Firm Reorganization, Chinese Imports, and US Manufacturing Employment*

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Abstract

What is the impact of Chinese imports on employment of US manufacturing firms? Previous papers have found a negative effect of Chinese imports on employment in US manufacturing establishments, industries, and regions. However, I show theoretically and empirically that the impact of offshoring on firms, which can be thought of as collections of establishments - differs from the impact on individual establishments - because offshoring reduces costs at the firm level. These cost reductions can result in firms expanding their total manufacturing employment in industries in which the US has a comparative advantage relative to China, even as specific establishments within the firm shrink. Using novel data on firms from the US Census Bureau, I show that the data support this view: US firms expanded manufacturing employment as reorganization toward less exposed industries in response to increased Chinese imports in US output and input markets allowed them to reduce the cost of production. More exposed firms expanded employment by 2 percent more per year as they hired more (i) production workers in manufacturing, whom they paid higher wages, and (ii) in services complementary to high-skilled and high-tech manufacturing, such as R&D, design, engineering, and headquarters services. In other words, although Chinese imports may have reduced employment within some establishments, these losses were more than offset by gains in employment within the same firms. Contrary to conventional wisdom, firms exposed to greater Chinese imports created more manufacturing and nonmanufacturing jobs than non-exposed firms.

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1 Introduction

Employment in US manufacturing has been declining for decades.[1] The rise in imports from China, as a consequence of China's joining the World Trade Organization (WTO) in 2001,[2] has been identified as the major driving force behind this trend. Previous papers have shown that increased imports in US output markets (Autor et al., 2013; Acemoglu et al., 2016) and the elimination of uncertainty related to setting bilateral tariffs between China and the US (Pierce and Schott, 2016) led to a decline in employment at more exposed US manufacturing establishments and manufacturing industries, as well as the local labor markets that hosted these establishments.[3] However, these employment losses measured at the establishment and local labor market levels could have been compensated for by gains resulting from cross-industry reorganization of the activities of firms that owned the exposed establishments.[4]

This paper uses the firm as the unit of analysis. Firms are bundles of establishments in the same or different industries,[5] using multiple material input products to produce multiple output products.[6] Thus, by focusing on the firm, I account for potential adjustments in employment due to reorganization. In particular, I consider the national activity of firms in the US that had a presence in US manufacturing industries ("US manufacturing firms" hereafter), and thus owned the exposed manufacturing establishments. I develop a methodology that allows me to characterize firms' organization and decompose their total employment into employment associated with manufacturing and other non-manufacturing industries. I construct a novel data set for firms in the US by using confidential micro data from the US Census Bureau. Using this data set, I show that the employment of US manufacturing firms rose in response to increasing Chinese imports in US output markets. More exposed firms expanded employment (i) in manufacturing, as they hired production workers whom they paid higher wages, and (ii) in non-manufacturing, by adding jobs in R&D, design, engineering, and headquarters services. In other words, China caused a relative expansion of US employment in firms operating in industries that experienced the largest growth in Chinese imports. I argue theoretically and provide reduced-form evidence that this was possible through firms' reorganization toward less

[1] Baily and Bosworth (2014) document a long-standing decline in the share of total employment attributable to manufacturing establishments in the last five decades.

[2] Autor et al. (2013) show that trade with China accounted for most of the decline in US manufacturing employment in the last two decades. They identify technological changes in the 1980s and early 1990s, and increased imports from China in the late 1990s and early 2000s, as the reasons behind this secular trend in US manufacturing employment.

[3] However, Baily and Bosworth (2014) argue that the persistence in this trend seems inconsistent with stories of a recent or sudden crisis in US manufacturing industries, or trade liberalization episodes between the US and other countries.

[4] Company reports and anecdotal evidence indicate that most of the major US firms in the Fortune 500 category that owned the shrinking manufacturing establishments have been experiencing a rapid increase in value added, sales, and employment.

[5] Bernard et al. (2007) document that only about 20 percent of US firms are multi-establishment. Yet they account for a huge part of the real economic activity in the US: 80 percent of sales and 75 percent of aggregate employment.

[6] According to the US Census Bureau, "A firm is a business organization consisting of one or more domestic establishments that were specified under common ownership or control. The firm and the establishment are the same for single-establishment firms."

exposed output industries, in which the US had a comparative advantage relative to China. In these output industries, firms expanded skilled employment by taking advantage of falling production costs due to increased offshoring to China. These findings, which are complementary to those in the previous literature, indicate that employment losses at the establishment level, measured in previous papers were compensated for by the employment gains that resulted from within-firm reorganization and employment growth in response to the combined effects of increased Chinese imports in US output and input markets.

The methodology I develop allows me to characterize firms' organization and derive decompositions of firm level and aggregate employment across both manufacturing and other non-manufacturing industries. I apply these decompositions to a novel data set on US firms, which I construct by using confidential data sets from the US Census Bureau (Census of Manufactures, Commodity Flow Survey, Longitudinal Business Dataset, and Longitudinal Foreign Trade Transaction Dataset) in four Census years between 1997 and 2012.[7] These data provide information on (i) the universe of firms' establishments, their industrial classification, employment, and average wage; (ii) firms' import and export transaction value, quantity, and prices at the product, country of origin, and destination level; and (iii) firms' material inputs and output products and their prices.

Exploiting the unique feature of the data set, I trace, for the first time in the international economics and industrial organization literature, many dimensions of US firms' organization. First, I characterize US firms' organization across manufacturing and other non-manufacturing industries, and compute the number of employees associated with these industries within the firm. Second, I document how US firms organize the sourcing of their material input products across four types of procurement: in-house production in the US, sourcing from a supplier in the US, producing abroad in a factory owned by the firm, or sourcing from an independent supplier located outside the US.

US firms, and in particular firms that initially owned US manufacturing establishments, exhibited a substantial change in their organization across industries between 1997 and 2012. The decomposition of aggregate national employment indicates that firms in the US exhibited different trends in employment than establishments did: aggregate national employment in establishments classified in manufacturing declined between 1997 and 2012, yet the firms that owned these establishments created jobs in non-manufacturing industries such as retail-wholesale, information, professional services, administrative support, and management. Thus, within-firm reorganization across industries was substantial, particularly in the case of US manufacturing firms. These firms compensated for job losses in manufacturing establishments through reorganization toward non-manufacturing industries. These descriptive facts strongly suggest that firms may respond to industry-specific shocks, such as the China shock, differently than establishments, as they may reorganize employment across industries. Therefore, the measured differential impact of the China shock on manufacturing establishments

[7]The Economic Census is conducted every five years. Thus, the data used in this paper consist of four repeated cross-sections in 1997, 2002, 2007, and 2012. These cross-sections can be linked over time by using the unique longitudinal firm identifier.

found in previous studies could only be part of the overall effect.

To account for potential adjustment in employment due to reorganization in response to increased Chinese imports, I move the unit of analysis from the manufacturing establishment to the manufacturing firm. I examine the effect of the surge in Chinese imports in US output and input markets on US manufacturing firms' employment between 1997 and 2007. I start my analysis by estimating the causal impact of Chinese imports in US output markets on US manufacturing firms' employment. I conduct this analysis in two steps. First, I estimate the impact at the industry level. This allows me to account for firms' entry and exit that may have occured between Census years. I define employment in manufacturing industries as the sum of employment across firms that have their main output product in the same manufacturing industry; in this way, I can take into account potential adjustments in employment due to reorganization. In line with previous literature, I measure the exposure to Chinese imports through US output markets as the growth in Chinese imports to US manufacturing industries. I use the same methodology as in previous studies (Acemoglu et al., 2016; Autor et al., 2013, 2015; Bloom et al., 2015; Hummels et al., 2016) to quantify and identify the causal impact of increased Chinese imports on the employment of US manufacturing firms. This consists of measuring the difference in employment growth across initially similar US manufacturing industries, but with different levels of exposure to increasing imports from China.

The estimation results provide a set of novel findings relative to previous studies. First, more exposed US manufacturing industries expanded total employment as more jobs were added, not only in manufacturing activities but also in non-manufacturing activities that are complementary to high-skill and high-tech intensive manufacturing, such as R&D, design, engineering, and headquarters services. Second, expansion in manufacturing employment in the more exposed industries was due to expansion in production activity rather than non-production activity, as the number of manufacturing establishments and production workers[8] increased in more exposed industries. The estimates imply a 1.5 percent faster growth per year in employment in the manufacturing industry with the 75th percentile exposure relative to the one with the 25th percentile exposure. This resulted from a faster increase in the number of manufacturing workers and high-skilled employment in services by 1 percent, and 0.5 percent per year. These findings are complementary to the previous literature, which uses establishment as the unit of analysis, and suggest that reorganization allowed US manufacturing firms to escape the negative impact of industry-specific shocks. For instance, relative to the findings of Acemoglu et al. (2016) or Autor et al. (2013), my findings suggest that reorganization toward non-exposed industries allowed US firms to create jobs that more than offset the losses measured at the establishment level.

To assess the importance of within-firm reorganization, the second step of the analysis focuses on

[8]Production workers are engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, shipping, maintenance, repair, janitorial and guard services, product development, auxiliary production for plant's own use (e.g., power plant), recordkeeping, and other services closely associated with these production operations.

estimating the causal impact of increased Chinese imports in US output markets on US manufacturing firms' employment. I quantify firms' exposure by computing the weighted average of the change in imports from China to the main output industries of the firms' establishments in the pre-shock year 1997. I identify the impact on US manufacturing firms' employment by exploring the variation in the exposure that resulted from differences in firms' initial patterns of industrial specialization.

I find that more exposed US manufacturing firms expanded employment in US manufacturing activities by hiring more production workers, whom they paid higher wages, and adding non-manufacturing jobs such as headquarters services. These findings are in line with those of the industry-level analysis, and suggest that more exposed US manufacturing firms reorganized their US activities toward less exposed industries. This reorganization allowed them to grow, as the number of jobs they created fully compensated for the number of jobs they destroyed in manufacturing industries in which they could not compete with the Chinese. The estimates predict that a US manufacturing firm with 75th percentile exposure, relative to one with 25th percentile exposure, grew by 1.2 percent faster per year as it added production workers in manufacturing. The estimates also imply that the average wage of workers in a US manufacturing firm with 75th percentile exposure relative to one with 25th percentile exposure increased by 2 percent faster per year. These findings suggest that expansion in employment happened in industries in which the US has a competitive and comparative advantage relative to China: skill- and high-tech intensive activities. All of these findings are suggestive of a mechanism akin to the trade in task theory developed in Grossman and Rossi-Hansberg (2008).

To illustrate this and guide my empirical investigation of the potential mechanism, I develop a firm-level theory in which firms own establishments. This theory embeds the Grossman and Rossi-Hansberg (2008) offshoring task technology into the firm. Trade liberalization in this model induces (i) within-firm cross-industry reorganization of domestic activity toward more skill-intensive production, and (ii) expansion in the employment of high-skilled employees in establishments of the firm that assemble the more skill-intensive intermediate good (i.e., less exposed establishments of the firm) relative to more exposed establishments. These qualitative predictions are consistent with my empirical findings that increased Chinese imports in US output markets leads to reorganization toward high-skill intensive production and expansion in US manufacturing firms' high-skilled employment.

The model predicts the following mechanism through which employment growth happens. As imports become cheaper, firms reorganize their domestic activity by offshoring more of the less skill-intensive production. This allows them to reduce the cost of production. Consequently, the price of outputs they produce falls and, thus, demand increases. To meet the increasing demand, the firm increases domestic production by hiring more workers. As more and less skill-intensive intermediates are complements in the production of the output, the firm expands the employment of high-skilled workers by adding more of this skill type in the less exposed establishment relative to the more exposed establishment.

Data on US manufacturing firms provide empirical evidence of this qualitative mechanism, and show that the increased Chinese imports in US input markets acted as a favorable cost shock to US manufacturing firms. Firms sourcing material products from industries that registered larger increases in Chinese imports offshored more. Data also indicate that a typical US manufacturer increased foreign outsourcing of a typical material input product from 15 percent in 1997 to 23 percent in 2007, mostly by replacing US suppliers with Chinese ones, while foreign direct investment went up by only 3 percentage points. Second, firms sourcing materials from more exposed industries registered a swift decline in the unit cost of material inputs which allowed them to reduce the cost and expand US production. Estimates indicate that the unit cost of a material input sourced by US manufacturing firms with 75th percentile exposure relative to one with 25th percentile exposure registered a 2 percent larger decline per year. Finally, my findings indicate that the decline in the cost of sourcing and the possibility of offshoring allowed US manufacturers to procure more materials and expanded employment in manufacturing.

All of these findings suggest that the dramatic increase in Chinese imports did not induce a decline in US manufacturing fims' activity. My findings strongly suggest that US manufacturing firms greatly benefited from the combined effects of the increased Chinese imports in US input and output markets, which allowed them to more efficiently allocate resources by reorganizing toward industries in which they had a comparative and competitive advantage relative to China. In these industries, US manufacturing firms expanded manufacturing employment as they created jobs that more than offset the number of jobs they destroyed in industries in which the US could not compete with China. This growth was possible as US manufacturing firms took advantage of the favorable Chinese cost shock that allowed them to reorganize their material sourcing and produce in the US at a lower unit cost.

This paper is related to four strands of literature. First, an extremely influential line of research (Acemoglu et al., 2016; Autor et al., 2013, 2014, 2016; Pierce and Schott, 2016) has shown that US manufacturing establishments more exposed to growing imports from China in their output markets - and industries and regions hosted these establishments - registered a sharp decline in employment relative to the less exposed. My paper complements this literature by showing that the relative employment losses measured by previous papers at the plant level have been more than offset by relative gains resulting from (i) within-firm reorganization and (ii) expansion of skilled employment due to the falling cost of production. Therefore, my paper provides a series of novel findings that suggest that the possibility of offshoring to China opened up new opportunities for US firms that had a presence in manufacturing industries which allowed them to achieve a more efficient allocation of resources through reorganization and expand their US employment, even in manufacturing. My paper complements the growing body of empirical trade literature that shows that offshoring (Hummels et al., 2016; Chang and Steinwender, 2016), and in particular offshoring to China (Bloom et al., 2015), may have benefited European manufacturing firms and their workers by enhancing the firms' productivity and innovation activity.

Second, my paper is closely related to a rapidly growing literature that examines the relationship between firm and plant organization and performance. Extensive work in this area has focused on theories on plants' material input sourcing decisions.[9] Recently a series of papers have attempted to document stylized facts consistent with these theories. However, due to a lack of data, they could only capture some part of the sourcing decision, such as domestic sourcing by US plants (Atalay et al., 2013) or foreign sourcing by US multinational firms (Ramondo et al., 2016). These papers show that firms and plants tend to make only a small share of their material inputs, and source the rest from third party suppliers. By considering, for the first time, make and buy decisions across borders - together with those in the US - I show that US firms tend to make a substantial part of their inputs (i.e., about one-quarter) in plants located in the US or abroad. Moreover, I show that firms frequently make and buy the same input, which suggests that the fixed-cost-based modeling of firms' sorting across different sourcing types may assume away interesting patterns in firms' behavior. Recent papers in this literature have further documented evidence on firms' organization across output markets by distinguishing between manufacturing and non-manufacturing industries (Bernard and Fort, 2015; Bernard et al., 2016). I contribute to this literature by providing descriptive findings that US firms exhibit a strong deindustrialization pattern as in aggregate they shift employment from manufacturing to non-manufacturing activities.[10]

Third, my paper contributes to the literature on how trade liberalization affects plant and firm performance. Several influential studies have examined how trade liberalization affects prices through the markup and marginal cost channel,[11] productivity,[12] innovation and R&D,[13] and product scope and quality.[14] Contrary to these papers, I move the unit of analysis from the plant to the firm and consider a new margin at which firms may adjust in response to trade shocks: reorganization. I show that changes in firms' organization in two dimensions - across manufacturing and non-manufacturing industries, and material input sourcing decisions in terms of buy versus produce domestically or abroad - in response to trade liberalization allow the firm to produce more cheap and grow. As my theoretical explanation consists in building a firm-level theory that imbeds the Grossman and Rossi-Hansberg (2008) reorganization, my paper also contributes to the trade theory literature[15] in this area that shows how offshoring impacts employment and firms' performance through changes in the organization of domestic economic activity.

Finally, a large body of the industrial organization literature provides theoretical explanations of

[9] Grossman and Helpman (2002), Grossman and Helpman (1999), Antras and Helpman (2004), and Antras and Chor (2013).

[10] A rapidly growing literature takes a further step in examines how plants organize workers across different occupational hierarchies (Caliendo et al., 2015; Garicano and Rossi-Hansberg, 2015), and document adjustment in these hierarchies in response to trade liberalization (Guadalupe and Wulf, 2010).

[11] Amiti and Konings, (2007), and DeLoecker et al. (2015).

[12] De Loecker (2007, 2011), Lileeva and Trefler (2010), and Bustos (2011).

[13] Baldwin and Robert-Nicoud (2008), and Atkeson and Burstein (2010).

[14] Amiti and Khandelwal (2013), Bas and Ledezma (2010), Bas and Bombarda (2013), Broda and Weinstein (2006), Goldberg, Khandelwal, Pavcnik, and Topalova (2010), Khandelwal (2010), and Kugler and Verhoogen (2012).

[15] Ossa and Chaney (2013), Baldwin and Robert-Nicoud (2014), Burstein and Vogel (2016).

the determinants of the firm's boundary (Williamson; 1975, 1979, 1985; Klein et al., 1978; Grossman and Hart, 1986; Hart and Moore, 1990; Loertscher and Riordan, 2016).[16] Most papers that study the empirical implications of these theories focus on a particular industry (Hortascu and Syverson, 2007) or use company case studies (Whinston, 2003) or large cross sections of firms across countries (Acemoglu et al., 2009). My paper provides new stylized facts on US firms' vertical integration patterns in US and across borders for the whole universe of US manufacturing industries (e.g., electrical equipment, transportation equipment, chemicals, etc.), as well as a series of novel findings on these firms' make and buy decisions that can be used as empirical evidence to discriminate between these theories.

The rest of the paper is organized as follows. Section 2 presents the methodology based on which I characterize firms' organization. Section 3 presents the data and documents descriptive facts on US firms' reorganization. Section 4 presents my analysis of the causal impact of increased Chinese imports in US output markets on employment by US manufacturing firms and manufacturing industries defined based on the firm. Section 5 provides a theory of the firm that qualitatively rationalizes this finding. This theory provides the mechanism through which increased offshoring can lead to expansion in firms' high-skilled employment: US manufacturing firms' reorganization toward industries in which the US had a comparative advantage, and expand employment in these industries by taking advantage of the favorable cost shock induced by China. Section 6 documents empirical facts consistent with this mechanism. Section 7 concludes.

2 Firms, Establishments, and Industries

To provide empirical evidence of within-firm and cross-industry reorganization and its implications for trends in employment, in this section I develop a methodology to characterize firms' organization and decompose firms' overall employment associated with manufacturing and other non-manufacturing industries. In particular, I outline a series of definitions that pin down the mapping between firms, establishments, and industries. I use this mapping in the rest of the paper to show the importance of changes in within-firm cross-industry reorganization for understanding the trends in US aggregate employment and how US manufacturing employment responded to the surge in Chinese imports. To describe the mapping between establishments, firms, and their industrial classification, I begin by defining each term. Next, I define the criteria I use to classify the establishments and firms into two types, manufacturing and non-manufacturing. Finally, I describe how establishments within the firm are classified into two types of activities, manufacturing and non-manufacturing.

Establishments, $e \in E_t$, are unique physical locations in the US where business is conducted and

[16] For a more recent review of the literature see Bresnahan and Levin (2012) and Riordan (2008).

are classified by the Census Bureau[17] to a industry based on their primary business activity.[18] By using this industrial classification of establishments, I define the set of *manufacturing establishments*, M_t, in the US, which consists of the collection of establishments classified by the US Census Bureau into industries with NAICS-2 codes between 31 and 33.[19] Thus, this set consists of plants and factories that specialize in the production of goods. Similarly, the set of *non-manufacturing establishments*, N_t, consists of the collection of establishments classified to industries with NAICS-2 codes such as 11, 21-23, and 42-81.[20] Given these definitions of the sets of manufacturing and non-manufacturing establishments, the set of all the establishments in the US, $E_t = M_t \cup N_t$, contains establishments in which private, non-farm business activities are conducted.[21]

Firms, $f \in F_t$, are collections of establishments in the US under common ownership and control.[22] This implies that each firm f at time t strategically decides on the size and the composition of the set of establishments it owns, E_{ft}, as it determines which industries to enter, how many establishments to operate in each of these industries, their geographical locations, and how many workers to hire in each establishment. Therefore, *decisions across establishments within the firm are interdependent.* The firm and the establishment are the same in the case of single-establishment firms, in which case the set E_{ft} has one element. Multi-establishment firms represent about 40 percent of all firms in the US in the period between 1997 and 2012, and they account for about 85 percent of aggregate sales and 75 percent of aggregate employment in the US.[23]

Given the industrial classification of the establishments within the firm, the set of establishments within firm f at time t, E_{ft}, can be decomposed into (i) the set of establishments classified to manufacturing industries, $e \in E_{M,f,t}$, which I label as *manufacturing activity* within firm f at time t, and (ii) the set of establishments classified to non-manufacturing industries, $e \in E_{N,f,t}$, which I label as *non-manufacturing activity* within firm f at time t.

