:

$$\mathrm{d}\log \vartheta^S_{ifj} = \left(1-\vartheta^S_{ifj}\right)\left[\mathrm{d}\ln w^S_i - \mathrm{d}\log w^P_i + \mathrm{d}\log L^S_{ifj} - \mathrm{d}\log L^P_{ifj}\right]. \tag{16}$$

Therefore, holding constant factor prices ($\mathrm{d}\ln w^S_i = 0$ and $\mathrm{d}\ln w^P_i = 0$), a rise in the share of professional services in labor costs ($\mathrm{d}\log \vartheta^S_{ifj} > 0$) implies a rise in professional services employment relative to production employment ($\mathrm{d}\log L^S_{ifj} > \mathrm{d}\log L^P_{ifj}$), and hence an increase in the share of professional services in employment.

[27] Although we hold factor prices constant here, wages of professional service workers rise faster than those of production workers during our sample period, which raises the share of professional services in unit costs under our assumption that professional and production services are complements.

To link these changes in labor cost and employment shares to the changes in unit cost shares examined earlier, we use the implication of the Cobb-Douglas function form for production costs that expenditures on intermediate inputs are a constant multiple of the wage bill for production workers:

$$Q_{ij}M_{ifj} = \frac{1-\beta_j}{\beta_j} w_i^P L_{ifj}^P, \tag{17}$$

where M_{ifj} is the quantity of intermediate inputs used by firm f from origin country i in sector j.

Using this linear relationship between intermediate input costs and production worker costs, we can rewrite the share of professional services in overall unit costs in equation (13) as:

$$\xi_{ifj}^S = \frac{w_i^S L_{ifj}^S}{w_i^S L_{ifj}^S + w_i^P L_{ifj}^P + Q_{ij}M_{ifj}} = \frac{w_i^S L_{ifj}^S}{w_i^S L_{ifj}^S + \left[1 + \frac{1-\beta_j}{\beta_j}\right] w_i^P L_{ifj}^P}. \tag{18}$$

Totally differentiating this relationship and using our earlier expressions for the total derivatives of unit costs (14) and labor costs (16), we find that the share of professional services in labor costs is linearly related to the share of professional services in unit costs as follows:

$$d \ln \vartheta_{ifj}^S = \left(\frac{1-\vartheta_{ifj}^S}{1-\xi_{ifj}^S}\right) \mathrm{d} \ln \xi_{ifj}^S, \tag{19}$$

where the shares of unit costs (ξ_{ifj}^S) and labor costs (ϑ_{ifj}^S) both lie strictly in between zero and one for $0 < \mu_j < 1$, thereby ensuring that the term in parentheses in equation (19) is strictly positive.

Combining the total derivative of the share of professional services in unit costs (14) with this linear relationship between unit cost and labor cost shares in equation (19), we can now characterize the effects of technology and trade shocks on the shares of professional services in labor costs and employment. Under our assumption that professional and production services are complements ($0 < \mu_j < 1$) and holding constant factor prices ($\mathrm{d} \ln w_i^S = 0$ and $\mathrm{d} \ln w_i^P = 0$), equations (14) and (19) imply that productivity growth ($\mathrm{d} \ln \varphi_{fj} > 0$) and lower prices of intermediate inputs due to lower trade costs ($\mathrm{d} \ln Q_{ij} < 0$) raise the share of professional services in unit costs ($\mathrm{d} \ln \xi_{ifj}^S > 0$) and hence the share of professional services in labor costs ($d \ln \vartheta_{ifj}^S > 0$). From the relationship between the share of professional services in labor costs and employment levels in equation (16), and holding constant factor prices ($\mathrm{d} \ln w_i^S = 0$ and $\mathrm{d} \ln w_i^P = 0$), this higher share of professional services in labor costs also translates into a higher share of professional services in employment.

Therefore, using only properties of the firm cost minimization problem, we obtain sharp empirical predictions for the effect of technology and input price shocks on structural transformation towards professional services. In contrast to the macroeconomic literature on structural transformation, these predictions are for a reallocation of economic activity between functions (professional services versus production activities) within sectors. For vertically-integrated firms that perform professional services in-house, these reallocations occur within the boundaries of the firm. For firms that outsource professional services, these

reallocations take place between each final goods firm and its standalone supplier. The magnitude of these reallocations depends on whether they occur within or beyond the boundaries of the firm, since only vertically-integrated firms invest in intangible knowledge capital accumulation.

4.7 Market Entry

We have thus completed our characterization of the final goods firm's equilibrium price and factor input choices. We now turn its choice of the sets of the countries and sectors to serve conditional on its vertical integration and intangible investment decisions. Using the firm's equilibrium pricing rule (10) in the definition of firm variable profits for a given sector and market, we obtain the standard result under CES demand and monopolistic competition that variable profits are a constant multiple of revenue in that sector and market:

$$\pi_{nifj} = \frac{1}{\sigma_j} x_{nifj}. \tag{20}$$

Given this solution for equilibrium variable profits, firm f from origin country i chooses to serve a given sector j and destination country n if these variable profits exceed the fixed market entry costs for that sector and country (F^N_{nj}). Therefore, the set of sectors J_{nif} served by the firm within a given destination country is simply the set of sectors for which these variable profits exceed the fixed market entry costs:

$$J_{nif} = \left\{ j : \frac{1}{\sigma_j} x_{nijf} - w^S_i F^N_{nj} \geq 0 \right\}. \tag{21}$$

Similarly, the set of countries N_{if} served by the firm is simply the set of countries for which there is at least one sector for which these variable profits exceed the fixed market entry costs:

$$N_{if} = \left\{ n : \max_j \left\{ \frac{1}{\sigma_j} x_{nijf} - w^S_i F^N_{nj} \right\} \geq 0 \right\}. \tag{22}$$