I define the *organizational structure of the firm* as the division of the firm's total activity across manufacturing and non-manufacturing activities. Using the previously introduced notation, this im-

[17]Ideally, the primary business activity of an establishment is determined by the relative share of production costs and/or capital investment. In practice, other variables, such as revenue, value of shipments, or employment, are used as proxies. The Census Bureau generally uses revenue or value of shipments to determine an establishment's primary business activity. For more detail, https://www.census.gov/econ/susb/definitions.html.

[18]Establishments can be, for example, a factory, mill, store, hotel, movie theater, mine, farm, sales office, warehouse, central administrative office, etc.

[19]The industrial classification in the US changed in 1997 from the Standard Industrial Classification to the North American Industrial Classification System. To ensure that my results are not contaminated by changes in industrial classification, I stick to the sample period between 1997 and 2012, which allows me to use a consistent industrial classification over time.

[20] This set contains all the establishments that specialize in retail-wholesale, business and professional services, research and development, finance, etc.

[21]Establishments owned by the government and classified by NAICS-2 code 92, *"Public Administration,"* are not included in this set.

[22]For more detail on this statistical definition, see https://www.census.gov/econ/susb/definitions.html.

[23]Bernard and Jensen (2007) document that in the period between 1992 and 1997 multi-establishment manufacturing firms are more likely to conduct multinational activity and are less likely to close down plants.

plies that the set of establishments of firm f at time t can be written as the union of the set of establishments in the two types of activities of the firm, $E_{ft} = E_{M,f,t} \cup E_{N,f,t}$. To illustrate this, panel A of Figure 1 shows a firm that owns three establishments. Two are in manufacturing industries 1 and 2, and the third is in non-manufacturing industry 1. Thus, in this example the two establishments in the manufacturing industries constitute the manufacturing activity within the firm, while the establishment in the non-manufacturing industry constitutes its non-manufacturing activity.[24]

One major advantage of using this definition of firm organization is that it capture establishment entry and exit within the firm. Therefore, if a firm relocates an existing establishment to another location within the US or changes the main industry of a given establishment, the resulting establishment entry and exit is captured by the change in set E_{ft} and by changes in the two components of the set.

Given the organizational structure of the firm,[25] total employment by firm f at time t, L_{ft}, can be decomposed into (i) *employment in manufacturing activity* within the firm, $L_{M,f,t}$, defined as the number of employees in the set of establishments that constitute the manufacturing activity within the firm, $e \in E_{M,f,t}$:

$$L_{M,f,t} = \sum_{e \in E_{M,f,t}} L_{e,f,t} \tag{1}$$

as well as (ii) *employment in the non-manufacturing activity* within the firm, $L_{N,f,t}$, as the number of employees in the set of establishments that constitute the non-manufacturing activity within the firm, $e \in E_{N,f,t}$:

$$L_{N,f,t} = \sum_{e \in E_{N,f,t}} L_{e,f,t} \tag{2}$$

Given the definition of employment in manufacturing and non-manufacturing activities within the firm, I group US firms into two categories. I divide the set of all firms in the US at time t, F_t, into the set of manufacturing, $F_{M,t}$, and the set of non-manufacturing firms, $F_{N,t}$, such that $F_t = F_{M,t} \cup F_{N,t}$. Firm f is a *manufacturing firm*,[26] $f \in F_{M,t}$, if it has employment in manufacturing activities at time $t-1$, $L_{M,f,t-1} > 0$. By using the illustrative example in panel A of Figure 1, this firm may be classified as a manufacturing firm if it has at least one employee in establishments classified to manufacturing industry 1 or 2.[27] Similarly, I define firm f as a *non-manufacturing firm*, $f \in F_{N,t}$, if it does not

[24]According to a case study published by the Reshoring Institute, General Electric (GE) owns both manufacturing and non-manufacturing establishments in the US. Thus, the set of manufacturing establishments owned by GE in the US constitutes the manufacturing activity within GE as a firm, while the collection of non-manufacturing establishments owned by GE in the US constitutes the non-manufacturing activity of GE. For more detail, see https://www.reshoringinstitute.org/wp-content/uploads/2015/05/GE-Case-Study.pdf.

[25]Since establishments are classified based on their main industry, the proportion of employment a firm has in manufacturing and non-manufacturing depends on whether the firm chooses to organize these activities within the same or different establishments. Future research investigates to what extent this choice have changed systematically over time.

[26]This is not the only possible definition. For instance, Bernard et al. (2016) uses a similar definition to classify firms in Denmark into the category of manufacturing firms. They assume that a firm is manufacturing if its manufacturing to total employment share is greater than 5 percent. As a robustness check, I use their definition. The results of my employment decompositions are robusts to this alternative definition.

[27]For example, based on the companies' public reports GE, GM, and Apple are manufacturing firms, as they own and employ workers in plants located in the US. For more information, see https://www.gm.com/mol/stockholder-

employ workers in manufacturing activities at time $t-1$, $L_{M,f,t-1} = 0$.[28] By using the illustrative example in panel A of Figure 1, this firm may be classified as a non-manufacturing firm if it has no employee in the establishments classified to manufacturing industry 1 or 2.[29]

Given the definitions of these firm types, the total firm level employment of each type of firm can be decomposed into employment in manufacturing and non-manufacturing activities within the firm. On the one hand, total employment of manufacturing firm f, $L^M_{f,t}$, can be decomposed into employment in manufacturing, $L^M_{M,f,t}$, and non-manufacturing activities, $L^M_{N,f,t}$, within the firm:

$$L^M_{f,t} = L^M_{M,f,t} + L^M_{N,f,t} \tag{3}$$

On the other hand, in the case of non-manufacturing firms, total employment can be decomposed by employment in manufacturing, $L^N_{M,f,t}$, and non-manufacturing activities, $L^N_{N,f,t}$, within the firm:

$$L^N_{f,t} = L^N_{M,f,t} + L^N_{N,f,t} \tag{4}$$

These decompositions of firm level employment clearly illustrate how interdependencies across establishments within the firm may contribute to changes in overall firm level employment. As I show in equation (5), changes in total employment by firm f at time t, $\triangle L_{ft}$, may result from changes in employment associated with manufacturing or non-manufacturing activities that are the results of adjustments in (i) the set of establishments associated with manufacturing, $E_{M,f,t}$, or non-manufacturing activities, $E_{N,f,t}$, within the firm (i.e., adding and dropping establishments from manufacturing or non-manufacturing), or (ii) employment associated with the newly added, dropped, or surviving establishments in each of these sets:

$$\triangle L_{ft} = \left(\sum_{e \in E_{M,f,t}} L_{e,f,t} - \sum_{e \in E_{M,f,t-1}} L_{e,f,t-1} \right) + \left(\sum_{e \in E_{N,f,t}} L_{e,f,t} - \sum_{e \in E_{N,f,t-1}} L_{e,f,t-1} \right) = \triangle L_{Mft} + \triangle L_{Nft} \tag{5}$$

Therefore, changes in total firm level employment may result not only from *changes in employment within the establishments of the firm* that survive from one period to the other, but also from *reorganizations of employment within the firm* across establishments in the same or different manufacturing or non-manufacturing industries. Therefore, these employment levels are jointly and endogenously determined and influence one another.

Reorganization within the firm may take place in many dimensions. First, firms may reorganize

information.html, http://www.ge.com/investor-relations/investor-services/personal-investing/annual-reports, or http://investor.apple.com/secfiling.cfm?filingid=1193125-15-356351&cik=320193

[28]Based on this definition, a firm is manufacturing if it has at least one employee in a manufacturing activity in year $t-1$ in the case of any $\{t-1,t\}$ pairs.

[29]For example, as their publicly available reports suggest, Goldman Sachs and UnitedHealth Group fall into this category of firms. For more information, see http://www.unitedhealthgroup.com/investors/financialreports.aspx or http://www.goldmansachs.com/investor-relations/financials/

employment within the same type of activity - i.e., *manufacturing* or *non-manufacturing* activity. In this case, firms may fire employees in manufacturing establishments or close down establishments, and hire new employees in other existing or newly opened manufacturing establishments. As a result of this reorganization, overall employment in the manufacturing activity of the firm may decline, stay the same, or increase, depending on the number of jobs eliminated relative to the number of jobs created. To illustrate this, Figure 1 shows how the structure of the firm in my example changed from one period to the next as the firm closed the establishment in manufacturing industry 1, kept the establishment in manufacturing industry 2, and opened up a new establishment in manufacturing industry 5. The relative importance of the changes in employment that resulted from these changes in the firm's organizational structure determines the overall changes in manufacturing employment within the firm. Similar types of *reorganization within the non-manufacturing activity* of the firm may lead to similar changes in employment in non-manufacturing activities within firms. Second, firms may *reorganize employment across manufacturing and non-manufacturing activities*.[30] Firms may eliminate jobs in manufacturing activities by reducing employment within or closing manufacturing establishments, and hire more employees in existing or newly opened establishments in non-manufacturing activities such that overall firm level employment may expand, shrink, or stay the same.[31]

Depending on the importance of the *reorganization* margin relative to the within-establishment adjustment, firms may expand in total employment or may expand in employment associated with manufacturing or non-manufacturing activities. These may not be the same jobs or the same employees in the same establishment of the firm classified to the same industry, but the firm may expand in its overall activity or in a certain type of activity even if it reduces employment in certain establishments. Thus, this suggests that within-firm reorganization could reconcile the fact that companies that had manufacturing activities grew over time, despite the fact that US manufacturing overall had been declining.

The possibility of within-firm reorganization may have implications for our understanding and measurement of the impact of industry-specific shocks on domestic economic activity. Since firms may reorganize from more exposed to less exposed industries, they may respond differently in terms of employment to industry-specific shocks than establishments. This is mainly because shocks with a differential impact across industries have differential impacts across the establishments of the firms classified to different industries. Thus, the firm may reduce employment in a negatively exposed industry by firing workers in or closing establishments classified to the exposed industries, while simultaneously expanding employment in existing or newly opened establishments in less exposed or non-exposed industries.[32] The overall firm level impact of the shock will depend on the extent

[30] Bernard et al. (2016) documents that this type of reallocation is substantial in Danish firms.

[31] For example, Apple's publicly available yearly reports show that in the last two decades, the company went through important organizational changes that mainly consisted of outsourcing all assembly to Foxconn in China, specializing in the production of high-tech sophisticated components in the US, and expanding design, engineering, R&D, and retail in the US.

[32] This implies that in the two-stage least squares estimator of the effect of the shock on establishments, $\hat{\beta}$, is an

to which the new jobs created within the firm through reorganization compensate for the decline in within firm employment in exposed industries.

To illustrate this, I assume that manufacturing industry 3 in Figure 1 is exposed to an industry-specific shock. Thus, this firm may reduce employmen or close the establishment in manufacturing industry 3, but expand or keep constant the level of employment in manufacturing industry 4 and non-manufacturing industry 1. At the same time, the firm may find it profitable to enter new industries, such as manufacturing industry 5, or non-manufacturing industry 2. An entry into manufacturing industry 5 would result in an expansion in the number of jobs in manufacturing within the firm; this could compensate for the decline in jobs due to the exit of manufacturing industry 1. All of these could lead to a decline, increase, or no change in manufacturing employment within the firm, depending on whether the newly created manufacturing jobs compensate or not for the number of jobs eliminated by the firm in manufacturing industry 1. This example clearly demonstrates that reorganization as a margin of adjustment in firm level employment in response to industry-specific shocks may allow firms to become net job creators even in manufacturing, despite the fact certain manufacturing establishments shrink.

Using these definitions, in the next section I derive a decomposition of aggregate US employment by firm and within-firm activity type. I use this decomposition to examine the importance of reorganization within US firms and its implications for understanding aggregate trends in US manufacturing employment. Then, as an example of an industry-specific shock in the US, I consider the swift increase in imports from China to US manufacturing industries that resulted from China's entry into the WTO. I estimate the impact of this shock on US manufacturing firms to show that reorganization within more exposed US firms was so substantial that it allowed them to escape the negative impact of the shock and expand employment in less exposed manufacturing industries.

3 Descriptive Evidence on Reorganization of US Firms

3.1 Data Sources

To characterize trends in employment by US manufacturing firms, estimate the causal impact of the China shock on these firms' employment, and document facts on the underlying mechanism, this paper builds on a novel data set with firm-establishment-product as unit of observation that covers the universe of US firms for Census years 1997, 2002, 2007, and 2012.[33] I construct this data set by

inconsistent estimator of the true effect, β. Let's denote the change in employment within establishments over time by Y, the shock to a particular establishment by X and the instrument of the shock by Z. If reorganization is present, then in the two-stage least square estimator $\hat{\beta} = (Z'X)^{-1}Z'Y = \beta + (Z'X)^{-1}Z'\varepsilon$ the term $(Z'X)^{-1}Z'\varepsilon$ is not zero. This is because the presence of reorganization across the establishments owned by the same firm leads to a correlation between the shock and error term across the establishments owned by the same firm. Statistically, this leads to a block diagonal $Z'\varepsilon$.

[33]The industrial classification in the US changed from the Standard Industrial Classification to the North American Industrial Classification System in 1997. In order to ensure my results are not contaminated by changes in industrial

combining four micro databases from the US Census Bureau: the Commodity Flow Survey (CFS), the Census of Manufactures (CMF), the Longitudinal Business Database (LBD), and the Longitudinal Foreign Trade Transaction Database (LFTTD).[34] I use the resulting data set to extract four types of information.

First, I characterize firm level employment and the organization of employment by industries within these firms. I exploit a unique feature of the LBD that allows me to observe the universe of firms in the US and their organizational structure across industries in terms of number of establishments, number of employees, and payroll by SIC-4 and NAICS-6 industries. Each of the firms in the LBD has a unique firm identifier,[35] and the dataset lists all the establishments the firm owns. By using this information, I can characterize the mapping between establishments and firms in the data. I measure the number of establishments and firm level employment by counting the number of establishments of the firm and summing employment across all establishments within the firm.

Each of the establishments of the firm is classified to an industry based on the main activity of the establishment. I use this information to define *manufacturing activity* (i.e., establishments with NAICS-2 between 31 and 33) and *non-manufacturing activity* (i.e., establishments with NAICS-2 as 11, 21-23, and 42-81) within the firm. Next, I define *manufacturing* and *non-manufacturing employment*, payroll, and the number of establishments within the firm as the sum of employment and payroll across establishments, and the number of establishments associated with each kind of activity within the firm. I further define the number of employees, payroll, and the number of establishments in retail-wholesale, transportation, professional services, finance, information, etc. as the sum of employment and payroll across the establishments classified to each of these industries[36] within the firm. Next, using this information, I define the firm's type as manufacturing if the firm has non-zero employment in manufacturing in $t-1$.[37] Finally, I define the firm's main manufacturing industry as the manufacturing industry in which the firm has the largest number of employees.[38]

Second, I use CMF base files to construct variables that capture the characteristics of the manufacturing activity (i.e., the collection of establishments classified to manufacturing within the firm according to the definition in Section 3) within the firm, such as the number of production and non-production workers employed in the manufacturing activity, capital intensity, average wage of workers in manufacturing, average wage of production workers, etc. The CMF contains information on the production characteristics of the whole universe of US establishments classified to manufacturing in-

classification, I stick to the sample period between 1997 and 2012 that allows me to use a consistent industrial classification over time.

[34]The Data Appendix contains technical details on the particular features of these databases. Also, I provide details on the way these four datasets are merged at the firm-product and firm-establishment-product level.

[35]The Census Bureau creates these firm identifiers by using information from the Business Register starting from 2002, and Standard Statistical Establishment List prior to 2002.

[36]Table 2 in the Data Appendix provides the exact definition of these activities in terms of NAICS2 classification.

[37]This definition of the manufacturing firm implies that the $t-1$ is different for each $\{t-1,t\}$ pairs. For instance, $t-1$ is 1997 when the {1997, 2007} years pair is considered.

[38]This definition is consistent with the definition of the main industry of the establishment used by the Census Bureau.

dustries, and thus the manufacturing activity within the firm. This allows me to construct production characteristics of the manufacturing activity within the firm by summing the number of production and non-production workers in the firm, total labor cost, capital expenditure, sales, value-added, etc. across manufacturing establishments within the firm. The average wage of workers in manufacturing is computed as the ratio between total payroll and total number of employees associated with the manufacturing activity within the firm. I compute the average wage of production workers as the payroll associated with production workers (i.e., the total manufacturing payroll times the share of production workers) divided by the number of production workers within the firm.

Third, I characterize the type of sourcing used by each firm to procure their material input products by combining information from the CMF base file, and material and product trailer files in the CMF, LBD, and LFTTD. Firms might source a fraction of their inputs of a given product within the firm and the remaining fraction outside the firm. Thus, in the case of each material input product used by the firm, I identify whether the firm produces or buys the material input domestically or abroad, and the total expenditure associated with each sourcing type.[39] The LBD contains information on the firm each establishment belongs to and the industrial classification of these establishments. I merge establishment-product level information from the CMF to firm-establishment mapping in the LBD. The resulting data set contains information on firms, the establishments of these firms, and the output and material input products of each firm's establishments. Thus, it becomes possible to identify whether a given material product used by the firm as material input is produced within the firm or procured from a third-party supplier. I assume that a given product of the firm results from domestic in-house production if there are two establishments within the firm such that one of them produces the product (i.e., the product is in the set of outputs of the establishment), while the other establishment uses the product as material input (i.e., the product is in the set of material input products of the establishment). Thus, this product is both output and material input within the firm. Once I have retrieved this information, I aggregate from the firm-establishment-product level to the firm-product level to measure the value and quantity of product at the firm level that is sourced from internal production of the firm ("*domestic insourcing*" hereafter).

The LFTTD import file contains information on the value and quantity of products, defined at the HS-10 level, that the firm imported in a given year from a given country. The LFTTD also has information on whether the import transaction is between related parties[40] or is an arm's-length transaction. Thus, I can distinguish between foreign direct investment (i.e., FDI) and foreign outsourcing. Using this information I identify, in the case of each HS product, if it falls into the category of *foreign insourcing* (i.e., produced in a plant of the firm located abroad) or *foreign outsourcing* (i.e., procured

[39]The Data Appendix includes detailed descriptions of the definitions and algorithms used to recover this information.

[40]Section 402(e) of the Tariff Act of 1930 defines related-party trade as transactions between parties with relationships as directly or indirectly, owning, controlling, or holding poIr to vote 6 percent or more of the outstanding voting stock or shares of any organization. Other sources of the US Census Bureau report that "a related party transaction is one between a U.S. exporter and a foreign consignee, where either party owns (directly or indirectly) 10 percent or more of the other party". For more information, see https://www.census.gov/foreign-trade/Press-Release/edb/2009/techdoc.pdf.

from a third-party supplier located abroad). Moreover, in the case of each firm-product pair, I define the value and quantity of imports from the five major trading partners of the US (i.e. Canada, China, Germany, Japan, and Mexico)[41] by using information about the country of origin of each import transaction.

To get a consistent product classification across products in the CMF, identified by NAICS-6 codes, and the products in the LFTTD, identified by HS-10 codes, I use the concordance tables constructed by Pierce and Schott (2011). This allows me to merge each HS-10 product code in the LFTTD import file with its NAICS-6 counterpart in the CMF. Then, I collapse the LFTTD import files from the HS-10 to the NAICS-6 product levels by adding up total value and quantity across the HS-10 products imported by the firm that fall into the same NAICS-6 category. Similarly, to measure total expenditure on foreign insourcing and outsourcing by NAICS-6 product category, I aggregate from HS-10 to NAICS-6 the total value and quantity of products imported based on arm's length and related party trade transactions.

I merge the firm-product level information, resulted from combining the LBD and CMF files, to the firm-product level information, which resulted from collapsing the import files to the firm-product level. The resulting data set contains information on the set of products used by the firm as material inputs; the value and quantity used by domestic insourcing, foreign insourcing, and foreign outsourcing; and the value and quantity of imports by the five major trading partners of the US. I assume that a material input product of the firm is sourced from a domestic supplier ("*domestic outsourcing*" hereafter) if the expenditure on the product by the firm is not zero after I subtract from the total per-product material expenditure the value of imports and the value of domestic in-house production.