Conditional on the firm's vertical integration and intangible investment decisions, its choice whether to enter one sector and country is independent of its choice whether to enter any other sector and country, because of the property of equation (8) that unit costs are constant. Substituting the equilibrium revenue function (11) into equation (21), the zero-profit condition to enter a given country and sector can be rewritten as:

$$J_{nif} = \left\{ j : \frac{1}{\sigma_j} \left(\frac{\sigma_j}{\sigma_j - 1} \tau_{nij} \frac{1}{\theta_f} \gamma_{ifj} \right)^{1-\sigma_j} X_{nj} P_{nj}^{\sigma_j - 1} - w^S_i F^N_{nj} \geq 0 \right\}. \tag{23}$$

This zero-profit condition highlights that the model also features conventional structural transformation between sectors in response to shocks to technology and trade costs that affect final demand within each sector (through sectoral expenditure (X_{nj}) or the sectoral price index (P_{nj})). While the conventional macroeconomics literature is typically silent as to whether these reallocations occur through the entry and exit of firms or through reallocations of resources within firms, our model features both of these margins of adjustment. As shocks to technology and trade costs increase variable profits in some sectors and reduce

them in others, the set of sectors chosen by entering firms will change (between-firm reallocations) and incumbent firms will choose to drop some sectors and add other sectors (within-firm reallocations).

From this zero-profit condition (23), a lower unit cost ($\frac{1}{\theta_f}\gamma_{ifj}$) increases a firm's variable profits and expands the set of countries and sectors that it finds it profitable to enter. As discussed in the previous section, firms that vertically integrate and invest in intangibles have lower unit costs ($\theta_f > 1$) than firms that outsource professional services and make no investment in intangibles ($\theta_f = 1$). Therefore, by reducing unit costs and increasing variable profits, these investments in intangibles increase the set of countries and sectors in which a firm operates.

4.8 Investments in Intangible Knowledge Capital

Finally, we turn to the final goods firm's vertical integration and intangible investment decisions. We already established that firms that outsource professional services make no investments in intangibles. Therefore, we first solve for a firm's optimal investment in intangibles conditional on vertically integrating professional services. Taking into account this optimal investment decision, we next determine whether the firm outsources or vertically integrates professional services by comparing the firm's total profits under these two alternatives.

Using the equilibrium revenue function (11), the total profits of a firm across all countries and sectors can be written as follows:

$$\Pi_{if}(\boldsymbol{\varphi}) = \sum_{n\in N_{if}}\sum_{j\in J_{nif}} \frac{1}{\sigma_j}\left(\frac{\sigma_j}{\sigma_j-1}\tau_{nij}\frac{1}{\theta_f}\gamma_{ifj}\right)^{1-\sigma_j} X_{nj}P_{nj}^{\sigma_j-1} - \sum_{n\in N_{if}}\sum_{j\in J_{nif}} w_i^S F_{nj}^N - \mathbb{I}_{if}^S w_i^S F^S - w_i^S \psi\left(\theta_f^{\zeta}-1\right), \tag{24}$$

which depends on the firm's vector of productivity draws across sectors ($\boldsymbol{\varphi}$).

Conditional on incurring the fixed cost of vertically integrating professional services in-house, the first-order condition for the firm's investment in intangibles yields the following optimal investment:

$$\theta_{if}^* = \left[\frac{\sum_{n\in N_{if}}\sum_{j\in J_{nif}} \frac{\sigma_j-1}{\sigma_j}\left(\frac{\sigma_j}{\sigma_j-1}\tau_{nij}\gamma_{ifj}\right)^{1-\sigma_j} X_{nj}P_{nj}^{\sigma_j-1}}{\zeta\psi w_i^S}\right]^{\frac{1}{\zeta-(\sigma_j-1)}}, \tag{25}$$

which depends on the firm's vector of productivity draws ($\boldsymbol{\varphi}$) through unit costs (though γ_{ifj}). As a firm that makes no investment in intangibles has a unit productivity ($\theta_f = 1$), only firms for which there is an interior solution in which $\theta_f^* > 1$ make positive investments in intangibles. For sufficiently convex research costs ($\zeta > (\sigma_j - 1)$), this optimal positive investment in intangibles is finite ($1 < \theta_f^* < \infty$).

From this solution for equilibrium investment in intangibles and the unit cost function (8), higher firm productivity across all sectors (φ_{fj}) lowers unit costs (through lower γ_{ifj}), which increases total firm profits in equation (24) on both the intensive margin (higher profits within each sector and country) and the extensive margin (entry into more sectors and countries). These higher total profits in turn raise the return

to intangible investments and increase the equilibrium level of these intangible investments. This role for the extensive margin of the range of sectors and countries served in influencing equilibrium intangible investment implies that there is an interdependence between a firm's decisions to serve each sector and country and its level of intangible investment. On the one hand, serving an additional sector and country raises the return to intangible investment. On the other hand, an increased investment in intangibles raises the variable profits from entering each sector and country.

Substituting this solution for optimal investment in intangibles (25) into equation (24), we obtain a firm's total profits from vertically integrating professional services in-house. A firm chooses to vertically integrate professional services in-house if the total profits from doing so exceed those from outsourcing professional services to a standalone supplier. As vertical integration involves incurring an additional fixed cost F^S, only the most productive firms find it profitable to perform professional services in-house. Through this selection mechanism, the model captures the property of the data that firms that vertically integrate professional services within the boundaries of the firm are more productive than those that do not.

4.9 General Equilibrium

All of the empirical predictions that we examine in the next section were derived above from the solutions to the firm problem for a given sectoral expenditure (X_{nj}), sectoral price index (P_{nj}), wage of professional service workers (w_i^S) and wage of production workers (w_i^P). In this section, we briefly discuss closing the model to determine these variables in general equilibrium.

The general equilibrium of the model is referenced by the following variables: (i) the set of sectors served for each country ($J_{ni}(\boldsymbol{\varphi})$) and the set of countries served ($N_i(\boldsymbol{\varphi})$) as a function of a firm's productivity vector across sectors ($\boldsymbol{\varphi}$); (ii) an indicator variable for whether a firm vertically integrates professional services ($\mathbb{I}_i^S(\boldsymbol{\varphi})$) as a function of its productivity vector; (iii) investment in intangibles as a function of a firm's productivity vector ($\theta(\boldsymbol{\varphi})$); (iv) the wage for professional service workers (w_i^S), (v) the wage for production workers (w_i^P); (vi) the price index for each sector and country (P_{nj}); and (vii) aggregate expenditure for each country (X_n). All other endogenous variables can be determined as functions of these elements of the equilibrium vector.

General equilibrium is determined by the following equilibrium conditions: (i) a firm with each productivity vector makes non-negative profits from all sectors and countries that it enters; (ii) a firm with each productivity vector incurs the fixed cost to vertically integrate professional services if this yields higher total profits than outsourcing professional services and vice versa; (iii) investment in intangibles equals zero for productivities for which firm's outsource professional services and is chosen to maximize profits for productivities for which firms vertically integrate; (iv) the labor market for professional service workers clears; (v) the labor market for production workers clears; (vi) revenue in each sector and country equals expenditure on goods produced in that sector and country; (vii) free entry ensures that the expected

value of entry is equal to the sunk entry cost.

5 Reduced-form Evidence on Complementarities

A key feature of the model presented in Section 4 is the potential existence of complementarities between a firm's design and manufacturing activities, as governed by μ. Whenever $\mu < 1$, design and manufacturing are complements, i.e., a reduction in firm's manufacturing input costs induce an increase in its share of professional services in unit costs.

In this section, we examine whether US manufacturing firms' exhibit evidence of such a complementarity by exploiting a plausibly exogenous shock to US firms' input costs, China's 2001 re-entry into the WTO and rapid rise as a low-cost location for manufacturing. A number of recent papers highlight the increase in US import competition associated with China's export growth (Autor, Dorn, and Hanson (2013), Pierce and Schott (2016)), while others focus on China's as a source of low-cost inputs (Antràs, Fort, and Tintelnot (2017) Amiti, Dai, Feenstra, and Romalis (2017)). .

We focus on the period 1997 to 2007 because these two Census years span China's WTO entry and are far enough apart to allow for the types of organizational changes predicted by the model to manifest. We begin by defining firms' potential exposure to China in 1997, and then relate this exposure to changes in a wide range of firm outcomes over the sample period. An important contribution of our analysis is to distinguish between two forms of exposure to China: greater import competition with respect firms' output, and potentially beneficial shocks to the prices of their inputs. We find that reductions in the latter are associated with declining manufacturing employment shares and increases in headquarter and professional and technical services employment, in terms of both shares and levels.

5.1 Estimating the impact of the China shock on within-firm structural change

To assess the impact of new production cost savings on firm employment across sectors, our baseline specification estimates

$$\Delta Outcome_f^{1997-2007} = +\gamma_1 \Delta Exposure_{f,1997}^{Ouput} + \gamma_2 \Delta Exposure_{f,1997}^{Input} + \epsilon_f, \tag{26}$$

where the first two terms on the right-hand side are firm-specific measures of exposure to Chinese imports based on firms' outputs and inputs in 1997. We consider a wide range of firm outcomes, including firms' total employment, manufacturing employment levels and shares, MPRO (i.e., NAICS 54 and 55) employment levels and shares, and various measures of export activity. Our focus on MPRO is motivated by the growth in employment and payroll in these sectors, their importance as an input in the production of other goods and services, and their correlation with manufacturing-firm diversification, all documented in Section 2.

5.2 Data

In addition to the LBD, in this section we use data from the US Census Bureau's Census of Manufactures (CM) to measure firms' output and input usage across sectors. The CM surveys all manufacturing establishments quinquennially in years ending in "2" and "7" (hereafter referred to as "census years"). In contrast to the LBD, the CM provides a rich portrait of establishment activity, including detailed information on their sales and material inputs purchases, and employment and wages by production versus non-production worker status.

5.3 Measuring US Firms' Exposure to Trade Liberalization with China

China's exports grew dramatically from $183 bilion in 997 to $1,120 billion in 2007, with its share of world exports rising from 3.5 percent to 9.0 percent over the period. A number of factors contributed to these changes. First, China implemented various reforms in the 1990s, such as allowing for private ownership and reducing internal migration restrictions, that led to productivity gains within China. Second, China re-entered the WTO in 2001, which required that it implement a number of reforms, including lowering tariffs on many imports and reducing production subsidies. As part of its re-entry into the WTO, China also received permanent normal trade relations (PNTR) status from the United States, eliminating the need for annual renewal of its access to the relatively low NTR tariff rates the US extends to is favored trading partners. This reduction in tariff uncertainty, discussed in Pierce and Schott (2016) and Handley and Limão (2017), increased Chinese exports relatively more in those goods that would have faced large tariff increases if annual renewal had failed.

In this paper, our goal is to capture the impact of all of these channels of Chinese export growth. As a result, we follow Bernard, Jensen, and Schott (2006) in exploiting variation in the growth of US import penetration from China across sectors to measure firms' differential exposure to both output competition and input cost savings. Using data from the US Census of Manufatures, we calculate

$$\Delta Exposure_f^{Output} = \sum_{k \in Output_{1997}} \frac{Sales_{k1997}}{Sales_{1997}} \Delta ImpPen_k \tag{27}$$

$$\Delta Exposure_f^{Input} = \sum_{k \in Input_{1997}} \frac{Inputs_{k1997}}{Inputs_{1997}} \Delta ImpPen_k, \tag{28}$$

where $Sales_{k1997}$ is the firm's sales in the six-digit NAICS industry k, and $Inputs_{k1997}$ is the firm's purchases of material inputs in the six-digit NAICS industry k. The change in output exposure for firm f between 1997 and 2007 is the change in the weighted average of US import penetration across the industries in which the firm is active in 1997, using its sales shares as weights. Likewise, firm f's change in input exposure is the change in the weighted average of US import penetration across all material inputs the firm used to produce these outputs, using input value shares as weights.