Fourth, I construct material input and output prices at the NAICS-6 product level by using the material and product trailer files from the CMF. These files contain information on the set of products used by the establishments of the manufacturing firm as material inputs, and the set of products produced by the establishments of the manufacturing firm as outputs. These files also record values and quantities of each of these products by NAICS-6 digit. I define prices as unit values computed as the ratio between the value and quantity.[42]

Finally, I augment the microdata described in this section with publicly available information on US manufacturing industries. More precisely, I use information from the UN Comtrade Database to construct the measures of the China shock to US manufacturing industries and their instruments.

[41] These five countries together account for about 70% of the international trade transactions of the US with the rest of the world.

[42] Unit value as a proxy for prices is widely used in the international trade and industrial organization literature when prices are not directly observed. For instance, Amiti and Konings (2007) use this definition to define the prices of Indonesian plants, and DeLoecker et al. (2016) define in this way the prices of Indian plants. The main caveat of the material input and output product trailer files is that in some cases, firms do not report quantities. The US Census Bureau has attempted to impute the missing quantities. However, these imputed quantities lead to outliers in the unit values. Thus, I only use the information on prices when quantities are reported by the firm. For more detail, see White et al. (2012) and White (2014).

In particular, I use information on exports from China to the US and exports from China to the rest of the world at the six-digit HS product level. I use the concordances created by Pierce and Schott (2011) between HS, SIC-4, and NAICS-6 industrial classifications to quantify imports from China to US manufacturing industries defined at the four-digit SIC level.[43] In addition, I use the NBER-CES Manufacturing Industry Database for 1997 and 2007 to measure the value of shipments, the price index associated with these shipments with base year in 2007, and the employment of US manufacturing industries, defined as the collection of establishments classified to the same four-digit SIC manufacturing industry.

3.2 Trends in US Firms' Employment and Organization

To show that reorganization has implications for trends in employment, in this section I derive a decomposition of aggregate US employment. In particular, I decompose the growth rate of aggregate employment into growth due to manufacturing and non-manufacturing firms, and manufacturing and non-manufacturing activities within these firms. I apply the decomposition to the data described in the previous section. The decompositions indicate that reorganization across industries was substantial, particularly in the case of US manufacturing firms, and led to a different trend in firm level employment relative to trends observed at the establishment level.

Consistent with the findings of previous literature, aggregate US employment in establishments classified to manufacturing industries declined between 1997 and 2012. However, firms that owned declining US manufacturing establishments not only eliminated jobs in manufacutring by firing workers from manufacturing plants or closing plants, but also created jobs by hiring more workers in non-manufacturing industries such as retail-wholesale, professional services information, administrative support, and management. These findings suggest that if we look at trends in aggregate employment in the US through the lens of the firm instead of the establishment, the aggregate employment picture looks better: Reorganization within firms across industries allows firms to compensate for employment losses created in manufacturing. These may not be the same workers or the same jobs in the same industries, but firms that manufactured created jobs in net.[44] In what follows, I derive the decomposition and discuss the results.

Given the definition of the types of firms and activities within these firms in Section 3, I derive a decomposition of aggregate national level employment, L_t, by firm and activity types within the firm. Aggregate national employment at each time t can be decomposed as the sum of employment across manufacturing and non-manufacutring firms:

$$L_t = \sum_{f \in F_{M,t}} L^M_{f,t} + \sum_{f \in F_{N,t}} L^N_{f,t} = L^M_t + L^N_t \tag{6}$$

[43]The Data Appendix discusses these datasets in detail.

[44]There still could be important distributional effects of trade on workers with different types of skills or workers located in regions that were more affected by the China shock.

By using the definition of the manufacturing and non-manufacturing activities within the firm, this can further be decomposed into employment in the two types of activities within the firm:

$$
\begin{aligned}
L_t &= \sum_{f \in F_{M,t}} L^M_{M,f,t} + \sum_{f \in F_{M,t}} L^M_{N,f,t} + \sum_{f \in F_{N,t}} L^N_{M,f,t} + \sum_{f \in F_{N,t}} L^N_{N,f,t} \\
&= L^M_{M,t} + L^M_{N,t} + L^N_{M,t} + L^N_{N,t}
\end{aligned} \tag{7}
$$

where the first two terms of the sum are aggregate employment in manufacturing, $L^M_{M,t}$, and non-manufacturing, $L^M_{N,t}$, activities by manufacturing firms, while the last two terms are aggregate employment in manufacturing, $L^N_{M,t}$, and non-manufacturing activities, $L^N_{M,t}$, by non-manufacturing firms.

Given the decomposition of aggregate employment in (7), the growth in aggregate national employment between time $t-1$ and t, $\Delta L_t/L_{t-1}$, can be decomposed into four components: (i) adjustment due to change in employment in manufacturing, $\Delta L^M_{M,t}/L_{t-1}$, and (ii) non-manufacturing, $\Delta L^M_{N,t}/L_{t-1}$, activities of manufacturing firms, and (iii) adjustment due to changes in employment in manufacturing, $\Delta L^N_{M,t}/L_{t-1}$, and (iv) non-manufacturing, $\Delta L^N_{N,t}/L_{t-1}$, activities of non-manufacturing firms:

$$
\frac{\Delta L_t}{L_{t-1}} = \frac{\Delta L^M_{M,t}}{L_{t-1}} + \frac{\Delta L^M_{N,t}}{L_{t-1}} + \frac{\Delta L^N_{M,t}}{L_{t-1}} + \frac{\Delta L^N_{N,t}}{L_{t-1}} \tag{8}
$$

I apply the decomposition in (8) to the data described in the previous section. First, I use the sample of surviving firms. The results of the decomposition on the sample of surviving firms are striking. As Table 1 indicates, manufacturing firms in the US contributed by 4 percentage points to the 28 percentage points expansion in aggregate employment between 1997 and 2007. This net job creation by firms that owned the manufacturing establishments in 1997 was possible, as the number of jobs they created in non-manufacturing industries (i.e., a 7 percentage points increase in the number of jobs in non-manufacturing activities relative to total employment in 1997) fully compensated for the number of jobs they eliminated in manufacturing industries between 1997 and 2007 (i.e., a 3 percentage points decline in the number of jobs in manufacturing activities relative to total employment in 1997). Thus, this descriptive fact clearly shows that firms' reorganization across industries was substantial and it had implications for trends in their employment.

To identify the type of the activities that led to the expansion of employment in non-manufacturing industries by surviving manufacturing firms, I further decompose the growth of aggregate employment in the non-manufacturing activities of manufacturing firms by NAICS-2 industries.[45] This decomposition is based on the following accounting equation:

$$
\frac{\Delta L^M_{N,t}}{L^M_{N,t}} = \frac{\sum_{n \in N} \Delta L^M_{n,t}}{L^M_{N,t}} \tag{9}
$$

where $n \in N$ is defined as the non-manufacturing activity mapped into the data at NAICS-2 levels such

[45]Table 22 of the Data Appendix gives the list of these activities and the NAICS2 codes associated with them.

as retail-wholesale, transportation, information, administrative services, management, professional services, health, education, etc. Table 2 shows the results of the decomposition. Activities such as management, administrative services, information, and retail-wholesale expanded substantially, and became an important part of the non-manufacturing activities of US manufacturing firms. Thus, hiring more people in management, logistics, and technology jobs allowed firms that were initially engaged in manufacturing to grow, and compensate in aggregate for the number of jobs they had eliminated in manufacturing.

These decomposition results are robust to other measures of the size of the firm's activities, such as the number of establishments or payroll. Figure 2 shows that manufacturing firms went through important organizational changes as they opened more establishments in non-manufacturing industries than the number of establishments they had closed in manufacturing industries. Moreover, the findings are also robust to other time periods than the one considered in the baseline analysis. In particular, Figures 2 and 3 show that US manufacturing firms went through important organizational changes not only over the 1997 and 2007 period, but also over the 1997-2012 period. Similarly, Figure 4 demonstrates that the findings are robust even if I allow for switching in and out of manufacturing by defining the manufacturing firm as a firm that has non-zero employment in manufacturing in any of the census years between 1997 and 2012. The decomposition results are also robust to alternative definitions of the manufacturing firm. In Table 3, I show the results of the decomposition based on equation (8) by defining the firm that manufactured in 1997 as the firm that had a ratio of employees in manufacturing activities relative to the total number of employees greater than 5 percent.[46] The results of the decomposition are very similar to the ones obtained based on the baseline definition of the manufacturing firm.

Finally, I use the sample of all the firms and apply this to the decomposition derived in equation (8). As the results of the decomposition reported in Table 4 show, accounting for firm entry and exit does not change the main conclusion of the baseline analysis: US manufacturing firms went through important cross-industry reorganization over time as they created jobs in non-manufacturing that compensated for the number of jobs they had eliminated in manufacturing. This reorganization had implications for the trend in aggregate employment.

The facts outlined in this section strongly suggest that firms have an additional margin to adjust employment relative to establishments: reorganization across industries. Thus, firms may respond to industry-specific shocks by not only adjusting employment within the establishments they own, but also by dropping and adding establishments in the same or different industries in which they were present when the shock hit them. Intuitively, this reorganization may allow firms to escape the negative impact of unfavorable shocks in certain industries by expanding their activity in less exposed or non-exposed industries. Thus, taking into account the reorganization margin by moving the

[46] This definition of the manufacturing firm is used by Bernard et al. (2016) to document facts about the de-industrialization pattern that the Danish economy went through in the last decade.

unit of analysis from the establishment to the firm may have implications for our understanding and measurement of the impact of industry-specific shocks on US manufacturing employment. The next section considers the swift increase in imports from China to US manufacturing industries, caused by China's entry into the WTO as an example of an industry-specific shock, and examines its impact on US manufacturing firms.

4 The Impact of Chinese Imports on US Manufacturing Employment

In this section, I estimate the causal impact of the surge in Chinese imports in US output markets - which resulted from China's entry into the WTO in 2001 - on the employment of US manufacturing firms. By using the manufacturing firm as the unit of analysis instead of the manufacturing establishment, this analysis takes into account the possibility of cross-industry reorganization within US firms. Estimation results indicate that more exposed manufacturing firms in the US did not reduce employment; instead they expanded employment in (i) manufacturing activities by hiring more production workers, whom they paid higher wages, and (ii) services complementary to high-skill and high-tech manufacturing, such as R&D, design, engineering, and headquarters services. These findings suggest that within-firm reorganization allowed US firms to escape the negative impact of the China shock by moving their activities to non-exposed industries, where they could grow.

China joined the WTO in 2001, which was followed by a large wave of non-tariff-based trade liberalization between China and the rest of the world. Administrative, institutional, and other non-tariff barriers on Chinese exports vanished (Chow, 2007; Kroeber, 2016). This triggered a surge in Chinese imports in US manufacturing industries: Aggregate imports from China to the US grew by 210.8 percent between 2001 and 2007 relative to the 1997 level, whereas the growth rate was only 50.2 percent between 1997 and 2001.[47] This rise in Chinese imports varied widely across US manufacturing industries. The electrical equipment and furniture industries registered the largest increase in Chinese imports, while food, beverages, and textiles exhibited the smallest increase.[48]

The surge in Chinese imports created more competition in US manufacturing industries as imported Chinese goods competed with goods produced in the US. What did this increased import competition do to employment in US manufacturing firms? On the one hand, the *increased competition in US output markets* may have caused US manufacturing firms to reduce employment or even exit US output markets in which they could not compete with Chinese imports (i.e., exposed industries). However, the possibility of reorganization may have given these firms the opportunity to

[47] For instance, Amiti and Freund (2010) documents the sectorial composition of this import growth.

[48] The Appendix provides detailed information on the institutional background of China's entry into the WTO and its implications for the changing patterns of trade flows over time (i.e., imports and exports of goods) between China and the rest of the world, in aggregate and by industries over the 1997-2012 period.

enter other US output markets in which they had a competitive and comparative advantage relative to China (i.e., less exposed or non-exposed industries). This reorganization within US manufacturing firms may have been directed toward both manufacturing and non-manufacturing industries in the US. On the other hand, the *increased competition in US input markets* may have incentivized US manufacturing firms to increase employment in non-exposed US output industries in which they were already present, or enter and expand employment in new ones in which they had a comparative and competitive advantage relative to China. This is because increased competition in input markets induces a decline in the prices of material inputs, and thus a decline in the cost of materials that firms use in the production of output. Therefore, the increased Chinese import competition in US input markets may have acted as a favorable cost shock to US manufacturing firms. This favorable shock may have compensated for or even overturned the negative impact of output market competition effect on US manufacturing firms' employment. In other words, the combined effects of increased Chinese imports in US input and output markets could have led to an expansion in US manufacturing firms' employment, even in manufacturing industries. Therefore, as Figure 1 illustrates, the overall impact of the China shock on the employment of US manufacturing firms is ambiguous, as the adjustment in firms' employment through reorganization and the favorable cost shock caused by China could have compensated for the decline or dampened the decline in more exposed industries.

By following the previous literature (Autor et al., 2013; Acemoglu et al., 2016; Bloom et al., 2015; Hummels et al., 2016), I estimate the causal impact of increased Chinese imports in US output markets ("China shock" hereafter) on the employment of US manufacturing firms in two steps.[49] First, I estimate the impact on US manufacturing industries. As the data come in cross-sections, one way to account for firm entry and exit is to aggregate from the firm to the industry level. In the second step, I estimate the impact on surviving US manufacturing firms. The rest of this section outlines this analysis and presents the results.

4.1 The Impact on US Manufacturing Industries Defined Based on the Firm

The methodology I use to measure the size and the impact of the China shock on employment by US manufacturing industries builds on recent work by Acemoglu et al. (2016), and Autor et al. (2013, 2015), Bloom et al. (2015) and Hummels et al. (2016).[50] In particular, I use the same identification strategy and the same measure of the China shock as these authors. This consists of measuring the difference in changes in employment across initially similar US manufacturing industries with different levels of exposure to the surge in Chinese imports. However, in contrast to these papers, I take into account adjustments in employment due to reorganization by moving the unit of analysis

[49] This type of analysis is in line with the one used in Trefler (2004).

[50] Future work will bring in the third way of measuring the shock. This is the PNTR tariff gap between China and the US used by Pierce and Schott (2016).

from the establishment to the firm, and consequently from the industry as defined by establishment type - as in the aforementioned papers - to the industry as defined by firm type.

There are two advantages of performing the analysis at this level of aggregation. First, the industry-level analysis allows me to compare results with previous findings in the literature that used industries defined based on the establishment as the unit of analysis (Acemoglu et al., 2016). This comparison can be used to assess the importance of the reorganization margin. Previous studies used the *standard definition of the manufacturing industry,* based on which the US Census Bureau and BLS publish industry level data. According to this definition, employment in a manufacturing industry i at time t, $\widetilde{L}_{it}$, is defined as the sum of employment across establishments classified to manufacturing industry i at time t based on the largest activity within the establishment: $\widetilde{L}_{it} = \sum_{e \in M_i^E} L_{e,t}$, where M_{it}^E is the set of establishments in the US that have their largest activity in manufacturing industry i in year t. However, this definition of the manufacturing industry ignores the firm and, thus, the fact that decisions across establishments within the firm are interdependent, and reorganization across industries is possible. An *alternative definition of the manufacturing industry* takes into account the firm, and potential interdependencies between establishments owned by the same firm and, thus, allows for adjustment in employment due to reorganization. According to this definition, employment in manufacturing industry i at time t, L_{it}, is the sum of the employment across firms classified as manufacturing industry i at time t based on the largest manufacturing activity within the firm,[51] $L_{it} = \sum_{f \in M_{it}^F} L_{f,t}$, where M_{it}^F is the set of US manufacturing firms that have their largest manufacturing activity in manufacturing industry i at time t. The main advantage of this definition relative to the standard one is that it keeps the organizational structure of the firm together in the same unit of observation (i.e., manufacturing industry in this case). Moreover, it allows me to quantify employment associated with manufacturing, $L_{M,i,t} = \sum_{f \in M_{it}^F} L_{M,f,t}$, and non-manufacturing activities, $L_{N,f,t} = \sum_{f \in M_{it}^F} L_{N,f,t}$, within the manufacturing firm as $L_{it} = L_{M,i,t} + L_{N,f,t}$. Thus, any difference in estimates obtained based on the standard versus the alternative definitions of the manufacturing industry is suggestive evidence of how the reorganization margin contributes to the estimated causal impact of the China shock. The second advantage of the industry-level analysis is that it allows me to take into account entry and exit, which ensures that selection is not driving the estimation results.

I estimate the impact of increased Chinese imports on industry-level employment by using the identification strategy used by Acemoglu et al. (2016), Autor et al. (2013, 2015), Bloom et al. (2015) and Hummels et al. (2016). This consists of estimating the following regression model:

$$\triangle logY_{it} = \beta_0 + \beta_1 Shock_{it} + \beta_2 X_{i1997} + \varepsilon_{it} \tag{10}$$

where $\triangle logY_{it}$ is the log change in employment in manufacturing industry i from 1997 to 2007 defined in the alternative ways, $\triangle logL_{it}$. As industries with a larger increase in imports from China

[51] In line with the BLS and US Census Bureau definitions of the main economic activity, industry i is the manufacturing industry with the largest number of employees within the firm.

may also be exposed to other shocks that drive employment down over time, I control for industry characteristics in the pre-shock year. These controls ensure that identification of the causal impact of the China shock is based on comparing two industries that would have shown the same trend in employment over time had the China shock not differentially impacted them. Thus, X_{i1997} contains a set of industry-level controls defined in 1997, which can be grouped in two categories:[52] (i) two-digit industry fixed effects that account for differential trends in employment across two-digit manufacturing industries and allow me to identify the impact of the China shock from variation in the shock variable across industries within the same two-digit industry,[53] and (ii) a series of other industry level controls defined in the base year, 1997, which allow for identification by using variation in the shock variable across industries with relatively similar technological characteristics. In line with the existing literature, I include in this category control variables such as capital intensity (defined as the ratio between capital expenditure and total employment); share of production workers (defined as the ratio between the number of production workers and total employment) as a proxy for skill intensity of the industry; share of payroll and employment in manufacturing activities (defined as the ratios between the payroll in manufacturing activities and total payroll, and as the ratio between the number of employees in manufacturing activities and total employment).[54]

$Shock_{it}$ measures the change in exposure to Chinese imports in manufacturing industry i between 1997 and 2007. β_1 captures the impact of the China shock on industry level employment, as it measures how changes in employment differ across initially similar US manufacturing industries that were differentially exposed to the China shock. I define the $Shock_{it}$ variable in two ways, by closely following Acemoglu et al. (2016), Autor et al. (2013, 2015), Bloom et al. (2015) and Hummels et al. (2016). To ensure the comparability of my results with those of previous literature, I define the industry at the four-digit SIC level as in previous papers.

The first measure I use to quantify the China shock to US manufacturing industries is the growth rate of imports from China to US manufacturing industries, defined as the change in log Chinese imports between 1997 and 2007:

$$\Delta logM_{it}^{CH,US} = logM_{i,2007}^{CH,US} - logM_{i,1997}^{CH,US} \tag{11}$$

where $M_{i,t}^{CH,US}$ is defined as the value of imports from China to the US in manufacturing industry i,

[52] Following the previous literature, the third category of industry level controls would include variables that control for pre-trends in industry level employment. As employment in manufacturing has been declining for the last three decades, it could be the case that by focusing only on the period between 1997 and 2007, the estimated impact overstates the impact of the China shock on US industry level employment. The microdata used in this paper does not allow me to construct industry level employment earlier than 1997, as the first year observed is 1997. However, as Acemoglu et al. (2016) show, controlling for the pre-trend does not have a significant impact on the estimates of the causal impact of increased imports on employment by industries defined based on establishment type.

[53] For instance, this allows me to compare plastic and chemicals industries, or machinery manufacturing and electrical equipment rather than a broader comparison such as textile versus electrical equipment.

[54] Acemoglu et al. (2016), Autor et al. (2013), and Pierce and Schott (2016) argue that, by controlling for these industry characteristics, one can ensure that the estimated impact is not contaminated by shocks due to technological progress.

defined at the four-digit SIC industry level, in year t and in 2007 dollars. This measure of the China shock is the industry level version of the measure used by Hummels et al. (2016) to quantify the impact of increased imports on Danish firms and their employees' wages[55] and is consistent with the industry level measure used by Bloom et al. (2015).

The year 1997 represents the pre-shock year, while 2007 the post-shock year. I choose 1997 as the base year, since it is the earliest year for which I have access to microdata. Also, 1997 is four years before China liberalized its international trade by joining the WTO and, thus, it was still uncertain in 1997 when China would actually join WTO. As a consequence of this liberalization, Chinese firms could freely enter international markets, export profitably based on their comparative advantage of having access to cheap, low-skilled labor (Paulson, 2015; Naughton, 2007), and upgrade productivity, all of which further increased Chinese exports (Hsieh and Ossa, 2016).[56] Thus, the measure in (11) intends to capture the change in Chinese imports in US manufacturing industries driven by the Chinese export supply shock.

To isolate the variation in measure (11) due to supply shocks in China, I instrument it by using the growth rate of imports from China to the eight major trading partners of China:

$$\Delta log M_{it}^{CH,OTH} = log M_{i,2007}^{CH,OTH} - log M_{i,1997}^{CH,OTH} \tag{12}$$

where $M_{i,t}^{CH,OTH}$ is defined as the value of imports from China to the eight major trading partners of China, except the US, in manufacturing industry i in year t, evaluated in 2007 dollars. The identification assumption is that the eight major trading partners of China were similarly exposed to the Chinese supply shock as the US, and import demand shocks were correlated across these high-income countries.[57] This identification strategy is in line with Acemoglu et al. (2016), Autor et al. (2013, 2014), Bloom et al. (2015) and Hummels et al. (2016). Table 4 contains descriptive statistics for the measures in (11) and (12), and reveals a large variation in the growth of Chinese imports across US manufacturing industries. The large R^2 and t-statistics indicate a strong predictive power of the instrument for the shock in Table 5, suggesting that industries in other developing countries that registered significant growth in Chinese imports were also the most exposed industries in the US.

[55]Hummels et al. (2016) aim to estimate the causal impact of increase in total imports by Danish firms on their employees' wages. This paper focuses on imports from China, which constitute a certain fraction of total imports.

[56]Appendix provides more details on the institutional background of this liberalization.

[57]This identification strategy is only valid if the only driving forces behind the surge in Chinese exports to the rest of the world between 1997 and 2007 were shocks that originated from China and not shocks that originated in the rest of the world (i.e., any type of shock that drove up demand for Chinese exports). In this respect, these identification assumptions are somehow in the spirit of the Hausman (1996) instrument frequently used in the industrial organization literature (i.e., instrument the price by the prices of the same product by the same firm in other markets). Based on a comparative advantage argument, industries that register a decline in demand for US production are the industries in the other countries that register a large increase in demand for Chinese imports. This negative correlation in demand shocks biases the two stage least square estimates downward and, thus, leads to underestimation of the true effect. As I expect that reorganization allows firms to expand employment in response to increasing imports from China, the true effect is even larger than the ones I estimate if demand shocks are correlated.

The second measure of the Chinese trade shock is in line with Acemoglu et al. (2016) and Autor et al. (2015). This measure is the change in the Chinese import penetration ratio to US manufacturing industries over the period between 1997 and 2007 defined as:

$$\Delta IPR_{it}^{CH,US} = \frac{\Delta M_{it}^{CH,US}}{Y_{i,1997} + M_{i,1997} - X_{i,1997}} \tag{13}$$

where $\Delta M_{it}^{CH,US}$ is the change in real imports from China to US in manufacturing industry i, defined as four-digit SIC, over the period 1997 to 2007. $Y_{i,1997} + M_{i,1997} - X_{i,1997}$ is the size of the market in manufacturing industry i in the base year 1997, measured as the real value of shipments, $Y_{i,1997}$, plus the real value of net imports in industry i defined as the difference between total imports, $M_{i,1997}$, and exports, $X_{i,1997}$.[58]

To isolate this variation in the change in the import penetration ratio in (13) from the variation induced by potential demand shocks in the US that may have affected US demand for Chinese imports, I use the identification strategy proposed by Acemoglu et al. (2016) and related papers by Autor et al. (2013, 2015). Thus, I instrument (11) with the change in the import penetration ratio from China to the eight major trading partners of China, except the US, defined as:[59]

$$\Delta IPR_{it}^{CH,OTH} = \frac{\Delta M_{it}^{CH,OTH}}{Y_{i,1997} + M_{i,1997} - X_{i,1997}} \tag{14}$$

where $\Delta M_{it}^{CH,OTH}$ is the change in real imports from China to the eight major trading partners of China, except the US, in manufacturing industry i between 1997 and 2007.[60] $Y_{i,1997} + M_{i,1997} - X_{i,1997}$ is defined as described in the case of measure (11). The identification assumption is that the eight major trading partners of China were similarly exposed to the Chinese supply shock as the US, but import demand shocks are not correlated across these high-income countries.[61] The descriptive

[58]All variables used to compute the import penetration ratio are expressed in 2007 dollars. As industry level price indices for imports and exports are not available in the US, following Acemoglu et al. (2016), I inflate imports from China to the US, total imports, and total exports in 1997 to prices in 2007 by using the Personal Consumption Expenditure (PCE) index in 1997 with base year 2007. Moreover, I inflate the total value of shipments by using the manufacturing shipment price index in 1997 with base year 2007, along with the nominal value of shipments, in the NBER-CES database. More details on my choice of the deflator and its implications for estimating the impact of the increase in Chinese import competition on US manufacturing industries defined based on aggregating from the establishments are included in the Appendix. The results of this exercise reported in the Appendix indicate that the choice of the price index to deflate US shipments matters for the robustness of the estimated impact on industries aggregated from the establishments. Thus, depending on the type of the deflator used and the type of the shock measure applied, the estimates indicate that the surge in Chinese imports had a negative or no effect on US manufacturing establishments.

[59]As a robustness check, I define another version of the instrument in which the change in imports from China to other countries is normalized by the lagged value of US market size (i.e., the value in 1994). One may worry that industries in the US in 1997 had already anticipated that China would join the WTO in 2001, and thus industry level employment was exposed to the anticipated trade shock. Thus, going back three more years and using the lagged market value in the instrument would mitigate this potential simultaneity bias.

[60]Following Acemoglu et al. (2015) and Autor et al. (2013, 2015), these countries are Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland.

[61]This identification strategy is only valid if the only driving forces behind the surge in Chinese exports to the rest of

statistics of the measures in (13) and (14) reported in Table 4 demonstrate a large variation in changes in the Chinese import penetration ratio across US manufacturing industries. However, in comparison with the statistical properties of the previous measure of the China shock, the growth rate of industry level Chinese imports, this measure exhibits a large dispersion across industries. This suggests that normalization in the import penetration ratio may induce more dispersion in the China shock than dispersion in actual Chinese import growth across industries. Thus, we could expect less precise estimates by using this measure of the China shock. Motivated by this, I use the measure in (11) as the main measure of the exposure to Chinese imports. Then, I use the second measure in the robustness check of my main results.[62]

Given these measures of the China shock and the identification assumptions, I estimate the regression model in (10) by two-stage least squares. I weight all the regression estimates by employment in 1997, which is the start of my sample period and the pre-China shock year. I cluster the standard errors at the two-digit industry level, which allows for correlation in errors across industries within a given two-digit industry category.[63] Thus, the causal impact of the China shock on US manufacturing industries is measured by two-stage least square estimates of coefficient $\beta_1$in model (10). The two-stage least square estimates are presented in Tables 5 to 7. The robustness checks based on measure (13) are reported in the Appendix.

The estimation results can be summarized in three main findings. First, increased imports from China did not lead to a decline in the employment of more exposed US manufacturing industries. Estimates indicate that employment in more exposed US manufacturing industries relative to less exposed industries did not fall between 1997 and 2007. The estimation results presented in Columns 2 of Table 5 suggest that when we aggregate from the firm to the industry level, more exposed industries expanded employment relative to the employment in less exposed industries. The estimates imply a 1.5 percent yearly increase in employment of the manufacturing industry with 75th percentile exposure relative to one with 25th percentile exposure. This suggests that cross-industry reorganization may allow firms to escape the negative impact of industry-specific shocks and expand employment. This finding is robust to other measures of manufacturing industry size: More exposed industries expand in the number of establishments, total payroll, and hours worked relative to less exposed industries (Columns 3 and 4 of Table 5).

Second, estimation results indicate that expansion in overall employment of the more exposed US manufacturing industries relative to less exposed ones is due to expansion of employment in both

the world between 1997 and 2007 were shocks that originated from China and not shocks that originated in the rest of the world (i.e., any type of shock that drove up demand for Chinese exports). In this respect, these identification assumptions are very much in the spirit of the Hausman (1996) instrument frequently used in the industrial organization literature (i.e., instrument the price by the prices of the same product by the same firm in other markets).

[62]The highly statistically significant point estimate of the coefficient on the instrument in the first-stage regression and the large R^2 in Table 5 indicate that industries in other developed countries that registered a large increase in import penetration ratio from China also registered a large increase in the US.

[63]The Appendix contains robustness checks by presenting estimation results with standard errors clustered at the four-digit industry level.

manufacturing and non-manufacturing activities within these industries (Columns 5 and 6 of Table 5). By defining the industry based on the firm, the growth rate of total industry level employment can be decomposed into changes due to adjustment in employment in different activities within the industry. Thus, the impact of the China shock on each of these components can be estimated to assess their contribution to the effect on overall employment. Results reported in Table 6 indicate that manufacturing industries more exposed to the China shock expanded employment of manufacturing activities, and headquarter and professional services, while employment of retail-wholesale and transportation activities did not change in response to the China shock. The estimates imply a 1 percent, and 0.5 percent yearly growth in the number of manufacturing workers, respectively high-skilled service workers in the manufacturing industry with 75th percentile exposure relative to one with 25th percentile exposure. Expansion in the employment of headquarters and professional services activities in the more exposed manufacturing industries is suggestive of reorganization within more exposed US manufacturing industries toward non-manufacturing activities that are highly complementary to skill- and high-tech intensive manufacturing, such as R&D, advertising, design, engineering, finance, etc. These striking findings suggest that the possibility of changing the organization of the overall activity of the firm, both within and across manufacturing and non-manufacturing industries, may allow for growth of US employment in industries in which the US has a comparative and competitive advantage relative to China.

Finally, estimation results demonstrate that the growing employment in manufacturing activities of the more exposed manufacturing industries is due to the expansion of production activity rather than non-production activity. The point estimates in Columns 2 and 3 of Table 7 show that manufacturing industries more exposed to the China shock grew as the number of production workers increased in the more exposed industries. This finding is robust to other definitions of the size of production activity within manufacturing industries, such as the number of manufacturing establishments or the number of hours worked. More exposed US manufacturing industries increased the number of manufacturing establishments in the US relative to the less exposed ones, while workers in these more exposed US manufacturing industries worked more hours.

These findings are complementary to previous literature that uses the establishment as the unit of analysis. For instance, relative to the findings of Acemoglu et al. (2016) or Autor et al. (2013), my findings suggest that reorganization toward non-exposed industries, in which the US has a comparative advantage relative to China, allowed US firms to create jobs that more than offset the losses measured at the establishment level. These findings may seem striking, but they are actually in line with the conclusions of Amiti and Wei (2006).[64] They show that increased offshoring may have led to the expansion in employment of US manufacturing industries, as cross-industry reallocation allowed for more efficient allocation of resources in the domestic economy. However, the estimated impact

[64]They document that at a more aggregated industry level, three-digit NAICS, employment in US industries that registered larger service ofshoring went up between 1992 and 2000.

of the China shock on US manufacturing industries is a combination of within-firm and cross-firm adjustments in employment in more exposed industries relative to less exposed ones. To assess the importance of within-firm adjustment, the next part of the analysis focuses on estimating the causal impact of the China shock on US manufacturing firms' employment.

4.2 Impact on US Manufacturing Firms

The estimated impact of the China shock on the employment of US manufacturing industries is a combination of within-firm impact and the reallocation of employment across firms classified as the same industry. However, I also aim to understand the implications of within-firm cross-industry reorganization for the measured impact of the China shock on US manufacturing employment. Thus, this section quantifies the within-firm effect by estimating the impact of increased imports in US output markets on the growth in employment of US manufacturing firms between 1997 and 2007. This analysis allows me to assess to what extent the industry level estimates are driven by changes in employment within firms relative to the adjustment in employment across firms within more exposed manufacturing industries.

I estimate the impact of the China shock on the growth of overall employment and employment in different activities of US manufacturing firms by using an identification strategy that is in line with the methodology I used in the industry level analysis in the previous section. This consists of estimating the following regression model:

$$\frac{\triangle Y_{ft}}{L_{f,1997}} = \beta_0 + \beta_1 Shock_{ft} + \beta_2 X_{f,1997} + \varepsilon_{it} \tag{15}$$

where $\triangle Y_{ft}/L_{f,1997}$ is the growth in overall employment of firm f from 1997 to 2007, and the growth in employment by activities of the firm relative to total firm level employment in 1997, $L_{f,1997}$.[65] X_{i1997} contains a set of firm level controls in 1997 that can be grouped in two categories. The first is a set of four-digit industry fixed effects, defined based on the main manufacturing industry of the firm in 1997;[66] These account for differential trends in employment across firms in different four-digit manufacturing industries. Thus, I identify the impact of variation across firms within the same four-digit industry. The second is a series of other firm level controls defined in the base year, 1997, that allow for identification by using the variation in the shock variable across firms with relatively similar technological characteristics. This category of control variables contains the capital intensity of the firm, defined as the ratio between capital expenditure and total employment; the share of production

[65] I measure the left-hand side variable as the change in each component of overall employment relative to total firm level employment in 1997 instead of the change in log employment in order to account for zeros in the data. For instance, the firm can have positive employment in a particular activity in 1997 and zero in another year.

[66] Following the alternative definition of the manufacturing industry outlined in Section 4.1., the main manufacturing industry in 1997 is the manufacturing industry within the firm with the largest number of employees in 1997.

workers within the firm defined as the ratio between the number of production workers and total employment, as a proxy for the skill intensity of the firm; the share of payroll and employment in manufacturing activities within the firm, defined as the ratio between the payroll in manufacturing activities and total payroll, and the ratio between the number of employees in manufacturing activities and total employment. $Shock_{ft}$ measures the change in the firm's exposure to increased Chinese imports through US output industries in which the firm had a presence in 1997. Thus, β_1 captures how changes in employment differ across initially similar firms that have different levels of exposure to the China shock due to differences in their initial pattern of industrial specialization.

I measure the China shock, $Shock_{ft}$,[67] as the weighted average of the China shock to the industries in which the firm had establishments in the pre-shock year, 1997. Thus, the firm level measure of the China shock aims to take into account differences in the exposure to the increase in Chinese imports across firms due to the differences in their initial pattern of industrial specialization.[68] As described in the previous section, the industry level shock is defined in two ways: (1) the growth rate of Chinese imports in industry i, and (2) the change in the Chinese import penetration ratio to industry i. Accordingly, the firm level shock can be defined in two ways as the weighted average of these two industry level shocks.

The first measure of firm-level Chinese import shock is defined as the weighted average of the growth in imports from China to the main output industry of the firm's establishments in the pre-shock year:

$$\Delta WM_{ft}^{CH,US} = \sum_{e(i) \in I_{f,1997}} w_{e(i),f,1997} \Delta log M_{it}^{CH,US} \tag{16}$$

where the weights, $w_{e(i),f,1997}$, are defined as described above and $\Delta log M_{it}^{CH,US}$ is measure (11), as described in the previous section.

The second measure of firm-level Chinese import shock is defined as the weighted average of the change in import penetration ratios to the main output industries of the firm's establishments in the pre-shock year:

$$\Delta WIPR_{ft}^{CH,US} = \sum_{e(i) \in E_{f,1997}} w_{e(i),f,1997} \Delta IPR_{it}^{CH,US} \tag{17}$$

where $w_{e(i),f,1997}$ is the employment weight of establishment e of firm f classified to output industry i, $e(i)$, in the pre-shock year 1997, defined as the number of employees in establishment e of the firm relative to the total number of employees of firm f in 1997, with $E_{f,1997}$ being the set of establishments

[67] The China shock to firms can be measured in two ways. A naive way would be to measure the shock to the main manufacturing industry of the firm by ignoring the fact that firms may do business in many different manufacturing industries (i.e., most of the firms are multi-product). However, there may not only be important variation in this industrial specialization across firms that can be used to better identify the impact of the China shock on firms, but there can also be correlation in the shock across industries within the firm.

[68] A similar idea is behind the China shock measure and the identification strategy used by Autor et al. (2013) to measure the impact of the surge in imports from China on local labor markets in the US. They examine how changes in employment differ across US commuting zones that have different levels of exposure to Chinese import competition due to differences in their initial industrial specialization.

that firm f has in 1997.[69] ΔIPR_{it}^{US} is the shock to industry i defined by measure (13), as described in the previous section. Thus, cross-firm variation in this shock measure comes from differences in the patterns of industrial specialization across firms in 1997, and through this from variation in the shock across industries.

There are two advantages of measuring the shock to the firm in this way. First, this measure takes into account differences in the pattern of industrial specialization across firms as another source of variation, in addition to cross-industry variation in the shock. The firm may have establishments in different industries that are exposed to the Chinese import shock in different ways. By computing the weighted average of the industry specific shocks within the firm, I take into account variation in the pattern of industrial specialization across firms. Moreover, from a statistical point of view, the weighted average ensures that I attribute greater importance to those industries in which the firm had larger economic activity. Second, by computing the weighted average of the industry level shocks the firm is exposed to, I account for potential within-firm cross-industry correlations in the China shock.

Since the within-firm establishment employment weights are fixed to the pre-shock year, the identification challenge I face at the firm level is similar to those in the industry level analysis. To isolate variation in the firm-level measure due to supply shocks in China, I use the industry-level instruments defined and described in the previous section, and bring it to the firm level by using within-firm employment weights.[70] Thus, I define the instrument to measure (17) as:

$$\Delta WM_{ft}^{CH,OTH} = \sum_{e(i)\in I_{f,1997}} w_{e(i),f,1997} \Delta logM_{it}^{CH,OTH} \tag{18}$$

Consistent with this, the instrument to measure (17) is defined as:

$$\Delta WIPR_{ft}^{CH,OTH} = \sum_{e(i)\in E_{f,1997}} w_{e(i),f,1997} \Delta IPR_{it}^{CH,OTH} \tag{19}$$

where $\Delta logM_{it}^{CH,OTH}$ and $\Delta IPR_{it}^{CH,OTH}$ are the changes in the growth rate of Chinese imports and Chinese import penetration ratio to developed countries other than the US, defined as described in the previous section. The large R^2 and t-statistics in Column 1 of Table 8, and the ones in Table 28 in the Appendix, show a strong predictive power of the instruments for the shocks. Moreover, the large values of the F-statistics confirm that these are relevant instruments for the two measures of the firm level shocks.

Given firm-level measures of the China shock and the identification assumptions, I estimate the

[69]More precisely, the weights are constructed as follows: $w_{e(i),f,1997} = L_{e(i),f,1997} / \left(\sum_{e(i)\in E_{f,1997}} L_{e(i),f,1997}\right)$ where $L_{e(i),f,1997}$ is total employment by establishment e, classified to industry i, of firm f in 1997.

[70]The identification assumption is that given the firms' initial industrial specialization pattern, variation in Chinese trade exposure through these industries is due to supply shocks that originate from China, as the eight major trading partners of China are similarly exposed to the Chinese supply shock as the US. Moreover, the import demand shocks are not correlated across these high-income economies.

regression model in (15) using a two-stage least squares method. Since the data are in the form of cross-sections in each Census year, this allows for the estimation of the specification in (15) only on the sample of continuing firms. Thus, in this section, I conduct my analysis on the sample of surviving US manufacturing firms. I weight all regression estimates by firm level employment in 1997, which is the start of my sample period and the pre-China shock year. I cluster standard errors at the four-digit industry level, which allows correlation in errors across industries. Thus, the causal impact of the China shock on employment by US manufacturing firms is measured by the two-stage least squares estimates of coefficient β_1 in model (15). In line with the industry-level analysis, I report the results based on the first measure while I use the change in import penetration ratio as a robustness check.

Estimation results of the firm level analysis - summarized in Tables 8, 9 and 10 - yield three sets of findings. First, more exposed US manufacturing firms did not reduce employment (Column 2 Table 8). The point estimate is positive, which suggests that more exposed firms may have grown in total employment relative to less exposed firms. However, the coefficients are not statistically significant, as standard errors of the point estimates are large. These are in line with the findings of Antras, Fort, and Tintelnot (2016), who document a small and not statistically significant coefficient on growth in Chinese firm level imports when they regress changes in surviving US firms' overall employment on changes in the firms' Chinese imports.