We measure firm sales across industries based on the NAICS industry of each of the firm's establishments. This measure is thus firm-specific for firms with establishments in more than one sector, but identical for firms with establishments in only one six-digit NAICS manufacturing industry. Our input measure shock is more novel, and compelling, since we exploit the material trailer files of the CM to construct a firm-specific measure based on the mix of six-digit NAICS inputs that the firms' manufacturing establishments use to manufacture their goods. The material trailer data are only available for a subset of manufacturing establishments that includes all large, multi-unit firms with industry-specific thresholds for the number of employees, as well as a random sample of smaller firms.[28] For those firms without material trailer data, we impute input usage across industries based on the establishment's output industry and the 1997 US input-output tables produced by the US Bureau of Economic Analysis (BEA).

Given the likely endogeneity of US import growth across sectors, we follow Antràs, Fort, and Tintelnot (2017) in instrumenting for the growth of US import penetration in industry k with the growth in Chinese market share in Europe in industry k. This approach, similar in spirit to Autor, Dorn, and Hanson (2013), identifies the portion of Chinese import growth in the United States that is attributable to Chinese gains in comparative advantage, due either to changes in trade policy or productivity gains in China.

5.4 Results

Results from estimating Equation (26) via ordinary least squares (OLS) are reported in Table 5. In line with a well-established literature on the negative effects of Chinese import competition, we find that an increase in exposure to Chinese import competition in a firm's output industries is associated with a decline in the firm's total employment and in its manufacturing employment. In contrast, increased Chinese import penetration in a firm's inputs has a positive, though not significant, relationship with changes in the firm's employment. Consistent with the idea that manufacturing and design are complementary, we also find that increased import penetration in a firm's inputs leads to a decrease in its share of manufacturing employment and an increase its share of professional and technical services employment.

Table 6 presents first-stage results. The estimated coefficients on input and output industry market share changes are positive and statistically significant at conventional levels in both cases. The Kleibergen-Paap F-statistic of 17.33 indicates that the input and output shock measures are sufficiently uncorrelated to identify input exposure separately from output exposure.

The results from the estimating Equation (26) via 2SLSs are presented in Table 7. As in the OLS regressions, there is a negative and statistically significant relationship between increased output exposure and a firm's total as well as manufacturing employment. In contrast, there is a positive, though still insignificant relationship between input exposure and overall employment. Consistent with the presence

[28] The Census of Manufactures includes all manufacturing establishments in the United States. For very small establishments, data are based only on administrative records. All establishments that belong to multi-unit firms with at least 250 employees are sent the long census form, which includes questions about input purchases and sales by detailed product categories. A random sample of smaller establishments are also sent the long form. Remaining establishments are sent the short form, which does not include the questions on detailed inputs.

Table 5: Estimates of Chinese exposure and firm-level employment changes

Dependent variable is the change from 1997 to 2007 in a firm's	Share Manuf Emp	Share Prof Emp	log Emp	log Manuf Emp
$\Delta Exposure_f^{Output}$	-0.033***	-0.005	-1.413***	-1.503***
	0.011	0.006	0.204	0.214
$\Delta Exposure_f^{Input}$	-0.312***	0.136***	0.709	-0.155
	0.084	0.039	1.020	1.082
Constant	0.001**	-0.000	0.037**	0.040**
	0.00	0.00	0.02	0.02
Observations	72,500	72,500	72,500	72,500

Notes: * p<0.10, ** p<0.05, *** p<0.01.
Standard errors clustered at the industry level.

Table 6: First stage estimates

Dependent variable is	$Exposure_f^{Output}$	$Exposure_f^{Input}$
$\Delta MktShareEU_f^{Output}$	0.188***	0.011***
	0.030	0.003
$\Delta MktShareEU_f^{Input}$	0.110***	0.106***
	0.038	0.009
Constant	-0.013***	-0.000
	0.0038	0.000
Observations	72,500	72,500
R-squared	0.209	0.479
Fstat	27.69	151.9

Notes: * p<0.10, ** p<0.05, *** p<0.01.
First Stage KP F-stat 17.33
Standard errors clustered at the industry level.

of complementarities between manufacturing inputs and design within the firm, an increase in Chinese import penetration in a firm's inputs, which we interpret as lowering the costs of inputs, is associated with a positive and statistically significant increase in the firm's share of professional and technical workers.

Table 7: IV Estimates of Chinese exposure and firm-level employment changes

Dependent variable is the change from 1997 to 2007 in a firm's				
	Share Manuf Emp	Share Prof Emp	log Emp	log Manuf Emp
$\Delta Exposure_f^{Output}$	-0.001	-0.033**	-1.698***	-1.747***
	0.0252	0.0164	0.633	0.658
$\Delta Exposure_f^{Input}$	-0.406***	0.275***	0.922	-0.087
	0.119	0.0583	2.159	2.316
Constant	0.002**	-0.001	0.041**	0.045**
	0.00	0.00	0.02	0.02
Observations	72,500	72,500	72,500	72,500

Notes: * p<0.10, ** p<0.05, *** p<0.01.
First Stage KP F-stat 17.33
Standard errors clustered at the industry level.

The OLS and IV estimates all point towards a reallocation of employment from manufacturing towards professional and technical services in response to a reduction in a firm's manufacturing inputs. To assess whether this reallocation also entails a level change in a firm's employment in R&D and design-related workers, we estimate Equation (26) with log changes in the levels of employment in professional and technical services employment as the dependent variable. To do so, we focus only on the balanced panel of firms with professional and technical services employment in both periods. As documented in Fort, Pierce, and Schott (2018), the majority of non-manufacturing employment added by manufacturing firms during this period is new establishments (which is captured in our share measure), so this subset of firms is thus much smaller.

Table 8 presents the results. Columns 1-3 show qualitatively similar patterns for these firms in terms of employment responses to both the input and output shocks as found when using the entire sample. The final column presents results for log changes in the firm's professional and technical employment and shows a negative and significant impact of increased product-market exposure, but a large, positive, and significant effect from increased input exposure. These results suggest that firms increase both their share and level of professional workers in response to cheaper manufacturing inputs.