Second, more exposed firms expanded employment in manufacturing and reduced employment in non-manufacturing (Columns 3 and 4 of Table 8). Firms more exposed to increasing Chinese imports in their output markets added jobs in headquarter and professional services (Columns 2 and 3 of Table 9). However, the China shock did not seem to have a statistically significant impact on employment in retail-wholesale activities within US manufacturing firms (Column 1 of Table 9). As the shock is measured to the set of the firm's industries in 1997, all of these represent suggestive evidence of within-firm reorganization from exposed industries to less or non-exposed industries. As a result of this reorganization, they may have expanded employment in manufacturing by hiring more workers in existing or newly opened non-exposed manufacturing establishments, which fully compensated for the number of workers they fired from the exposed establishments. Moreover, these findings also suggest that the nature of reorganization toward non-manufacturing industries is such that US firms that used to engage in manufacturing before the China shock expanded in non-manufacturing industries that are complementary to high-skill, high-tech intensive manufacturing such as management, financial planning, R&D, engineering, design, advertising, etc. These findings are in line with those of the industry level analysis, suggesting that the estimated industry level impact on manufacturing employment is mostly driven by within-firm cross-industry reorganization, rather than cross-firm within-industry adjustment in manufacturing employment in response to the China shock.

Finally, the within-firm expansion in manufacturing employment was the result of growth in the number of production workers whom firms paid higher wages. More exposed US manufacturing firms hired more workers in production activities, while they did not adjust the number of non-production workers (Columns 1 and 2 in Table 10). Moreover, more exposed firms spent on average more on workers in manufacturing activities, and in particular on production workers, relative to less exposed firms. The point estimates reported in Columns 3 and 4 of Table 10 indicate that more exposed firms registered an increase in the average wage of production and manufacturing workers.[71] The expansion in the scale of manufacturing production was not only in terms of hiring more production workers in manufacturing, but also by opening new plants (Column 5 of Table 10) and adding new products to the set of output produced by the firm (Column 6 of Table 10).

All of these findings are suggestive of reorganization within manufacturing toward more skill intensive industries, and are in line with the theoretical predictions of Burnstein and Vogel (2016). They show that trade liberalization induces an increase in the skill premium in countries with a comparative advantage in more skill-intensive sectors, as factors are reallocated toward more productive and skill-intensive firms within sectors and toward skill-intensive sectors.

As firms may be multi-product, an expansion in manufacturing employment may also suggest that US manufacturing firms repositioned in the product space in response to the China shock by dropping products from their product set that were cheaper to source from China and adding new products in markets in which they could compete with the Chinese. The data suggest that US manufacturing firms also went through this type of reorganization too. In particular, they re-organized their production toward higher quality varieties within the broadly defined output product groups. One of the best features of the data collected by the US Census Bureau is that they provide information on the set of output products, values at the factory gate and the quantities of each of these produced in the firm's manufacturing establishments at the six-digit NAICS level. Using this information, I define the real value of output prices, $price^{output}_{fept}$, in the US as the ratio between the value and quantity, adjusted by industry level inflation between 1997 and 2007. Using this information on output prices, I examine how US manufacturing firms adjusted the price of their output products in response to increased Chinese imports. Thus, I estimate the following regression model on the sample of firm-establishment-product pairs that survived between 1997 and 2007:[72]

$$\triangle log\left(price^{output}_{fept}\right) = \gamma_0 + \gamma_1 Shock_{pt} + \gamma_e + \varepsilon_{fept} \tag{20}$$

where $\triangle log\left(price^{output}_{fept}\right)$ is the change in the price of output product p produced in establishment e owned by firm f at time t, γ_e contains a set of industry fixed effects that are defined based on the main output industry of the establishment and controls for macroeconomic shocks to the output prices that are common across firms in a given output industry. $Shock_{pt}$ is the import penetration ratio from China to manufacturing industry p in the US, as defined in Section 4.1. I use the same

[71] This finding is in line with the increasing importer wage premium documented by Koren and Csillag (2016) in the case of Hungarian workers.

[72] Figure 9 in the Appendix shows the distribution of output prices in 1997 and 2007 in the case of the sample of surviving firm-establishment-product pairs, and indicates no significant shift in overall distribution of output prices over time.

identification strategy and instrument the shock variable by using the same instrument as outlined in Section 4.1. Thus, γ_1 captures the impact of the China shock on output prices in the US as the difference in the output price between initially similar firm-establishment-product pairs in the same broadly defined output industry, but with different exposure to Chinese import competition. The estimation results reported in Table 23 in the Appendix are notable. They indicate that US firms that manufactured output products in industries more exposed to Chinese import competition registered an increase in the price of the output product they continued to produce in the US. This is suggestive evidence of upgrading production in the US to higher quality output varieties within the six-digit product category (Khandelwal, 2010; Amiti and Khandelwal, 2013; Medina, 2016) or an adverse effect of reorganization on prices (Conconi, Legros and Newman, 2012; Legros and Newman, 2013).

All of these findings are suggestive evidence of reorganization of manufacturing activity within US manufacturing firms toward more skill-intensive manufacturing industries. This is consistent with the predictions of the trade-in-tasks model of Grossman and Rossi-Hansberg (2008),[73] who show that trade liberalization, which resulted from reductions in the cost of offshoring, may lead to expansion in domestic employment of less-exposed industries and an increase in wages of the less exposed skill category. One way to capture this cross-industry reorganization in a reduced-form way is to view the data through the lens of a firm that may span multiple industries. As skill-intensive manufacturing industries are less exposed or non-exposed to the China shock in the US, my findings are suggestive evidence of reorganization within US manufacturing firms toward more skill-intensive manufacturing. This cross-industry reorganization within US manufacutring firms may explain why firm level manufacturing employment responds differently to the China shock than does establishment level manufacturing employment, and may also reconcile my findings with those of previous literature, in which employment in more exposed manufacturing establishments declines (Pierce and Schott, 2016). What is the potential mechanism that explains growth in employment within firms in non-exposed industries, toward which US manufacturing firms may reorganize in response to the China shock? The next section describes a potential mechanism through the lens of a theory of the firm and establishments, in which I imbed the Grossman and Rossi-Hansberg (2008) offshoring task technology, and thus rationalizes the finding that increased imports from China lead to reorganization and growth of skilled employment in less exposed industries.

5 Theoretical Explanation

This section develops a theory of the firm and establishments in which I imbed the Grossman and Rossi-Hansberg (2008) offshoring task technology. In this model, firms in the domestic economy produce differentiated varieties by using two intermediate goods, each of which they assemble using a

[73] Any trade model that assumes relative factor endowment or productivity differences across countries predicts that trade liberalization implies specialization based on comparative advantage. See Burnstein and Vogel (2011) for a general framework.

continuum of tasks performed by high- or low-skilled workers. Assembly of one of these intermediate goods is more skill-intensive than assembly of the other. Tasks performed by low-skilled workers can be conducted in either the domestic economy or abroad, where low-skilled labor is cheaper, but offshoring the task involves a cost that is heterogenous across firms.

This framework rationalizes my main empirical finding, that US manufacturing firms expanded manufacturing employment in response to the China shock through the following mechanism. As a consequence of the decline in the cost of offshoring, firms re-organize their domestic production; they shift their domestic activity into areas that are more skill-intensive by offshoring tasks that are less skill-intensive. As the cost of offshoring exhibits heterogeneity across firms, a decline in the cost of offshoring has a differential impact on within-firm cross-industry reorganization, the unit cost of production, and employment across firms. Firms that register a larger decline in the cost of offshoring (i.e., more exposed firms) shift more of the low-skill intensive tasks abroad and, thus, register a larger decline in the relative cost of assembly of the intermediate goods. As a consequence, the price of the variety produced by the more exposed firm declines more relative to the price of the variety produced by the less exposed firm. Thus, consumers substitute their consumption toward the variety that registered the larger price decline. To meet the increasing demand, the more exposed firm increases employment. If the two intermediate goods are complements in the production of the final good variety, the more exposed firm expands employment of high-skilled labor relative to less exposed firms by hiring more of these workers in the production of high-skill-intensive intermediate good assembly (i.e., less exposed establishment within the firm) relative to the number of high-skilled hired in the production of a low-skill-intensive intermediate good (i.e., more exposed establishments within the firm). This section is organized as follows. First, I present the assumptions and characterize the equilibrium conditions. I then derive predictions on how a decline in the cost of offshoring impacts firms' sourcing decisions, costs of production, and employment.

5.1 Assumptions and Equilibrium Conditions

There are two countries: one domestic and one foreign. I assume that technologies are the same in both. However, there is a productivity gap between the two countries. In particular, I assume that the domestic country is more productive than the foreign country. Denoting total factor productivities by A in the domestic country and A^* in the foreign country, the assumption on the productivity gap implies that $A > A^*$. This productivity gap generates a gap in factor prices between the two countries, such that domestic wages are large relative to foreign wages.

Domestic firms produce differentiated varieties. The production of variety z by any firm f requires two intermediate inputs, $j \in \{x, y\}$.[74] There are two labor skill types - low-skill, L, and high-skill, H

[74] Making these types of assumptions on the structure of production is common in industrial organization, international trade, and international macro literatures that study the role of intermediate inputs in firms' pricing and production decisions (Acemoglu and Guerrieri, 2008; Amiti, Itskhoki, and Konings, 2014; Helpman, Koren, and Szeidl, 2016; Blaum,

- used by the firm as factors of production to assemble intermediate goods x and y. Production of a unit of either input x or y involves a continuum of low-skill intensive tasks (L-tasks), and a continuum of high-skill intensive tasks (H-tasks). Firms can either produce L-tasks at home or offshore them to the foreign country. The difference in factor prices across countries incentivizes domestic firms to offshore (i.e., the benefit of offshoring). However, to offshore a task, the firm must pay not only the wages of the foreign country, but also the cost of moving the task abroad (i.e., the cost of offshoring tasks), which is firm specific.[75] Figure 5 presents a chart that illustrates the structure of this production process. Given the differences in factor prices across countries and the cost of offshoring, the domestic country exports the final good varieties to the foreign country, in exchange for importing L-tasks from the foreign country in equilibrium.[76] In the rest of this section, I characterize the demand for varieties, firms' production and offshoring technology, firms' cost minimization, and profit maximization problem.

5.1.1. Assumptions on Preferences and Technologies

Consumer preferences and demand: In each country, consumers derive utility from the consumption of F differentiated goods. Their utility takes the standard constant elasticity of substitution form:

$$U = \left[\sum_{f=1}^{F} z_f^{\frac{b-1}{b}}\right]^{\frac{b}{b-1}} \tag{21}$$

where z_f denotes the quantity of variety f, and the elasticity of substitution across varieties is b. Consumers' utility maximization problem yields the demand for variety f :

$$z_f = \frac{Y}{P^{1-b}} p_f^{-b} \tag{22}$$

where $P = \left[\sum_{f=1}^{F} p_f^{1-b}\right]^{\frac{1}{1-b}}$ is the aggregate price index of the differentiated goods and Y is the total income. I assume that labor supply is prefectly inelastic, and Y/P^{1-b} is normalized to 1.

Production technology: Firm f produces variety z in the domestic economy by a constant elasticity of substitution technology, using as inputs intermediate goods x and y :

$$z_f = \left[\gamma x_f^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma) y_f^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{23}$$

Lelarge, and Peters, 2016).

[75]This idea was first developed by Grossman and Rossi-Hansberg (2002) in a two-sector open economy model.

[76] This balances trade between the two countries.

where $\varepsilon \in [0,\infty)$ is the elasticity of substitution[77] between the intermediate goods x and y in the production of z, while $\gamma \in (0,1)$ is the share of intermediate good x in the production of z. Firm f assembles intermediate good. $j \in \{x,y\}$ by using Cobb-Douglas technologies that combine low-skill, L, and high-skill, H, labor as factors of production:[78]

$$x_f = AL_{f,x}^{\alpha_x} H_{f,x}^{1-\alpha_x} \tag{24}$$

$$y_f = AL_{f,y}^{\alpha_y} H_{f,y}^{1-\alpha_y} \tag{25}$$

where α_x and α_y are the shares of low-skill labor in the assembly of x and y. I assume that the assembly of x is relatively high-skill intensive, which implies the parameter restriction $\alpha_x < \alpha_y$. Firm f pays wages w for one unit of low-skill labor in the domestic country, and w^* for one unit of low-skill labor in the foreign country. One unit of high-skill labor costs s in the domestic country, and s^* in the foreign country.[79]

Following Grossman and Rossi-Hansberg (2008), I assume that production of a unit of good j involves a continuum of low-skill tasks (L-tasks) and a continuum of high-skill tasks (H-tasks), with the measure of each of these types of tasks normalized to one, $i \in [0,1]$.[80] Moreover, in line with Grossman and Rossi-Hansberg (2008), I assume that tasks using the same type of skill require the same amount of labor of that particular skill type.[81]

Offshoring technology: Firm f can perform L-tasks, $i \in [0,1]$, either in the domestic economy or offshore them to the foreign country. Offshoring is preferred because of the benefit of offshoring: Low-skill labor is cheaper in the foreign country, given the assumption on the technology gap between the domestic and the foreign countries. However, offshoring is costly. Following Grossman and Rossi-Hansberg (2008), I assume that firm f performing L-task i pays $\beta\gamma_f t(i)$ as the cost of offshoring one unit of task i. β is a shift parameter that captures the technological characteristics of offshoring common across firms. γ_f is an idiosyncratic component of the offshoring cost that captures the technological characteristics of offshoring specific to firm f, such that firms with lower γ_f face a lower cost of offshoring. $t(i)$ allows for heterogeneity in the cost of offshoring across tasks $i \in [0,1]$. I assume that $t(i)$ is a continuously differentiable function, and $\beta\gamma_f t(i)$>1 for all i. $i \in [0,1]$ are ordered

[77] $\varepsilon < 1$ implies that intermediates x and y are complements in the production of z, while $\varepsilon > 1$ implies substitution between the two intermediates.

[78] One way to think about assembly of these intermediate goods within the firm is to view them as two establishments within the firm that specialize in the assembly of different components used by the firm in the production of the final good.

[79] I assume that the final good sector is small relative to the overall size of the economy. Therefore, firms in this sector do not affect wages. This means that firms take wages as given.

[80] Ossa and Chaney (2013) introduces the Grossman and Rossi-Hansberg (2008) type of tasks based production technology in the Krugman (1979), and assume that final good varieties are produced by performing sequentially a continuum of tasks. They framework, however, does not make the distinction between intermediate goods with different skill intensity.

[81] For example, if tasks i and i' are performed by the same skill type, then the factor requirement for performing i and i' is such that the same amount of labor is required for each. This implies that $L_{f,j} = \int_0^1 L_{f,j} di$ and $H_{f,j} = \int_0^1 H_{f,j} di$.

such that the costs of offshoring are non-decreasing $\frac{\partial t(i)}{\partial i} > 0$. I assume that tasks in the production of the two intermediate goods have the same offshorability. This implies that offshoring costs are similar in the case of x and y: $t_x(i) = t_y(i) = t(i)$. Therefore, if I_f is the fraction of offshored tasks, the unit cost of low-skilled labor is $w(1-I_f) + w^* \int_0^{I_f} \beta\gamma_f t(i)di$

5.1.2. Equilibrium Conditions

Offshoring decision: The tension between the benefits and costs of offshoring creates a trade-off that firm f faces when deciding about the set of L-tasks offshored and performed in the foreign country. Since domestic wages are large relative to foreign wages and offshoring is costly, only the firms in the domestic country engage in offshoring, and pay $\beta\gamma_f t(i)w*$ for one unit of task offshored and performed abroad.[82] As the firm offshores to take advantage of the lower foreign wage - but at the same time pays the cost of offshoring - the marginal task performed in the domestic economy by firm f, I_f, is pinned down at the task for which saving on the labor cost of performing the task abroad relative to performing it in the domestic economy exactly balances the cost of offshoring:[83]

$$w = \beta\gamma_f t(I_f)w* \tag{26}$$

This condition is the same in the case of both intermediate goods x and y, given the assumption on the equality of the offshoring cost, $t_x(i) = t_y(i) = t(i)$. Thus, I_f is the equilibrium marginal L-task such that all L-tasks with index $i \in [0, I_f]$ are performed by firm f abroad, while all L-tasks with index $i \in [I_f, 1]$ are performed in the domestic country. Given these assumptions, the wage bill for low-skilled labor hired by firm f to perform the L-tasks in the assembly of intermediate good j consists of the wage bill of low-skilled who perform the set of $i \in [I_f, 1]$ in the domestic economy and the wage bill of low-skilled who perform the set of $i \in [0, I_f]$ abroad. Thus, using condition (26), the cost of one unit of low-skilled labor becomes $w\Omega(I_f)$, where $\Omega(I_f)$ is the cost-saving that results from offshoring, and is given by the following expression:[84]

$$\Omega(I_f) = 1 - I_f + \frac{\int_0^{I_f} t(i)di}{t(I_f)} \tag{27}$$

Cost minimization: Given the equilibrium set of offshored L-tasks, the cost associated with one unit of low-skilled worker, $w\Omega(I_f)$, and one unit of high-skilled worker, s, firm f solves the following cost minimization problem to determine the number of high- and low-skilled workers to

[82]Thus, the cost of offshoring is in fact a wage premium paid by the firm on the foreign wage.

[83]Notice that in order to have an interior solution, $I_f > 0$, one additional assumption is needed: $w > \beta t(0)w^*$. This assumption is made by Grossman and Rossi-Hansberg (2008), and makes offshoring some tasks profitable.

[84]This expression is derived by substituting in $w(1-I_f) + w * \int_0^{I_f} \beta\gamma_f t(i)di$ the expression of w* given by (26).

hire for assembly of intermediate good $j \in \{x,y\}$:

$$\min_{\{L_{f,j},H_{f,j}\}} \left\{ w\Omega(I_f)L_{f,j} + sH_{f,j} - c_{f,j}AL_{f,j}^{\alpha_j}H_{f,j}^{1-\alpha_j} \right\} \tag{28}$$

which implies the following relative factor requirement in the assembly of j:

$$\frac{H_{f,j}}{L_{f,j}} = \frac{w\Omega(I_f)}{s}\frac{1-\alpha_j}{\alpha_j} \tag{29}$$

Given Cobb-Douglas technology, the cost of assembly of intermediate good j, which is the total costs of low-skill, $w\Omega(I_f)$, and high-skill labor, s is:

$$c_{f,j} = \frac{1}{A}\left(w\Omega(I_f)\right)^{\alpha_j} s^{1-\alpha_j} \tag{30}$$

As $\Omega(I_f) < 1$ for any $I_f > 0$ given $\frac{\partial t(i)}{\partial i} > 0$, offshoring reduces the total cost of low-skill labor. Given the heterogeneity in the cost of offshoring across firms and the properties of the offshoring technology $t(i)$, offshoring reduces the total cost of low-skill labor more in the case of firms with a lower firm specific component of the offshoring cost $\left(\gamma_f < \gamma_{f'}\right)$, as these firms shift a larger set of L-tasks abroad in equilibrium, $\left(I_f > I_{f'}\right)$.

The cost minimization problem of firm f also implies the following demand for high- and low-skilled labor per unit of production of intermediates x and y:

$$L_{f,j} = \frac{\alpha_j\Omega(I_f)}{A}\left(w\Omega(I_f)\right)^{\alpha_j-1} s^{1-\alpha_j} \tag{31}$$

$$H_{f,j} = \frac{1-\alpha_j}{A}\left(w\Omega(I_f)\right)^{\alpha_j} s^{-\alpha_j} \tag{32}$$

By using these, we can define the total number of high-skilled workers hired by firm f in the assembly of intermediate good x and y, as $h_{f,x} = H_{f,x}x$ and $h_{f,y} = H_{f,y}y$, where x and y are the quantities of intermediate $j \in \{x,y\}$ assembled by the firm in equilibrium. Thus, the total number of high-skilled workers by firm f is given by $h_f = h_{f,x} + h_{f,y}$. We can similarly define $l_{f,x}$, $l_{f,y}$ and l_f.

Profit maximization: Firms $f = 1,..,F$ engage in monopolistic competition. Hence, each firm f faces a downward sloping demand curve, but it takes the price index of the final good varieties, P, wages, and the consumers' expenditure as given. Given the cost of assembly of intermediate good j, $c_{f,j}$, and the inverse demand for variety z, $p_f = \left(\frac{Y}{P^{1-b}}\right)^{-\frac{1}{b}} z_f^{-\frac{1}{b}}$ with $b > 1$,[85] firm f solves the following profit maximization problem:

[85] The condition $b > 1$ guarantees the existence of the firm's optimum. Otherwise, if $b < 1$ the markup over the marginal cost is negative and the firm does not find it profitable to produce.

$$\max_{\{x_f, y_f\}} \Pi_f = \left(\frac{Y}{P^{1-b}}\right)^{-\frac{1}{b}} \left[\gamma x_f^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma) y_f^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon(b-1)}{b(\varepsilon-1)}} - c_{f,x}x - c_{f,y}y \tag{33}$$

The solution to this problem pins down the relative requirement of intermediate goods x and y for the production of final good variety f as a function of relative unit costs:

$$\frac{y}{x} = \frac{\gamma}{1-\gamma} \left(\frac{c_{f,y}}{c_{f,x}}\right)^{-\varepsilon} \tag{34}$$

5.2 The Impact of the Decline in the Cost of Offshoring on Firms' Sourcing Decisions and Employment

In this section, I consider how the decline in the cost of offshoring L-tasks impacts firms' sourcing decisions, their cost of production of the final good, and their demand for skilled labor in the domestic country.[86] A decline in the cost of offshoring L-tasks in the model is equivalent to a reduction in parameter β. This is equivalent to the China shock in my empirical exercise. In the following propositions, I summarize the results of a comparative statics analysis in the partial equilibrium.[87] In particular, for given wages, I show how (i) the marginal L-task, I_f, and thus the set of offshored L-tasks $[0, I_f]$; (ii) the cost of sourcing L-tasks, $\Omega(I_f)$; and (iii) the total employment of high-skilled, and (iv) the employment of high-skilled in the production of high-skill intensive intermediate good x, $h_{f,x}$, relative to the demand for high-skill in the production of low-skill intensive intermediate good y, $h_{f,y}$, change[88] in the case of firm f in response to a decline in β. Moreover, I derive predictions on how all these margins adjust in the case of a firm that is more exposed to a decline in β (i.e., has a lower γ_f) relative to a less exposed firm (i.e., has a larger γ_f).

Proposition 1 If $I_f > 0$, then in equilibrium the set of L-tasks offshored by firm f expands as β declines:

$$\hat{I}_f > 0 \tag{35}$$

Proof See the Appendix.

Proposition 1 shows that if offshoring L-tasks becomes cheaper as β declines, firms offshore more of the L-tasks abroad. These newly offshored tasks are performed by foreign low-skill labor, while

[86] One can think of the domestic country as the US, and the foreign country as China.

[87] In particular, I assume that the final good sector is small relative to the overall size of the economy. Therefore, firms in this sector do not affect wages.

[88] Throughout this section, I measure the changes in log-differences and denote them with hat. For instance, the change in variable I_f measured in log-difference, is $\hat{I}_f = dI_f/I_f$.

firm f performs more skill-intensive tasks in the domestic country. This intuition is in line with Grossman and Rossi-Hansberg (2008).

Proposition 2 If $I_f > 0$, then in equilibrium the cost of sourcing L-tasks by firm f declines as β declines:

$$\hat{\Omega}_f < 0 \tag{36}$$

Proof See the Appendix.

Proposition 2 states that as the cost of offshoring L-tasks declines, firm f registers a decline in the cost of assembly of intermediate goods. This is the combination of two effects. First, holding the marginal task, I_f, constant, the decline in β leads to a decline in the cost of production of firm f (i.e., *direct cost effect of offshoring*). Second, as summarized in Proposition 1, the decline in β leads to a reorganization of the set of L-tasks across borders (i.e., expansion in the set of L-tasks offshored), which further increases the cost saving from offshoring (i.e., *reorganization effect of offshoring*). Thus, the second effect reinforces the decline in the cost of production resulted from the first effect. Consequently, the overall cost of assembly of both intermediate goods x and y falls. However, as y is the less skill-intensive intermediate good, firm f registers a larger decline in the cost of assembly of y than in the case of the more skill-intensive intermediate good x. In this way, the assembly of y is more exposed to the decline in the cost of offshoring.[89] This intuition is in line with Grossman and Rossi-Hansberg (2008).

Proof See the Appendix.

Proposition 3 If $I_f > 0$, then the equilibrium employment of high-skilled by firm f increases as β declines if and only if $\varepsilon < b$:

$$\hat{h}_f > 0 \tag{37}$$

Proof See the Theory Appendix.

Proposition 3 shows that the decline in the cost of offshoring has an implication for high-skilled labor employed by firm f. It states that the number of high-skilled hired by the firm increases if the elasticity of substitution between the final good varieties (i.e., b) is larger than the elasticity of substitution between the high- and low-skill intensive intermediate goods in the production of the final good varieties (i.e., ε). The intuition behind this is the following. The decline in β leads to a decline in the cost of production as summarized by Proposition 2. As a result of this cost reduction, the variety produced by the firm becomes cheaper. As varieties are substitutes in the consumption basket

[89] If we view the assembly of x and y within the firm as two establishments within the firm specialized in the assembly of different components used by the firm in the production of the final good, then this result implies that the more exposed establishment registers a larger decline in the cost of production.

of the consumer (i.e., $b > 1$), the demand for the variety of the firm increases. To meet the increasing demand, the firm expands the scale of production of the final good variety (i.e. *output expansion effect of offshoring*) by hiring more skilled-workers.[90] However, as the decline in β leads to a larger decline in the cost of assembly of y, the firm tends to substitute towards the cheaper input, y, which is less skill intensive. This leads to an expansion of the low-skilled and a contraction of the high-skilled employment at the firm level. Condition $\varepsilon < b$ ensures that the output expansion effect is large enough to trigger such a large expansion in the skilled-employment that it compensates for the decline resulted from the substitution to the cheaper input. This intuition is in line with the results of other papers that document theoretical results, in frameworks lacking the firm, that cross-industry reorganization of the domestic economic activity in response to the decline in the cost of offshoring (Grossman and Rossi-Hansberg, 2008), migration (Burnstein et al., 2016) or capital deepening (Acemoglu and Guerrieri, 2008) can lead to an expansion of the domestic economic activity.

This prediction of the model highlights the fact that even if certain tasks are offshored, which may have negative consequences on the firm's employment, other tasks are performed at a larger scale in the domestic economy. Therefore, even if there is no reorganization, the firm's employment may increase, as reduction in the cost leads to an expansion in the scale of production. Reorganization amplifies this effect, as it leads to further cost reduction and ouput expansion.

Proposition 4 If $I_f > 0$, then, as β declines, the equilibrium employment of high-skilled by firm f in the assembly of intermediate input x (i) increases relative to the equilibrium employment of high-skilled in the assembly of intermediate input y if and only if $\varepsilon < 1$:

$$\hat{h}_{x,f} - \hat{h}_{y,f} > 0 \tag{38}$$

(ii) decreases relative to the equilibrium employment of high-skilled in the assembly of intermediate input y if and only if $\varepsilon > 1$:

$$\hat{h}_{x,f} - \hat{h}_{y,f} < 0 \tag{39}$$

and (iii) there is no effect if $\varepsilon = 1$.

Proof See the Theory Appendix.

Proposition 4 shows that the decline in the cost of offshoring has an implication for high-skilled labor hired in the less exposed establishment of the firm (i.e., the assembly of x, which is more skill-intensive) relative to the more exposed establishment. It states that the number of high-skilled hired in the assembly of x increases relative to the number of high-skilled hired in the assembly of y if and only if x and y are complements in the production of the final good variety f (i.e. $\varepsilon < 1$). The intuition behind this is the following. The decline in β leads to a decline in the cost of production (Proposition

[90]Thus, the condition on the elasticity of substitution between the final good varieties triggers the expansion in the output.

2). As a result of this cost reduction, the price of the variety produced by the firm becomes cheaper which trigger an expansion in the demand. To meet the increasing demand, the firm expands the scale of production of the final good variety. If x and y are complements in the production of the final good variety (i.e., $\varepsilon < 1$), then the firm expands the assembly of both x and y. This is associated with an expansion of high-skill employment, such that the firm hires more of the high-skilled in the assembly of the more skill-intensive intermediate x. However, x is less exposed to the decline in β, since it employs fewer low-skilled. Therefore, the decline in the cost of offshoring leads to a larger expansion of high-skill employment in the less exposed establishment of the firm relative to the more exposed establishment.[91]

Proposition 5 If $I_f > 0$, $I_{f'} > 0$, $\gamma_f < \gamma_{f'}$, and $\frac{\partial^2 t(I_f)}{\partial I_f^2} < 0$, then (i) the equilibrium set of L-tasks offshored by firm f expands more relative to firm f' as β declines:

$$\hat{I}_f > \hat{I}_{f'} > 0 \tag{40}$$

(ii) in equilibrium the cost of sourcing L-tasks by firm f declines more relative to firm f' as β declines:

$$\hat{\Omega}_{f'} < \hat{\Omega}_{f'} < 0 \tag{41}$$

(iii) the equilibrium employment of high-skilled by firm f increases more relative to firm f' as β declines if and only if $\varepsilon < b$:

$$\hat{h}_f > \hat{h}_{f'} > 0 \tag{42}$$

(iv) the relative equilibrium employment of high-skilled by firm f in the assembly of intermediate input x increases more relative to firm f' as β declines if and only if $\varepsilon < 1$:

$$\hat{h}_{x,f} - \hat{h}_{y,f} > \hat{h}_{x,f'} - \hat{h}_{y,f'} > 0 \tag{43}$$

Proposition 5 shows that the decline in the cost of offshoring has a heterogenous impact across firms. Firms with a lower idiosyncratic component in the cost of offshoring L-tasks (γ_f) register a larger expansion in the set of offshored L-task and, thus, a larger cost decline if the task specific component of the offshoring cost is concave (i.e. $\frac{\partial^2 t(I_f)}{\partial I_f^2} < 0$). This condition guarantees that the marginal cost of offshoring is decreasing in I_f. This means that firms with a lower γ_f (i.e., firms that offshore more initially) can offshore an extra unit of L-tasks at a lower cost and, thus, benefit more from the decline in β. As a consequence, they register a larger expansion in the set of offshored L-tasks, a larger cost saving, and a larger expansion in high-skilled employment relative to less exposed

[91] The condition on the elasticity of substitution between intermediate goods in the production of the final good varieties (i.e. $\varepsilon < 1$) triggers the expansion of skilled employment in the less exposed establishment relative to the more exposed establishment.

firms. Moreover, these more exposed firms expand more the employment of high-skilled in the less exposed establishment relative to the more exposed establishment.

The qualitative prediction summarized in part (iii) of Proposition 5 is consistent with the findings documented in Section 4: increased offshoring to China led to an expansion of high-skilled employment by US manufacutring firms. As part (iv) of Proposition 5 shows, this expansion in high-skilled employment documented from the data may be the result of a larger expansion of high-skilled employment in the non-exposed establishments of the firm. As in the model the non-exposed establishments are in high-skilled intensive industries, in which the home country has a comparative advantage, the model suggests the expansion of high-skilled employment in response to the China shock documented from the data may have been the result of US firms increasing high-skilled employment in non-exposed industries in the US.

6 Empirical Evidence on the Proposed Mechanism

In this section I document a series of empirical facts that provide evidence of the mechanism through which firms expand domestic high-skilled employment. The theory presented in Section 5 predicts that the decline in the cost of offshoring of low-skill intensive intermediate goods induces an expansion in the set of intermediates sourced from abroad by firms in the domestic economy (Proposition 1). This reorganization of domestic economic activity allows firms to register a decline in the cost of production (Proposition 2). As costs fall, the price of the final good variety falls; this leads to an expansion in the demand. To meet the increasing demand, firms expand the scale of domestic production of the final good by assembling more intermediate goods. As more and less skill-intensive intermediate goods are complements in the production of the final good variety, firms expand the scale of assembly. As a consequence of this, firms expand high-skilled employment (Proposition 3) by hiring more of this skill type in the less exposed establishment (i.e., more skill intensive intermediate good) relative to the more exposed establishment within the firm (Proposition 4). Finally, the theory also predicts a larger effect of the decline in the cost of offshoring in the case of the more exposed firm relative to the less exposed (Proposition 5). The rest of this section provides suggestive evidence for these theoretical predictions.[92] In particular, I document how US manufacturing firms changed their material input sourcing decisions over time. I then consider the change in Chinese import competition in US input markets between 1997 and 2007 as a measure of the cost shock that resulted from China's entry into the WTO, which hit US firms through the markets in which they sourced their material inputs. I estimate the impact of this cost shock on US firms' sourcing decisions and material

[92] Anecdotal evidence and publicly available reports of major manufacturers in the US provide information that is in line with the findings of this section. For instance, a senior board member of a major car manufacturer declared, "we buy components from wherever is cheaper ... what we save on sourcing from abroad we reinvest in the US to expand our business ... a typical carmaker hires more software engineers, computer scientists and electrical engineers than blue collar."

input prices (i.e., proxy for the cost of sourcing material inputs) as a test of Proposition 1 and 2, and parts (i) and (ii) of Proposition 5. Finally, I document how the rise in firms' material input sourcing impacted manufacturing employment by US manufacturing firms as a test of Proposition 3 and part (iii) of Proposition 5.

6.1 Increased Offshoring to China

According to Proposition 1, the decline in the cost of offshoring low-skilled intensive tasks, which in our case is China's entry into the WTO, induces an expansion in the set of intermediates sourced by firms from abroad. Part (i) of Proposition 5 predicts that this effect is larger in the case of more exposed firms relative to the less exposed ones. To check whether this prediction is in line with the data, I document how US manufacturing firms changed their material input sourcing over time and estimate the causal impact of the China shock on these firms' sourcing decisions.

The richness of US microdata allows me to characterize and analyze changes over time in firms' material input sourcing decisions at the six-digit product level and across four types of sourcing: buy or produce material inputs in the US or abroad. Thus, I decompose the expenditure by firm f in year t on material input, p, by the country of origin of the sourcing from the US (i.e., domestic) or a foreign country (i.e., imported):

$$\frac{Material_{fpt}}{Material_{fpt}} = \frac{Domestic\ material_{fpt}}{Material_{fpt}} + \frac{Foreign\ material_{fpt}}{Material_{fpt}} \tag{44}$$

Moreover, I decompose both the domestic and the foreign components based on whether the material input is produced in a plant owned by the firm (i.e., insourcing) or procured from a third-party supplier (i.e., outsourcing). Thus, each of the domestic and foreign components of the material input expenditures can be decomposed by these two margins:

$$\frac{Domestic\ material_{fpt}}{Material_{fpt}} = \frac{Domestic\,Insourcing_{fpt}}{Material_{fpt}} + \frac{Domestic\,Outsourcing_{fpt}}{Material_{fpt}} \tag{45}$$

$$\frac{Foreign\ material_{fpt}}{Material_{fpt}} = \frac{Foreign\,Insourcing_{fpt}}{Material_{fpt}} + \frac{Foreign\,Outsourcing_{fpt}}{Material_{fpt}} \tag{46}$$

I apply the decompositions in (45)-(46) to a data set that I construct on US manufacutring firms with firm-material input product as the unit of observation. The product is defined at the six-digit NAICS level.[93] This data set allows me to quantify each element of the decomposition based on the definitions and assumptions outlined in Section 3. The results of the decomposition are presented in

[93]The data appendix provides a detailed description of how this data set was constructed.

Tables 11-13 in the form of weighted averages of each component of the decomposition.[94] These results provide a series of novel findings that convey information on how US manufacturing firms organize their sourcing of material inputs, as well as how these sourcing patterns have changed over time, in particular after China's entry into the WTO in 2001.

First, the results show that US manufacturing firms most frequently source the largest share of their material inputs from independent suppliers, and in particular domestic suppliers, rather than produce them in-house in the US or abroad. Table 11 shows that the typical firm sources between 25 percent and 30 percent of its material inputs from in-house production[95] as about 10 percent of the materials are produced in-house in the US[96], while material inputs produced in a factory owned by the firm abroad and shipped back to the firm in the US for further processing account for about 15 percent or 20 percent of the total material spending. In terms of foreign sourcing, Table 12 shows that a typical firm sources most of its materials from the five major trading partners of the US (i.e., Canada, China, Mexico, Germany, and Japan) such that most of the material sourcing from China involves buying from Chinese suppliers rather than producing the input in China through foreign direct investment.[97] As Table 13 indicates, firms frequently mix different sourcing types (i.e., about four out of ten cases). In particular, they frequently both buy and produce inputs in the same six-digit product category.[98]

Second, my findings on decomposition by industries suggest an important cross-industry heterogeneity in the importance of each type of sourcing in firms' sourcing strategy. As Figures 6 and 7 indicate, industries that are less site specific or are more assembly intensive, such as electrical equipment or transportation equipment, rely more on outsourcing, both at the extensive (i.e., the frequency

[94] To account for within-firm heterogeneity across product groups, and for the cross-firm heterogeneity in the size of the material expenditure, I compute the weighted average of each component of the decomposition across the material input product categories within the firm. I then compute the weighted average of the firm level weighted averages across firms. The product weight within the firm is computed as the total expenditure on a particular material input product relative to the total firm level material expenditure. The firm level weights are computed as the firm level material input expenditure relative to the total material expenditure in the cross-section.

[95] This number is larger than the one documented by Atalay et al. (2015), who decompose the total material spending of US firms by domestic in-sourcing and domestic out-sourcing (i.e., they only consider the first component of the decomposition considered in this paper, based on equation 40). They find that US manufacturing establishments in the US source about 9 percent of their materials from other establishments that are vertically integrated within the firm. This number is about the same as the 10 percent that I document. However, if one takes into account the fact that firms in the US can own establishments in other countries which may specialize in the production of the material inputs that the firm uses for the production of its output in the US, then this number goes up to 25 percent as documented in Table 14. This suggests that once we take into account the fact that the boundary of the firm can expand across borders, firms do vertically integrate to source materials from in-house production and facilitate the shipment of these materials.

[96] This is not a surprising finding, as most of the shift from vertical integration toward outsourcing in the US had occured by the early 1990s (Whitford, 2005).

[97] As Table 15 indicates, about 90 percent of the expenditure on sourcing from China in the case of a typical material input product of a typical US firm that manufactures in the US is based on arm's-length transactions rather than related-party trade transactions.

[98] This is suggestive evidence of the fact that risks related to contracting with independent suppliers, disruption in supply chains, the presence of other types of transaction costs (Antras and Chor, 2013; Grossman and Hart, 1986; Loertscher and Riordan, 2016; Williamson, 1985), or the presence of quality differentiation within the six-digit product category may induce the firm to produce some of the total required quantity of a particular input or some varieties of a particular input classified as the broad six-digit NAICS product category.

of choosing a particular sourcing type) and intensive margins (i.e., the share of spending on a particular sourcing type). By comparing sourcing patterns across industries based on the country of foreign outsourcing, firms in industries that are more assembly intensive by low-skill workers tend to source more from China (Tables 14 and 15). For instance, firms in the electrical equipment industry tend to source more of their inputs from China than firms in the transportation equipment industry.

Third, by comparing distribution of material expenditure by the four types of sourcing across years, Table 11 shows a rapid shift from domestic to foreign sources between 1997 and 2007. This mostly occured after 2001, when China joined the WTO. In addition to this, Table 12 indicates that most of this shift took place in terms of switching to Chinese suppliers rather than foreign direct investment in China. Moreover, this shift in sourcing from domestic to Chinese suppliers is more pronounced in the case of firms in industries that use material inputs that are more assembly intensive by low-skilled workers or are less site specific, or where transporting in large volumes is not expensive (Table 14).

All of these descriptive findings suggest that, in line with the predictions of the theory, China's entry into the WTO shaped US firms' sourcing strategies across borders and countries. This was particularly true in the case of firms in US manufacturing industries that are intensive users of material inputs for which China has a comparative advantage. To provide direct evidence of the causal impact of this link, I estimate the impact of increased Chinese import competition in US input markets on US manufacturing firms' input sourcing decisions. In particular, I estimate a system of four equations, as follows:[99]

$$\triangle y_{fpt} = \alpha_0 + \alpha_1 Shock_{pt} + X_{f,1997} + \varepsilon_{fpt} \tag{47}$$

where $\triangle y_{fpt}$ is a vector with four components $\triangle \frac{Domestic\,Insourcing_{fpt}}{Material_{fpt}}$, $\triangle \frac{Domestic\,Outsourcing_{fpt}}{Material_{fpt}}$, $\triangle \frac{Foreign\,Insourcing_{fpt}}{Material_{fpt}}$, and $\triangle \frac{Foreign\,Outsourcing_{fpt}}{Material_{fpt}}$. Each of these components capture the change in the expenditure share by firm f and material input product p on a particular sourcing type between 1997 and 2007.[100] $Shock_{pt}$ captures the change in Chinese import competition in the US manufacturing industry that firm f sources the material input from. I define the China shock by using the two industry level measures presented in Section 5. $X_{f,1997}$ contains a series of firm level controls defined in the pre-shock year 1997, such as the main manufacturing industry of the firm defined at the three-digit level and total employment of the firm in manufacturing activities taken in logarithm. To assess the causal impact of the China shock on firms' sourcing strategy choice, I use the same identification strategy and instrument

[99] As choices across the four types of sourcing of a particular material input product by the firm are interdependent, changes in expenditures over time on the four types of sourcing are also interdependent. Thus, to capture this correlation when the impact of the China shock on the change in each component of the decomposition is estimated, I set up the econometric model as a system. The other advantage of estimating the system is related to the efficiency of the estimates, as correlation in errors across the four equations of the system can be taken into account.