Finally, we examine the effect of Chinese import penetration on firms' export behavior. Table 9 presents the results. In the first column, we estimate Equation (26) using a Davis-Haltiwanger-Schuh (DHS) growth

Table 8: IV estimates for subset of firms with professional and technical services employment

Dependent variable is the change from 1997 to 2007 in a firm's					
	Share Manuf Emp	Share Prof Emp	log Emp	log Manuf Emp	log Prof Emp
$\Delta Exposure_f^{Output}$	-0.565**	-0.175	-3.582**	-5.667***	-4.346***
	0.222	0.262	1.410	1.662	1.570
$\Delta Exposure_f^{Input}$	-2.673***	2.220***	0.343	-5.794	14.47***
	0.703	0.714	5.283	6.186	4.848
Constant	0.007	-0.007	0.036	0.045	-0.004
	0.006	0.005	0.033	0.040	0.047
Observations	2,900	2,900	2,900	2,900	2,900

Notes: * p<0.10, ** p<0.05, *** p<0.01.
First Stage KP F-stat 26.09
Standard errors clustered at the industry level.

rate in exports that captures both intensive and extensive margin changes in exports.[29] The estimates show that increased exposure to Chinese import competition in a firm's outputs decreases its exporting activities. In contrast, increased Chinese import penetration in a firm's inputs leads to positive growth in a firm's exports. Columns 2 and 3 present similar relationships for the log number of countries to which a firm exports and the log number of six-digit HS code products exported by the firm. Firms that face increased Chinese import penetration in their product markets decrease both the countries and products that they export, while firms that experience increased Chinese imports into the US in the set of inputs that they use in 1997 export more products and to more countries. These results are all consistent with the scale effect evident in the theoretical framework presented in section 4, but we find that the results hold even when controlling for changes in firm sales over the period. This suggests a possible role for the firm's increased use of professional workers in expanding its export market participation, which we aim to investigate in subsequent drafts.

To summarize, we find that increased Chinese import penetration in a firm's output industries lead the firm to shrink its employment across sectors, and to decrease its export activity. In contrast, increased Chinese import penetration in a firm's input industries leads to a decline in the share, but not the level of manufacturing employment and increases in both the shares and levels of professional and technical employment. In addition, this reallocation towards design and innovative activities is accompanied by a growth in exports, in terms of the value of exports, the number of exported products, and the number of countries to which firms export. We interpret these results as evidence that negative demand shocks cause

[29]The DHS growth rate of $x$is calculated as $GrX = \frac{x_t - x_{t-1}}{(x_t + x_{t-1})/2}$. Firms that begin exporting or stop exporting over the period thus have growth rates of 2 and -2, respectively.

Table 9: IV estimates of Chinese exposure and firm-level exports

Dep var is the change from 1997 to 2007 in a firm's	DHS Exports	Log No. Exp Countries	Log No. Exp HS6 Prods
$\Delta Exposure_f^{Output}$	-3.433**	-2.189**	-1.970**
	1.500	0.989	0.846
$\Delta Exposure_f^{Input}$	16.11**	11.56***	9.963***
	6.630	4.390	3.854
Constant	0.227***	0.129***	0.120***
	0.04	0.03	0.03
Observations	72,500	72,500	72,500

Notes: * p<0.10, ** p<0.05, *** p<0.01.
First Stage KP F-stat 17.33
Standard errors clustered at the industry level.

firms to contract, while a shock to inputs leads manufacturing firms to grow their design and engineering capabilities and penetrate more new markets.

In subsequent drafts, we aim to tie these empirical results more directly to the model, and ultimately to use the model to quantify the impact of structural change within firms on aggregate outcomes, such as the firm size distribution and growth.

6 Conclusion

None yet.

References

Alaimo, D. (2019): "Target to Hire 1,000 for IT, Reduce Outsourcing," *Fierce Retail*.

Amiti, M., M. Dai, R. C. Feenstra, and J. Romalis (2017): "How Did China's WTO Entry Benefit U.S. Consumers?," Working Paper 23487, National Bureau of Economic Research.

Amiti, M., and J. Konings (2007): "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia," *American Economic Review*, 97(5), 1611–1638.

Antràs, P., T. C. Fort, and F. Tintelnot (2017): "The Margins of Global Sourcing: Theory and Evidence from U.S. Firms," *American Economic Review*, 107(9), 2514–64.

Atalay, E., A. Hortacsu, and C. Syverson (2014): "Vertical Integration and Input Flows," *American Economic Review*, 104(4), 1120–48.

Autor, D., D. Dorn, L. F. Katz, C. Patterson, and J. V. Reenan (2017): "The Fall of the Labor Share and the Rise of Superstar Firms," mimeo.

Autor, D. H., D. Dorn, and G. H. Hanson (2013): "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 103(6), 2121–68.

Bernard, A. B., and T. C. Fort (2015): "Factoryless Goods Producing Firms," *American Economic Review Papers and Proceedings*, 105(5), 518–523.

Bernard, A. B., T. C. Fort, V. Smeets, and F. Warzynski (2018): "Heterogeneous Globalization: Offshoring and Reorganization," Discussion paper, Tuck School of Business.

Bernard, A. B., J. B. Jensen, S. Redding, and P. Schott (2011): "Multi-Product Firms and Trade Liberalization," *Quarterly Journal of Economics*, 126(3), 1271–1318.

Bernard, A. B., J. B. Jensen, and P. K. Schott (2006): "Survival of the Best Fit: Exposure to Low-Wage Countries and the (Uneven) Growth of U.S. Manufacturing Plants," *Journal of International Economics*, 68, 219–237.

Bernard, A. B., V. Smeets, and F. Warzynski (2017): "Rethinking deindustrialization," *Economic Policy*, 32(89), 5–38.

Berry, S., M. Gaynor, and F. Scott Morton (2019): "Do Increasing Markups Matter? Lessons from Empirical Industrial Organization," *Journal of Economic Perspectives*, 33(3), 44–68.

Bloom, N., M. Draca, and J. Van Reenen (2016): "Trade Induced Technical Change: The Impact of Chinese Imports on Innovation, Diffusion, and Productivity," *Review of Economic Studies*, 83, 87–117.

Bloom, N., K. Handley, A. Kurmann, and P. Luck (2019): "The Impact of Chinese Trade on U.S. Employment: The Good, The Bad, and The Apocryphal," Stanford University, mimeo.

Boehm, C. E., A. Flaaen, and N. Pandalai-Nayar (2017): "Multinationals, Offshoring, and the Decline of US Manufacuturing," working paper, University of Texas at Austin.

Brandt, L., J. Van Biesebroeck, L. Wang, and Y. Zhang (2017): "WTO Accession and Performance of Chinese Manufacturing Firms," *American Economic Review*, 107(9), 2784–2820.

Brandt, L., J. Van Biesebroeck, and Y. Zhang (2012): "Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing," *Journal of development economics*, 97(2), 339–351.

Breinlich, H., A. Soderbery, and G. C. Wright (2018): "From Selling Goods to Selling Services: Firm Responses to Trade Liberalization," *American Economic Journal: Economic Policy*, 10(4).

Comin, D., D. Lashkari, and M. Mestieri (2018): "Structural Change with Long-run Income and Price Effects," Northwestern, mimeograph.

De Loecker, J., and J. Eeckhout (2017): "The rise of market power and the macroeconomic implications," Discussion paper, National Bureau of Economic Research.

Decker, R., J. Haltiwanger, R. Jarmin, and J. Miranda (2014): "The Role of Entrepreneurship in U.S. Job Creation and Economic Dynamism," *Journal of Economic Perspectives*, 28, 3–24.

Decker, R. A., J. Haltiwanger, R. S. Jarmin, and J. Miranda (2016): "Where has all the skewness gone? The decline in high-growth (young) firms in the US," *European Economic Review*, 86, 4–23.

Dent, R. C., F. Karahan, B. Pugsley, and A. Sahin (2016): "The Role of Startups in Structural Transformation," *American Economic Review: Papers & Proceedings*, 106(5), 219–223.

Dey, M., S. H. Houseman, and A. E. Polivka (2012): "Manufacturers' Outsourcing to Staffing Services," *ILR Review*.

Fort, T. C., and S. Klimek (2016): "The Effects of Industry Classification Changes on US Employment Composition," CES Working Paper 18-28, US Census Bureau.

Fort, T. C., J. R. Pierce, and P. K. Schott (2018): "New perspectives on the decline of us manufacturing employment," *Journal of Economic Perspectives*, 32(2), 47–72.

Foster, L., J. Haltiwanger, and C. Syverson (2008): "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?," *American Economic Review*, 98(1), 394–425.

Ganapati, S., et al. (2016): "The Modern Wholesaler: Global Sourcing, Domestic Distribution, and Scale Economies," Discussion paper, Yale mimeo.

Goldberg, P. K., A. K. Khandelwal, N. Pavcnik, and P. Topalova (2010): "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India," *The Quarterly Journal of Economics*, 125(4), 1727–1767.

Grossman, S. J., and O. D. Hart (1986): "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94, 691–719.

Halpern, L., M. Koren, and A. Szeidl (2015): "mported Inputs and Productivity," *American Economic Review*.

Haltiwanger, J., R. S. Jarmin, and J. Miranda (2013): "Who Creates Jobs? Small Versus Large Versus Young," *The Review of Economics and Statistics*, 95, 347–361.

Handley, K., and N. Limão (2017): "Policy Uncertainty, Trade, and Welfare: Theory and Evidence for China and the United States," *American Economic Review*, 107(9), 2731–83.

Hart, O. (2011): "Thinking about the Firm: A Review of Daniel Spulber's The Theory of the Firm," *Journal of Economic Literature*, 49(1), 101–113.

Hart, O. D., and J. Moore (1990): "Property Rights and the Nature of the Firm," *Journal of Political Economy*, 98, 1119–58.

Herrendorf, B., R. Rogerson, and A. Valentinyi (2013): "Two Perspectives on Preferences and Structural Transformation," *American Economic Review*, 103(7), 2752–89.

——— (2014): "Growth and Structural Transformation," in *Handbook of Economic Growth*, ed. by P. Aghion, and S. N. Durlauf. Elsevier North Holland, Amsterdam.

Houseman, S. N., T. J. Bartik, and T. J. Sturgeon (2018): "Measuring Manufacturing: How the Computer and Semiconductor Industries Affect the Numbers and Perceptions," 14(209), Upjohn Institute working paper.

Jarmin, R. S., and J. Miranda (2002): "The Longitudinal Business Database," *Center for Economic Studies Working Paper*, 02(17).

Khandelwal, A. (2010): "The Long and Short (of) Quality Ladders," *Review of Economic Studies*, 77(4), 1450–1476.

Lafontaine, F., and M. Slade (2007): "Vertical Integration and Firm Boundaries: The Evidence," *Journal of Economic Literature*, 45(3), 629–685.

Magyari, I. (2017): "Firm Reorganization, Chinese Imports, and US Manufacturing Employment," Columbia University, mimeograph.

Ngai, L. R., and C. A. Pissarides (2007): "Structural Change in a Multisector Model of Growth," *American Economic Review*, 97(1), 429–443.

Pierce, J. R., and P. K. Schott (2016): "The Surprisingly Swift Decline of U.S. Manufacturing Employment," *American Economic Review*, 106(7), 1632–1662.

Prince, M., and W. Plank (2012): "A Short History of Apples Manufacturing in the U.S.," *Wall Street Journal*.

Pugsley, B., and A. Sahin (2019): "Grown-up Business Cycles," *Review of Financial Studies*, Forthcoming.

U.S. Census Bureau (1998): "NAICS Clarification Memorandum 3: Classifying SIC Auxiliary Establishments in NAICS," Discussion paper.

Williamson, O. E. (1981): "The Economics of Organization: The Transaction Cost Approach," *The American Journal of Sociology*, 87(3), 548–577.

Online Appendix (Not for Publication)

This online appendix contains additional empirical results as well as more detailed explanations of data used in the main text.

A Defining Firms

The longitudinal firmids created by Census for the LBD may be too restrictive for answering some research questions. As noted in the main text, they break by construction when firms grow and shrink in a particular way. That is, if a newly born single-unit (SU) firm adds another establishment in a following year, it receives a new firmid by construction because Census firmids take a different form for SU and multiple-unit (MU) firms. Likewise, if an existing MU firm sheds all but one establishment, it's firmid also will break as its firmid is changed to fit the SU pattern. A second issue with Census firmids is that they may ignore information useful for some research questions. For example, changes in legal ownership status or mergers and acquisitions activity can lead to breaks in Census firmids even when the firm's name and main activities are unchanged.