[100] Given the form of the specification in (24), α_1 captures the adjustment in the expenditure shares across the four types of sourcing within a product category. Thus, it does not take into account product enty and exit, and the possibility that the China shock may have led to introduction of new imported varieties to the set of material inputs used by the firm (Broda and Weinstein, 2006; Goldberg, Khandelwal, Pavcnik, and Topalova, 2010).

as outlined in Section 4.

I find that US manufacturing firms that sourced their material inputs from industries that were more exposed to the China shock tended to shift the sourcing of their material inputs from domestic suppliers toward foreign sources (i.e., both foreign suppliers and by producing the material input in factories owned by the firm abroad). In particular, estimates reported in Table 17 indicate, using both definitions of the China shock, that US manufacturing firms sourcing from industries more exposed to the China shock reallocated resources across the four types of sourcing: they reduced spending on domestic suppliers, and increased offshoring to the rest of the world.[101] These more exposed industries in the US registered a large influx of imports from China (i.e., the industries in which China had a comparative advantage). Thus, this finding is empirical evidence of the theoretical prediction (Proposition 1, part (i) of Proposition 5) that a decline in the cost of offshoring of low-skill intensive intermediate goods induces a larger expansion in the set of intermediates sourced from abroad by more exposed firms relative to less exposed.

6.2 Cheaper Material-Input Sourcing Due to China

As Proposition 2 and part (ii) of Proposition 5 summarize, the shift in sourcing toward foreign locations must have been accompanied by a larger decline in the cost of materials in the case of more exposed firm relative to the less exposed. To test this prediction in the data, I examine how the unit cost of material inputs used by US manufacturing firms in the production of their output adjusted in response to the China shock.

One of the unique features of the data on US manufacturing firms collected by the Census Bureau is that it contains information on the set of material input products used by the manufacturing establishments of the firm, and the value and the quantity associated with these material inputs at the six-digit NAICS level of aggregation. I define the cost of the material input, $cost^{input}_{fept}$, as the real unit value computed as the ratio between the value and quantity and adjusted by industry level inflation between 1997 and 2007. To ensure that outliers in the cost measure do not contaminate the results of the analysis, I remove observations below and above the 5th and the 95th percentile when I construct the sample for estimation.[102] I plot in Figure 8 the distribution of these material input costs in 1997 and 2007 in the case of firm-establishment-product pairs that are present in both years. The figure does not indicate any substantial shift in the distribution of these material input costs to the right or left between 1997 and 2007, but it indicates an increase in the tailedness of the distribution.[103]

[101]This finding is in line with Antras et al. (2016) who show in a counterfactual exercise that China's entry to WTO increased offshoring of US firms not only to China but also to other countries.

[102]The choice of percentile size does not have any impact on estimation results, which are robust for other cleaning rules, such as dropping observations below and above the 3rd or 10th, and 97th and 90th percentiles.

[103]The shape of the cost distribution in 2007 in comparison with the shape of the distribution in 1997 clearly shows that there is an increase in the mass of the costs greater than the median in 1997 and a decline in the mass of costs larger than the median, while the tails stay approximately unchanged over time.

To examine how these material input costs were adjusted between 1997 and 2007 in response to increased Chinese import competition in US input markets, I write down and estimate the following regression model both on the set of surviving firm-establishment-product pairs and on the entire sample:[104]

$$\triangle cost^{input}_{fept} = \gamma_0 + \gamma_1 Shock_{pt} + \gamma_e + \varepsilon_{fept} \tag{48}$$

where γ_e contains establishment characteristics such as a set of industry fixed effects that are defined based on the main output industry of the establishment and controls for macroeconomic shocks to material input costs that are common across firms in a given output industry. $Shock_{pt}$ is defined in Section 4. I use the same identification strategy and instrument the shock variable by using the same instrument as outlined in Section 4. Thus, γ_1 captures the difference in material input costs across initially similar firm-establishment-product pairs, but with different exposure to Chinese imports in the market of material input p.

I find that US manufacturing firms that sourced material inputs from industries more exposed to the China shock registered a decline in the cost of the material input in 2007 relative to 1997. Table 18 reports the two-stage least squares estimates of γ_1 on the sample of surviving (Columns 1 and 2) and on the sample of all firm-establishment-product pairs (Column 3). These estimates indicate that an average 10 percentage point increase in imports from China to the US induces an average decline in the firms' cost of materials between 1 percent and 3.5 percent. This finding supports the theoretical prediction that the decline in the cost of offshoring the production of low-skill intensive intermediates induces a decline in the unit cost of production. There can be different channels through which this cost reduction occurs, even if the model does not explicitly account for different sources of the decline in the unit cost. For instance, the decline in upstream prices in the US due to the pro-competitive effect of Chinese imports is one channel (Amiti and Konings, 2007; Loecker, Goldberg, Khandelwal and Pavcnik, 2016; Feenstra and Weinstein, 2016); others are access to new imported intermediate goods that are cheaper in China (Broda and Weinstein, 2006; Goldberg, Khandelwal, Pavcnik, and Topalova, 2010), and buying or producing the intermediate good more cheaply in China.

6.3 The Role of Cheaper Sourcing in the Adjustment of US Manufacturing Employment

The theory predicts that a decline in the cost of offshoring induces an increase in domestic employment of high-skilled (Proposition 3, part (iii) of Proposition 5). This is possible, since offshoring of low-skill intensive tasks allows domestic firms to reduce the cost of production and, thus, expand the

[104] The entire set consists of the cross-sections in 1997, 2002, and 2007 pooled over time. Thus, it accounts for not only the surviving firm-establishment-product pairs, but also for the firms, establishments, and products that entered or exited between these years. When I estimate the model on the set of all firm-establishment-product pairs, the estimated model in levels is: $cost^{input}_{fept} = \gamma_0 + \gamma_1 Shock_{pt} + \gamma_f + \gamma_p + \gamma_{e,t} + \varepsilon_{fept}$, where γ_f and γ_p control for variations in prices that are common over time in the case of a firm f and product p pair. γ_e contains establishment characteristics such as a set of industry fixed effects defined as the main output industry of the establishment.

scale of production of the final good, for which they hire more high-skilled labor. Thus, according to this theory, the decline in the cost of offshoring acts as a favorable cost shock to the firm. In the previous sub-sections I documented empirical evidence that the China shock was a favorable cost shock to US firms. This section examines whether the boost in US manufacturing firms' material expenditure, resulted from the favorable cost shock due to China, had a direct impact on these firms' employment in manufacturing activities. This consists of estimating the following regression model:

$$\frac{\triangle L^M_{ft}}{L_{f,1997}} = \beta_0 + \beta_1 \triangle logMaterial_{ft} + \beta_2 X_{f,1997} + \varepsilon_{it} \tag{49}$$

where $\triangle L^M_{ft}/L_{f,1997}$ is the growth in manufacturing employment by firm f from 1997 to 2007,[105] $\triangle logMaterial_{ft}$ is the change in the logarithm of real value of total material expenditures of firm f from 1997 to 2007, X_{i1997} contains a set of firm level controls in 1997, which are the same as those listed in Section 4.2. To identify variation in material expenditure over time due to the declining cost of sourcing induced by China, I instrument $\triangle logMaterial_{ft}$ with the weighted average of the industry specific instrument defined in Section 4.1.[106] The weights are defined as the share of total spending on material input p by firm f relative to the total material expenditure of the firm in 1997.[107] Thus, the two-stage least squares estimate of β_1 measures the difference in manufacturing employment across two firms that, on average, have the same initial characteristics in 1997, but one registered a larger increase in spending on materials than the other due to the larger exposure to the change in Chinese imports by the US manufacturing industries that firm f sourced its material inputs from (i.e., larger exposure to the favorable cost shock).

My findings indicate that US manufacturing firms that spent more on materials, by taking advantage of the favorable cost shock due to China, expanded manufacturing employment more. The highly statistically significant and positive point estimate of β_1 in Column 2 of Table 19 provides empirical evidence that US manufacturing firms expanded employment in manufacturing industries less exposed to the China shock. This shock not only created import competition in some of their output industries, but also reduced the cost of sourcing their material inputs, which made possible the expansion of the scale of production and employment of US manufacturing firms in industries in which the US had a comparative advantage relative to China. Columns 3 to 5 provide additional reduced-form evidence of US manufacturing firms expanding the scale of their domestic production in response

[105] I measure the left hand side variable as the change in each component of employment by activity relative to total firm level employment in 1997, instead of the change in log employment, to account for zeros in the data.

[106] The last two rows of Column 1 in Table 19 contain the value of the F-statistics and the associated p-value of the F-test that tests, in the first-stage, the relevance of this instrument for the change in log material expenditure of the firms that manufactured in 1997. The zero p-value and the large value taken by the F-statistics indicate that this is a strong instrument.

[107] More precisely, $w_{p,f,1997}$=$Material_{p,f,1997}/\sum_{p \in P^{input}_{f,1997}} Material_{,f1997}$. By using this weighting scheme, I capture all the upstream shocks the firm is exposed to through the material input product it uses. Moreover, material input products that are less important in the production of the output product (i.e., low cost share) are given less importance through the small weight in the computation of the instrument.

to the favorable cost shock due to China. In particular, more exposed firms hired more production workers in manufacturing, opened more plants and added new products to the set of outputs they produced.

Column 1 of Table 20 provides additional empirical evidence that supports this hypothesis. This specification contains as right hand side variable, in addition to the ones listed above: the firm level China shock measure from Section 4.2 that is actually the measure of the China shock to which the firm is exposed in its output markets (i.e., weighted average of the China shock to the output industries the firm has establishments in). The sign and size of the point estimates suggest that the mechanism through which China induced expansion in the manufacturing employment of US manufacturing firms was through the reductions in the cost of sourcing material inputs. The point estimate of the change in imports from China in US output markets drops to zero which suggests that there is a high correlation[108] between the Chinese import competition faced by the firm in the US output and input markets. This correlation makes it impossible to assess the relative importance of vertical and horizontal shocks in a reduced-form exercise.

All these findings are suggestive evidence that US manufacturing firms (i) reorganized their activities from US output industries, where they were more exposed to Chinese imports through the output products they produced, to US output industries less exposed or non-exposed to Chinese imports, and (ii) expanded employment in these non-exposed US ouput industries by taking advantage of the favorable cost shock that China created through increased imports in the US input industries from which these firms sourced their material inputs and the opportunity to shift sourcing from domestic to cheaper suppliers abroad.

7 Conclusions

In this paper I examined the causal impact of increased Chinese imports in US manufacturing industries on the employment of US manufacturing firms. The literature seems to have reached a near-uniform consensus on the negative effect of Chinese imports on employment in US manufacturing establishments, industries, and regions. However, the impact of on firms, which can be thought of as collections of establishments, can differ from the effect on individual establishments, because offshoring reduces costs at the firm level.

This paper used the firm as the unit of analysis. In particular, I considered the national activity of firms in the US that had a presence in US manufacturing industries, and thus owned the exposed manufacturing establishments. I developed a methodology that allowed me to characterize firms'

[108]By using the industry level input-output matrix in 1997 from the Bureau of Economic Analysis, I construct the industry level input market shock as the weighted average of the growth rate in imports from China to the use industries of each output industry in the US. The correlation coefficient between the input and output market shock measures at the industry level is 0.9. As the firm level shock measures are computed as the weighted average of the industry level shocks, this large correlation at the industry level is transmitted to the firm level.

organization and decompose firms' overall employment into employment associated with manufacturing and non-manufacturing industries. I constructed a novel data set on US firms in the US by using confidential microdata from the US Census Bureau. Using this data set, I showed that the employment of US manufacturing firms rose in response to increasing Chinese imports in US output markets. More exposed firms expanded employment (i) in manufacturing, as they hired production workers whom they paid higher wages, and (ii) in non-manufacturing, by adding jobs in R&D, design, engineering, and headquarters services. In other words, China caused a relative expansion of US employment in firms operating in industries that experienced the largest growth in Chinese imports. I argued theoretically, and provided reduced-form evidence, that this was possible through firms' reorganization toward less exposed output industries, in which the US had a comparative advantage relative to China. In these output industries, firms expanded skilled employment by taking advantage of falling production costs due to increased offshoring to China.

The evidence provided in this paper indicate that the employment losses at the establishment level, measured by the previous papers (Acemoglu et al., 2016; Autor et al., 2013), were compensated by the *employment gains* that resulted from *two sources*. First, within-firm *reorganization* allowed US manufacutring firms to escape the negative impact of the China shock; US manufacturing firms reorganized their activities in many dimensions in response to the China shock. On the one hand, they reorganized their US activity from exposed to non-exposed US output markets. On the other hand, they reorganized their input sourcing as they replaced domestic suppliers with foreign suppliers and increased foreign direct investment. Second, employment at US manufacturing firms expanded in response to the combined effect of increased Chinese imports in US output and input markets. This is because increased imports in the input markets put downward pressure on US manufacturing firms' cost of sourcing material inputs. Thus, the China shock to the firm's input markets acted as a *favorable cost shock* that compensated for some or all of the negative impacts of the increased output market competition.

All of these suggest that the China shock impacted US manufacturing employment in a more nuanced way than simply increasing output market competition at the establishment level, which captures only the losses that resulted from the shock. Reorganization at the firm level and the combined effects of input and ouput market shocks can lead to net job creation. However, this may not involve the same workers in the same industries, in the same regions of the US or the same establishments of the firm.

Future research should focus on documenting empirical evidence that can deepen our understaning of the sources of job creatinon in response to the surge in imports from China. In particular, examining the relative importance of the margins that may lead to job creation at the firm level (i.e., reorganization, upstream market competition) is a natural next step. Also, accounting for changes in the firms' boundary across US industries and local labor markets would broaden our understanding of the extent to which the job creation is the result of within- versus cross-firm adjustment in response to the surge in Chinese imports. The findings of this paper and those of the future research may provide policy makers a better insight into potential impacts of increasing trade barriers on the performance of US firms and trends in US manufacturing employment.

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Table 1: Growth in national employment between 1997 and 2007 by firm and type of the establishments owned by these firms relative to the total employment in 1997 (%)

	Employment in manufacturing establishments	Employment in non-manufacturing establishments	Total employment
Manufacturing firm	-3.0	7.0	4.0
Non-manufacturing firm	0.4	23.4	24.0
All firms	-2.6	30.6	28.0

Note: The table contains the decomposition of the growth rate of the aggregate US employment - constructed by aggregating the firm-establishment level employment in the case of the firms in the Longitudinal Business Database that survived between 1997 and 2007, by the type of the firm and establishments within the firm in line with the definitiosn and decomposition in the main text. The firm that manufactured is the firm that had positive employment in manufacturing in 1997. The manufacturing establishment is an establishment classified to a manufacturing industry based on its largest activity.

Table 2: Change of employment in non-manufacturing activites between 1997 and 2007 by US manufacturing firms (%)

Non-manufacturing activity	Type of occupation within the activity	Change relative to total employment in non-manufacturing activities in 1997
Retail and wholesale		13.1
Transportation		3.9
Information	Data Processing, Software Telecommunication, Broadcasting	12.4
Finance		1.3
Real Estate		2.1
Professional sevices	Engineering, Design, Scientific R&D Advertising, Legal, Accounting	1.5
Management	Offices of Companies, Corporate and Regional Management	14.9
Administrative Services	Office Administration, Business Support Security, Employment Services	8.8
Education		0.7
Health		-1.2
Other services	Agriculture, Mining, Utilities, Construction , Entertainment, Accommodation, Food Services Art, Other Services	-2.8

Note: The table contains the decomposition of the growth rate of the aggregate US employment in non-manufacturing establishments by US manufacturing firms by the type of activities in non-manufacturing listed in the first column of the table, defined at the two digit SIC industry level. The second column lists the activites contained by each of these industries at a more disaggregated level. The aggregate numbers at the national level are constructed by aggregating the firm-establishment level employment in the case of the firms in the Longitudinal Business Database that survived between 1997 and 2007. The third column contains the change in aggregate employment between 1997 and 2007 associated with each of the non-manufacturing activites within manufacturing firms relative to the total non-manufacturing employment by these firms in 1997.

Table 3: Growth in national employment between 1997 and 2007 by firm and type of the establishments owned by these firms relative to the total employment in 1997 (%)

	Employment in manufacturing establishments	Employment in non-manufacturing establishments	Total employment
Firms that manufacture	-3	6	3
Firms that do not manufacture	0.7	23.3	24
All firms	-2.3	29.3	27

Note: The table contains the decomposition of the growth rate of the aggregate US employment - constructed by aggregating the firm-establishment level employment in the case of the firms in the Longitudinal Business Database that survived between 1997 and 2007, by the type of the firm and establishments within the firm in line with the definition and decomposition in the main text. The firm that manufactured is the firm that had manufacturing employment share in 1997 greater than 0.05. The manufacturing establishment is an establishment classified to a manufacturing industry based on its largest activity.

Table 4: Changes in the Chinese import penetration ratio and Chinese imports to US manufacturing industries between 1997 and 2007

	Mean	St. dev.	Median	Min	Max
Change in the Chinese import penetration ratio to the US	0.07	0.16	0.02	-1.48	1.65
Change in the Chinese import penetration ratio to other developed countries	0.05	0.14	0.02	-1.05	1.40
Change in log Chinese imports to the US	2.22	1.50	2.04	-2.61	7.81
Change in log Chinese imports to other developed countries	1.71	1.24	1.68	-4.19	11.36

Note: The variables listed in the table are the measures of the China shock to 384 manufacturing industries, defined at four digit level of the Standard Industrial Classification system, and included in the NBER-CES. It also contains the instruments constructed based on the definition presented in the main text of the table. Data used to construct these variables come from the UN Commtrade and NBER-CES database, where HS10 and SIC4 industries are matched by using the concordance constructed by Pierce and Schott. All the import and export variables in 1997 are inflated to 2007 by using the Personal Consumption Expenditure index, while the nominal value of shipments is inflated by using the industry specific shipment price index from NBER-CES.