For this reason, studies of firm dynamics typically identify firm entry and exit using a broader conceptualization of a firm. In decomposing employment growth between begin year b and end year e, Haltiwanger, Jarmin, and Miranda (2013), for example, defines entrants as Census firmids in year e consisting of plants that were not in the LBD in year b, and exiters as Census firmids in year b whose plants all exit the LBD before year e. Employment at all other plants in years b and e are categorized as being part of continuing firms. Note that this approach *does not* create alternate firmids to replace the Census firmids, as they are not needed to answer the research question addressed in the paper. Indeed, this approach just identifies the sets of establishments in each year that are "from exiting firms", "from entering firms" and "from continuing firms". Moreover, note that an attempt to create such firmids in the spirit of Haltiwanger, Jarmin, and Miranda (2013) likely would be unsatisfactory, particularly for research questions examining how outcomes (e.g., productivity) change within firms over time. That is because the alternate firmids to which this approach would give rise might encompass an uncomfortably large number of establishments.

Assume, for example, that 10 Census firmids encompassing 10 plants each are present in year b. Between year b and year e, assume that one plant from each of these firms splits off to join the other splitters, and that these 10 splitters constitute a new 10-plant firm that is given its own firmid by Census in year e. Finally, assume that each of the now 9-plant firms in year e retain their 10 original Census firmids, so that there are 11 Census firmids in total in year e. Using the approach taken in Haltiwanger, Jarmin, and Miranda (2013), all of the Census firmids in year b and year e would be classified as continuers, so all of their employment growth – including the growth among the plants of the new firmid in year e – would be counted toward the intensive margin. With respect to Census firmids, however, there would be 10 incumbents in year e and one entrant. If one wanted to create a new firmid in the spirit of Haltiwanger,

Jarmin, and Miranda (2013), one would have to include all of the establishments at all of these firms in one new (continuing) firmid. It is not clear that estimating productivity growth across this firm would be meaningful.

In our examination of the share of employment accounted for by "legacy" firms in Section 3, we make use of the conceptualization of a firm introduced by Haltiwanger, Jarmin, and Miranda (2013), which we label DL, as well as an even broader definition that accounts for all mergers and acquisition activity, which we label IL. In both cases, like Haltiwanger, Jarmin, and Miranda (2013), we *do not* create alternate firmids using these approaches, for the reason just explained. Rather, like Haltiwanger, Jarmin, and Miranda (2013), we use these conceptualizations of a firm to identify plants that match a certain criteria, i.e., whether they can be thought of as "legacy" firms given their association with long-lived plants.

Let a "long-lived" establishment be a plant that survives from year b to year e, e.g., 1977 to 2016. A collection of plants in a Census firmid in year t, $b \leq t \leq e$, is "directly" linked (DL) to a long-lived establishment in that year if it includes such an establishment. As described above the number of DL firms in a particular year can exceed the number of Census firmids in that year that actually survive from year b to year e for several reasons. For example, if a single long-lived establishment changes formal ownership over the period, such that its Census firmid breaks before year t, we classify it as DL.

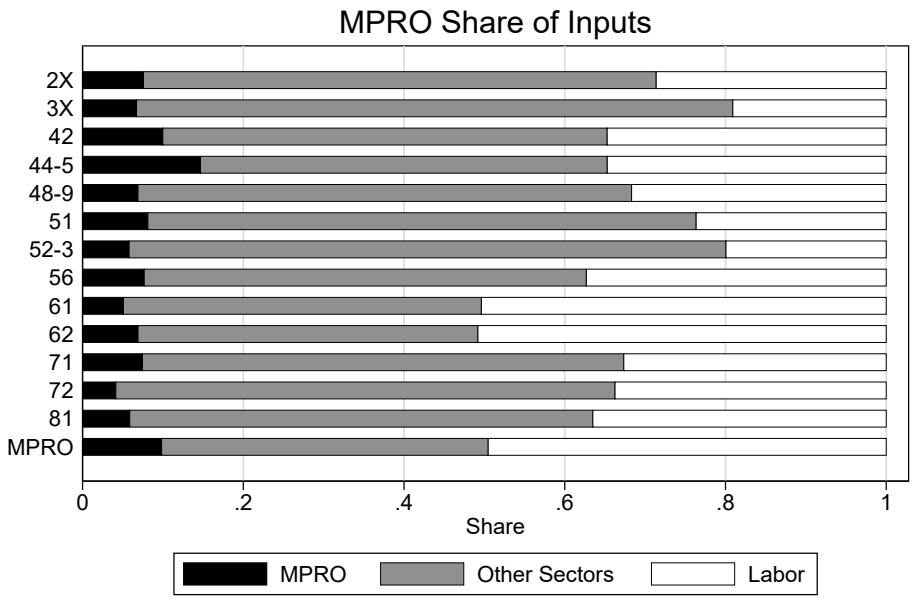
A collection of plants in a Census firmid in t, $b \leq t \leq e$, is "indirectly" linked (IL) to a long-lived establishment in that year if it includes a plant that has ever (from b to e) been associated with a plant or plants that were alive in b and will be alive in e, up to any degree of separation.[30] All DL firms are IL firms, by definition.

B MPRO as a Share of Sector Inputs

Figure A.1 reports the share of each two-digit NAICS sector's inputs represented by Management (NAICS 55) and Professional Services (NAICS 54) versus labor (BEA code V00100) and other sectors.

[30] We identify IL plants in four steps. First, within each firm-year, we identify the minimum birth year and maximum death year of all plants. Second, within plants, we identify the minimums and maximums just computed across the firms with which the plant is associated from year b to year e. Third, for each firm-year, we compute the minimum and maximum of the just-computed plant information. Finally, we repeat these three steps until no more changes are made, with each step representing a degree of separation, e.g., associated with a plant, associated with a plant that was associated with a plant, and so on. This iteration captures all shuffling of plants across firmids that takes place between years b and e, and can account for firms that completely change their mix of plants over time, as long as there is some overlap. While this algorithm allows for any number of degrees of separation, in practice we find the largest to be 7 (one more than John Guare!). The number of IL firms in a typical year does not change substantially as one allows for from 1 to 7 degrees of separation.

Figure A.1: MPRO Share of Sector Inputs, 1997



Source: Bureau of Economic Analysis and authors' calculations. Figure displays the share of each sector's inputs accounted for by Management (NAICS 55) and Professional Services (NAICS 54). Data are from the detailed 1997 US Supply-Use Table published on the BEA website. The activities encompassed by the various two-digit NAICS sectors are listed in Figures 1 and 3 of the main text.

C Additional Within-Firm Employment and Payroll Change Results

Tables A.1 and A.2 report changes in manufacturing (M) and non-manufacturing (NM) employment across firms taking one of three actions each with respect to manufacturing (M) and non-manufacturing (NM) employment between 1977 and 2016: decrease it, leave it unchanged, or increase it. Table A.1 reports results for M firms that enter after 1977 or exit before 2016, while Table A.2 displays results for continuing and entering or exiting NM firms. Analogous results for continuing M firms are reported in Table 3 of the main text. These results are discussed in Section 2.5 of the main text.

Table A.1: Employment Growth Among Manufacturer Births and Deats

M Firm Birth/Death
M Employment Change

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	-6.3	-5.1	0.0	-11.4
$\Delta Emp^{M} = 0$	0.0	0.0	0.0	0.0
$\Delta Emp^{M} > 0$	0.0	4.1	2.8	6.9
Total	-6.3	-1.0	2.8	-4.5

M Firm Birth/Death
NM Employment Change

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	-5.6	0.0	0.0	-5.6
$\Delta Emp^{M} = 0$	-1.2	0.0	3.9	2.7
$\Delta Emp^{M} > 0$	0.0	0.0	3.6	3.6
Total	-6.8	0.0	7.5	0.7

Source: Longitudinal Business Database and authors' calculations. Table reports the change in manufacturing (M) and non-manufacturing (NM) employment, in millions of workers, across manufacturing firms that are born or die between 1977 and 2016 engaged in one of nine mutually exclusive activities: dropping, maintaining or increasing their M employment (i.e., $\Delta Emp^{M} < 0$, $\Delta Emp^{M} = 0$, and $\Delta Emp^{M} > 0$), and dropping, maintaining and increasing their NM employment (i.e., $\Delta Emp^{NM} < 0$, $\Delta Emp^{NM} = 0$, and $\Delta Emp^{NM} > 0$). Panels 1 and 2 report changes in M and NM employment, respectively. Firms are defined according to Census firmids, as outlined in Section 2.1.2. Manufacturing firms are defined as firms that have manufacturing employment in at least one year of the 1977 to 2016 sample period.

Table A.2: 1977 to 2016 NM Employment Growth Among NM Firms

Continuing NM Firms

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	na	na	na	na
$\Delta Emp^{M} = 0$	-1.8	0.0	14.5	12.7
$\Delta Emp^{M} > 0$	na	na	na	na
Total	-1.8	0.0	14.5	12.7

NM Firm Birth/Death

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	na	na	na	na
$\Delta Emp^{M} = 0$	-29.6	0.0	69.7	40.1
$\Delta Emp^{M} > 0$	na	na	na	na
Total	-29.6	0.0	69.7	40.1

Source: Longitudinal Business Database and authors' calculations. Table reports the change in non-manufacturing (NM) employment, in millions of workers, across non-manufacturing firms engaged in one of nine activities between 1977 and 2016: dropping, maintaining or increasing their M employment (i.e., $\Delta Emp^{M} < 0$, $\Delta Emp^{M} = 0$, and $\Delta Emp^{M} > 0$), and dropping, maintaining and increasing their NM employment (i.e., $\Delta Emp^{NM} < 0$, $\Delta Emp^{NM} = 0$, and $\Delta Emp^{NM} > 0$). Panel 1 reports changes for firms that survive the 1977 to 2016 sample period, while panel 2 reports results across firms that enter or exit over this period. Firms are defined according to Census firmids, as outlined in Section 2.1.2. Non-manufacturing firms are defined as firms that do no have manufacturing employment in any year of the sample period.

Table A.3: Payroll Growth Among Continuing Manufacturers

Continuing M Firms
M Payroll Change

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	-11.6	3.1	20.3	11.8
$\Delta Emp^{M} = 0$	0.0	0.3	0.0	0.3
$\Delta Emp^{M} > 0$	23.7	27.9	126.6	178.2
Total	12.1	31.3	146.9	190.3

Continuing M Firms
NM Payroll Change

	$\Delta Emp^{NM} < 0$	$\Delta Emp^{NM} = 0$	$\Delta Emp^{NM} > 0$	**Total**
$\Delta Emp^{M} < 0$	28.7	0.0	263.4	292.1
$\Delta Emp^{M} = 0$	11.7	0.0	259.4	271.1
$\Delta Emp^{M} > 0$	6.5	0.0	310.2	316.7
Total	49.6	0.0	833.0	879.9

Source: Longitudinal Business Database and authors' calculations. Table reports the change in manufacturing (M) and non-manufacturing (NM) payroll, in trillions of workers, across manufacturing firms that survive (i.e., continue) from 1977 to 2016 and engage in one of nine mutually exclusive activities: dropping, maintaining or increasing their M employment (i.e., $\Delta Emp^{M} < 0$, $\Delta Emp^{M} = 0$, and $\Delta Emp^{M} > 0$), and dropping, maintaining and increasing their NM employment (i.e., $\Delta Emp^{NM} < 0$, $\Delta Emp^{NM} = 0$, and $\Delta Emp^{NM} > 0$). Top panel reports changes in M payroll while bottom panel reports changes in NM payroll. Firms are defined according to Census firmids, as outlined in Section 2.1.2. Manufacturing firms are defined as firms that have manufacturing employment in at least one year of the 1977 to 2016 sample period.