Table 5: The impact of Chinese imports on the change in the size of US manufacturing industries between 1997 and 2007 - aggregation from the firm

	Chinese import growth in the US	Total employment	Number of establishments	Payroll	Manufacturing employment	Non-manufacturing employment
	(1)	(2)	(3)	(4)	(5)	(6)
	1st stage	2SLS	2SLS	2SLS	2SLS	2SLS
Chinese import growth in other developed countries	0.747***					
	(0.101)					
Chinese import growth in the US		0.158**	0.179**	0.378***	0.277**	0.217**
		(0.083)	(0.074)	(0.099)	(0.134)	(0.117)
Observations	384	384	384	384	384	384
R-squared	0.45	0.44	0.35	0.38	0.56	0.42
F-statistics	53.6					
p-value	0.00					

Note: N=384 industries defined at the SIC-4 level. The outcome variables are changes in the log of each variable between 1997 and 2007. They are constructed by aggregating firm level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the industry level based on the methodology and the definitions described in the main text. The table reports two-stage least square estimates of the coefficient on the growth rate of Chinese imports, defined and instrumented as described in the main text of the paper. All specifications include the initial year control variables described in the main text and two-digit industry fixed effects. Estimates are weighted by employment in 1997. () contains standard errors that are clustered at two digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 6: The impact of Chinese imports on the growth of employment in manufacturing and non-manufacturing activities by US manufacturing industries between 1997 and 2007 - aggregation from the firm

	Chinese import growth in the US	Manufacturing	Retail and wholesale	Transportation	Information	Headquarter services	Professional services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	1st stage	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Chinese import growth in other developed countries	0.747***						
	(0.101)						
Chinese import growth in the US		0.082***	-0.072	-0.016	-0.014	0.026**	0.021**
		(0.025)	(0.055)	(0.013)	(0.020)	(0.014)	(0.009)
Observations	384	384	384	384	384	384	384
R-squared	0.45	0.22	0.06	0.16	0.15	0.11	0.14
F-statistics	53.6						
p-value	0.00						

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total industry level employment in 1997. These variables are constructed by aggregating firm level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the industry level based on the methodology and the definitions described in the main text. The table reports two-stage least square estimates of the coefficient on the growth rate of Chinese imports, defined and instrumented as described in the main text of the paper. All specifications include the initial year control variables described in the main text and two-digit industry fixed effects. Estimates are weighted by employment in 1997. () contains standard errors that are clustered at two digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 7: The impact of Chinese imports on the change in characteristics of manufacturing activity by US manufacturing industries between 1997 and 2007 - aggregation from the firm

	Chinese import growth in the US	Number of production workers	Number of non-production workers	Number of manufacturing establishments	Number of hours
	(1)	(2)	(3)	(4)	(5)
Chinese import growth in other developed countries	0.747***				
	(0.101)				
Chinese import growth in the US		0.293***	-0.149	0.039**	0.292***
		(0.098)	(0.093)	(0.019)	(0.122)
Observations	384	384	384	384	384
R-squared	0.45	0.56	0.60	0.53	0.53
F-statistics	53.6				
p-value	0.00				

Note: The outcome variables are constructed by aggregating firm level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database and Census of Manufactures, to the industry level based on the methodology and the definitions described in the main text. The outcome variables in column (1)-(4) are constracted as the change in production, respectively non-production workers between 1997 and 2007 relative to the total number of employees in 1997. The outcome variables in (5)-(8) are measured as the change in the log of the variable listed in the table between 1997 and 2007. The table reports two-stage least square estimates of the coefficient on the growth rate of Chinese imports, defined and instrumented as described in the main text of the paper. All specifications include initial year control variables described in the main text and two-digit industry fixed effects. Estimates are weighted by employment in 1997. () contains standard errors that are clustered at two digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 8: The impact of Chinese imports to US output markets on US manufacturing firms' employment growth between 1997 and 2007

	Weighted Chinese import growth in US firms' US output industries	Total employment	Manufacturing employment	Non-manufacturing employment
	(1)	(2)	(3)	(4)
	1st stage	2SLS	2SLS	2SLS
Weighted Chinese import growth in other developed countries	0.635***			
	(0.040)			
Weighted Chinese import growth in US firms' US output industries		0.019	0.111***	-0.092**
		(0.068)	(0.038)	(0.049)
Observations	60,000	60,000	60,000	60,000
R-squared	0.98	0.35	0.21	0.49
F-stat	250.03			
p-value	0.00			

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total firm level employment in 1997. These variables are constructed by aggregating firm-establishment level information defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the firm level based on the methodology and the definitions described in the main text. The sample contains surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the weighted growth rate of Chinese imports in the output industries of US firms, defined and instrumented as described in the main text of the paper. All specifications include initial year firm level control variables and four-digit industry fixed effects as described in the main text of the paper. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 9: The impact of Chinese imports to US output markets on US manufacturing firms' non-manufacturing employment growth between 1997 and 2007

	Retail-Wholesale	Headquarter services	Professional services
	(1)	(2)	(3)
	2SLS	2SLS	2SLS
Weighted Chinese import growth in US firms' US output industries	-0.005	0.005**	0.002**
	(0.015)	(0.001)	(0.001)
Observations	60,000	60,000	60,000
R-squared	0.58	0.40	0.37
F-stat	250.03		
p-value	0.00		

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total firm level employment in 1997. These variables are constructed by aggregating firm-establishment level information defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the firm level based on the methodology and the definitions described in the main text. The sample contains surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the weighted growth rate of Chinese imports in the US output industries of US firms, defined and instrumented as described in the main text of the paper. All specifications include initial year firm level control variables and four-digit industry fixed effects as described in the main text of the paper. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 10: The impact of Chinese imports to US output markets on US manufacturing firms' manufacturing activity between 1997 and 2007

	Production workers	Non-production workers	Manufacturing wage	Production wage	Number of manufacturing establishments	Number of products
	(1)	(2)	(3)	(4)	(5)	(6)
	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Weighted Chinese import growth in US firms' US output industries	0.171**	-0.058	0.186**	0.274*	0.091***	0.090*
	(0.084)	(0.059)	(0.088)	(0.171)	(0.021)	(0.070)
Observations	60,000	60,000	60,000	60,000	60,000	60,000
R-squared	0.16	0.15	0.472	0.29	0.15	0.45
F-stat	250.03					
p-value	0.00					

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total firm level employment in 1997. These variables are constructed by aggregating firm-establishment level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the firm level based on the methodology and the definitions described in the main text. The sample contains surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the weighted growth rate of Chinese imports in the US output industries of US firms, defined and instrumented as described in the main text of the paper. All specifications include initial year firm level control variables and four-digit industry fixed effects. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 11: Weighted average material input product expenditure shares by sourcing types

	1997	2002	2007
Domestic insourcing	0.098	0.085	0.073
Domestic outsourcing	0.617	0.592	0.520
Foreign insourcing	0.143	0.162	0.176
Foreign outsourcing	0.142	0.161	0.231

Note: The table contains the mean of the shares of material expenditure on the four types of sourcing relative to the total material expenditure on a particular material input product category within the firm weighted by the size of the product category within the firm and the size of the firm. The weight of the product category within the firm is computed as the share of expenditure on the product category by the firm relative to the total material expenditure by firm. The weight of the firm in the cross section is computed as the share of the material expenditure by the firm relative to the sum of material expenditure across all the firms in the cross section. The sample contains the set of US manufacturing firms and their material input products in each of the yearly cross sections. The sample are constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Table 12: Weighted average imported material input product expenditure shares by countries

Share of imports from	1997	2002	2007
Canada	0.100	0.108	0.118
China	0.013	0.024	0.044
Germany	0.034	0.035	0.034
Japan	0.069	0.051	0.051
Mexico	0.055	0.049	0.046
Outsourcing from China	0.011	0.019	0.035
Insourcing from China	0.002	0.005	0.009

Note: The table contains the mean of the shares of imported material expenditure on country of sourcing relative to the total imported material expenditure on a particular material input product category within the firm weighted by the size of the product category within the firm and the size of the firm in four US manufacturing industries. The weight of the product category within the firm is computed as the share of expenditure on the product category by the firm relative to the total material expenditure by firms. The weight of the firm in the cross section is computed as the share of the material expenditure by the firm relative to the sum of material expenditure across all the firms in the cross section. The sample contains the set of US manufacturing firms and their material input products in each of the yearly cross sections. The sample are constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Table 13: Average frequency of the choice of each type of sourcing of material input products by US manufacturing firms

	1997	2002	2007
Domestic insourcing	0.133	0.129	0.113
Domestic outsourcing	0.640	0.616	0.543
Foreign insourcing	0.377	0.391	0.515
Foreign outsourcing	0.468	0.477	0.413
Mixed sourcing	0.437	0.429	0.449
Make and buy	0.414	0.433	0.486
Make only	0.043	0.047	0.043
Buy only	0.543	0.520	0.471

Note: The table contains the frequency of each of the four types of sourcing of material input product categories within the firm weighted by the size of the product category within the firm and the size of the firm. The weight of the product category within the firm is computed as the share of expenditure on the product category by the firm relative to the total material expenditure by firms. The weight of the firm in the cross section is computed as the share of the material expenditure by the firm relative to the sum of material expenditure across all the firms in the cross section. The sample contains the set of US manufacturing firms and their material input products in each of the yearly cross sections. The sample are constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Table 14: Weighted average imported material input product expenditure shares by country in four US manufacturing industries

	Chemical products		Plastic products		Transportation equipment		Electrical equipment	
	1997	2007	1997	2007	1997	2007	1997	2007
Canada	0.066	0.069	0.088	0.065	0.346	0.342	0.050	0.030
China	0.010	0.042	0.006	0.045	0.002	0.011	0.052	0.148
Germany	0.077	0.044	0.037	0.042	0.036	0.052	0.036	0.037
Japan	0.059	0.033	0.070	0.059	0.134	0.101	0.046	0.032
Mexico	0.024	0.037	0.054	0.036	0.100	0.086	0.086	0.074
Outsourcing from China	0.009	0.033	0.005	0.041	0.0020	0.009	0.049	0.118
Insourcing from China	0.001	0.009	0.001	0.004	0.0003	0.002	0.003	0.030

Note: The table contains the mean of the shares of imported material expenditure on each country of sourcing relative to the total imported material expenditure on a particular material input product category within the firm weighted by the size of the product category within the firm and the size of the firm in four US manufacturing industries. The weight of the product category within the firm is computed as the share of expenditure on the product category by the firm relative to the total material expenditure by firm. The weight of the firm in the cross section is computed as the share of the material expenditure by the firm relative to the sum of material expenditure across all the firms in the cross section. The sample contains the set of US manufacturing firms and their material input products in each of the yearly cross sections. The sample are constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Table 15: Average frequency of the choice of each type of sourcing of material input products by US firms in four US manufacturing industries

	Chemical products		Plastic products		Transportation equipment		Electrical equipment	
	1997	2007	1997	2007	1997	2007	1997	2007
Make and buy	0.440	0.457	0.358	0.369	0.701	0.726	0.369	0.407
Make only	0.040	0.045	0.019	0.042	0.018	0.039	0.024	0.025
Buy only	0.520	0.498	0.623	0.589	0.281	0.235	0.607	0.568
Mixed sourcing	0.453	0.427	0.402	0.370	0.722	0.665	0.348	0.324

Note: The table contains the frequency of each of the four types of sourcing of material input product categories within the firm weighted by the size of the product category within the firm and the size of the firm in four US manufacturing industries. The weight of the product category within the firm is computed as the share of expenditure on the product category by the firm relative to the total material expenditure by firms. The weight of the firm in the cross section is computed as the share of the material expenditure by the firm relative to the sum of material expenditure across all the firms in the cross section. The sample contains the set of US manufacturing firms and their material input products in each of the yearly cross sections. The sample are constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Table 16: The frequency of switching from one type of input sourcing to the other four between 1997 and 2007

	Domestic insourcing in 2007	Domestic outsourcing in 2007	Foreign insourcing in 2007	Foreign outsourcing in 2007
Domestic insourcing in 1997	0.481	0.235	0.246	0.436
Domestic outsourcing in 1997	0.019	0.874	0.062	0.105
Foreign insourcing in 1997	0.019	0.072	0.786	0.796
Foreign outsourcing in 1997	0.025	0.084	0.535	0.535

Note: The sample contains the set of surviving firms that manufacture and their material input products between 1997 and 2007. The sample is constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Table 17: The impact of Chinese imports to US input markets on US firms' material input sourcing decisions - coefficient on the Chinese import growth in US input markets

Change between 1997 and 2007 in the share of:	SUR	3SLS
	(1)	(2)
Domestic insourcing	0.003	0.005***
	(0.002)	(0.001)
Domestic outsourcing	-0.056***	-0.011**
	(0.004)	(0.001)
Foreign insourcing	0.024***	0.005***
	(0.005)	(0.001)
Foreign outsourcing	0.028***	0.008***
	(0.006)	(0.001)
Chi-squared test	457.50	
p-value	0.00	

Note: The table contains the three stage-least square estimates of the coefficients on the shock measures in the system specified in the main text of the paper

Table 18: The impact of the China shock on the change in the cost of material input products between 1997 and 2007

	dlog(Material Input Price)		log(Material Input Price)
	(1)	(2)	(3)
Chinese import growth in US firms' input industries	-0.132*** (0.038)	-0.142*** (0.049)	
Log Chinese imports to US firms input industries			-0.357** (0.1763)
R-squared	0.02	0.07	0.82

Note: The outcome variables are expressed as the change between 1997 and 2007 in log material input cost (Column 1 and 2) or log material input cost (Column 3). These variables are constructed by using the micro-data provided by the US Census Bureau in material trailer files of the Census of Manufactures in 1997, 2002 and 2007. Column 1 does not contain any fixed effects, Column 2 contains main output industry fixed effects, Column 3 contains time-industry, product-firm fixed effects. () contains standard errors that are clustered at the product level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 19: The impact of increased sourcing from China on US manufacturing firms' manufacturing activity between 1997 and 2007

	Material expenditure	Manufacturing employment	Production workers	Number of manufacturing establishments	Number of products
	(1)	(2)	(3)	(4)	(5)
	1st stage	2SLS	2SLS	2SLS	2SLS
Change in log material expenditure		0.535**	0.462*	0.319**	1.455*
		(0.235)	(0.279)	(0.193)	(0.920)
Weighted Chinese import growth in US firms input industries	0.186***				
	(0.059)				
Observations	60,000	60,000	60,000	60,000	60,000
R-squared	0.04	0.13	0.27	0.18	0.21
F-statistics	9.75				
p-value	(0.002)				

Note: The outcome variables are expressed as growth between 1997 and 2007 relative to 1997. These variables are constructed by aggregating firm-establishment level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database and the Census of Manufactures, to the firm level based on the methodology and the definitions described in the main text. The sample contain surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the change in log material expenditure between 1997 and 2007 of these firms, instrumented as described in the main text of the paper. All specifications include four-digit industry fixed effects and other firm level controls. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 20: The impact of increased imports from China on the growth of manufacturing employment between 1997 and 2007 of US manufacturing firms: 2SLS estimates

	Manufacturing employment	Production workers	Number of manufacturing establishments	Number of products
	(1)	(2)	(3)	(4)
Weighted Chinese import growth in US firms input industries	0.070	0.087	0.079	-0.038
	(0.191)	(0.396)	(0.061)	(0.593)
Change in log material expenditure	-1.315	-2.619	-0.365	-4.091
	(2.972)	(0.260)	(6.016)	(8.939)
R-squared	0.140	0.269	0.178	0.214

Note: The outcome variables are expressed as the change between 1997 and 2007 in manufacturing employment relative to the total firm level employment in 1997. These variables are constructed by aggregating firm-establishment level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database and the Census of Manufactures, to the firm level based on the methodology and the definitions described in the main text. The sample contains surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the weighted change in Chinese import growth in the US output markets of the firms, respectively on the change in log material expenditure between 1997 and 2007 of these firms, instrumented as described in the main text of the paper. All specifications include four-digit industry fixed effects and other firm level controls. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

A.2 Figure Appendix

Figure 1: Example of a multi-establishment firm

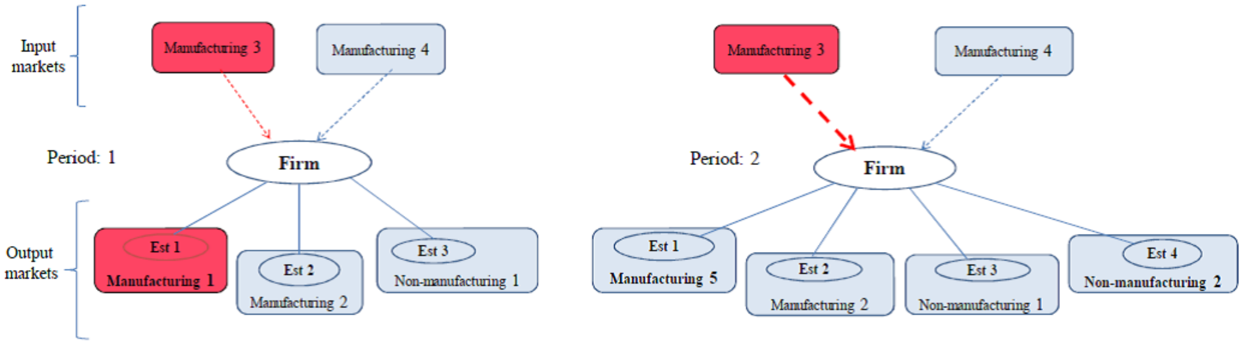
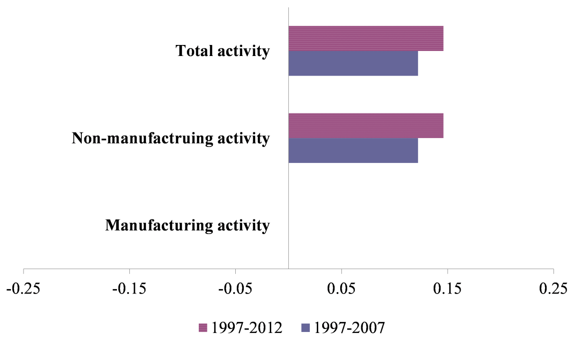


Figure 2: Decomposition of the growth rate of the number of establishments in the US by firm and establishment type

Panel A: Manufacturing firms

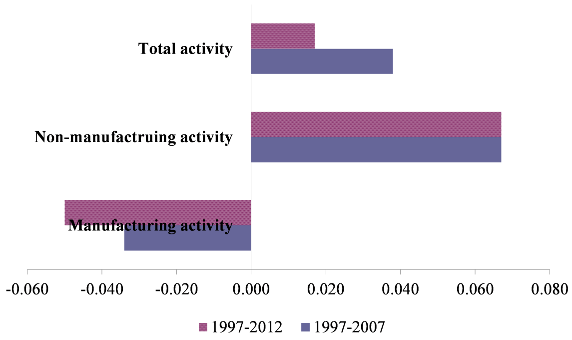
Panel B: Non-manufacturing firms



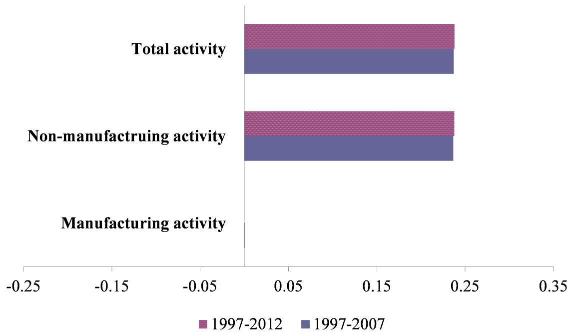
Note: The graph contains the decomposition of the growth rate between 1997 and 2007, respectively between 1997 and 2012 of the number of establishments by types of firms - firms that manufactured in 1997 and firms that did not manufacture in 1997, and types of establishments - manufacturing and non-manufacturing. Panel A of the graph contains the growth rate between 1997 and 2007, respectively between 1997 and 2012 of the overall number of establishments due to firms that manufactured in 1997, which is then broken down by two types: establishments classified to manufacturing and non-manufacturing within these firms. Panel B contains the same decomposition over the same sample periods in the case of firms that did not manufacture in 1997. Calculations are based on the set of surviving firms between 1997 and 2012 in the Longitudinal Business Database (LBD) provided by the US Census Bureau.

Figure 3: Decomposition of the growth of aggregate US employment by firm and establishment types

Panel A: Manufacturing firms



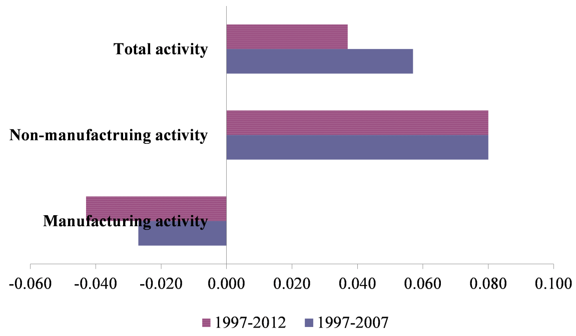
Panel B: Non-manufacturing firms



Note: The graph contains the decomposition of the growth rate between 1997 and 2007, respectively between 1997 and 2012 of the aggregate US employment of firms that manufactured in 1997 and firms that did not manufacture in 1997, by the types of establishments within these firms - manufacturing and non-manufacturing. Panel A of the graph contains the growth rate between 1997 and 2007, respectively between 1997 and 2012 of the growth in aggregate employment due to firms that manufactured in 1997, which is then broken down by two types: establishments classified to manufacturing and non-manufacturing within these firms. Panel B contains the same decomposition over the same sample periods in the case of firms that did not manufacture in 1997. Calculations are based on the set of surviving firms between 1997 and 2012 in the Longitudinal Business Database (LBD) provided by the US Census Bureau.

Figure 4: Decomposition of the growth of aggregate US employment by firm and establishment types: allowing for switching in and out of manufacturing

Panel A: Manufacturing firm



Panel B: Non-manufacturing firm

Note: The graph contains the decomposition of the growth rate between 1997 and 2007, respectively between 1997 and 2012 of the aggregate US employment by firms that did some manufacturing in any of the years between 1997 and 2012, and firms that did not do any manufacturing in this period. Panel A of the graph contains the growth rate between 1997 and 2007, respectively between 1997 and 2012 of the growth in aggregate employment due to firms that did some manufacturing in the 1997-2012 period, which is then broken down by two types: establishments classified to manufacturing and non-manufacturing within these firms. Panel B contains the same decomposition over the same sample periods in the case of firms that did not do manufacturing. Calculations are based on the set of surviving firms between 1997 and 2012 in the Longitudinal Business Database (LBD) provided by the US Census Bureau.

Figure 5: Sketch of the firm's production process

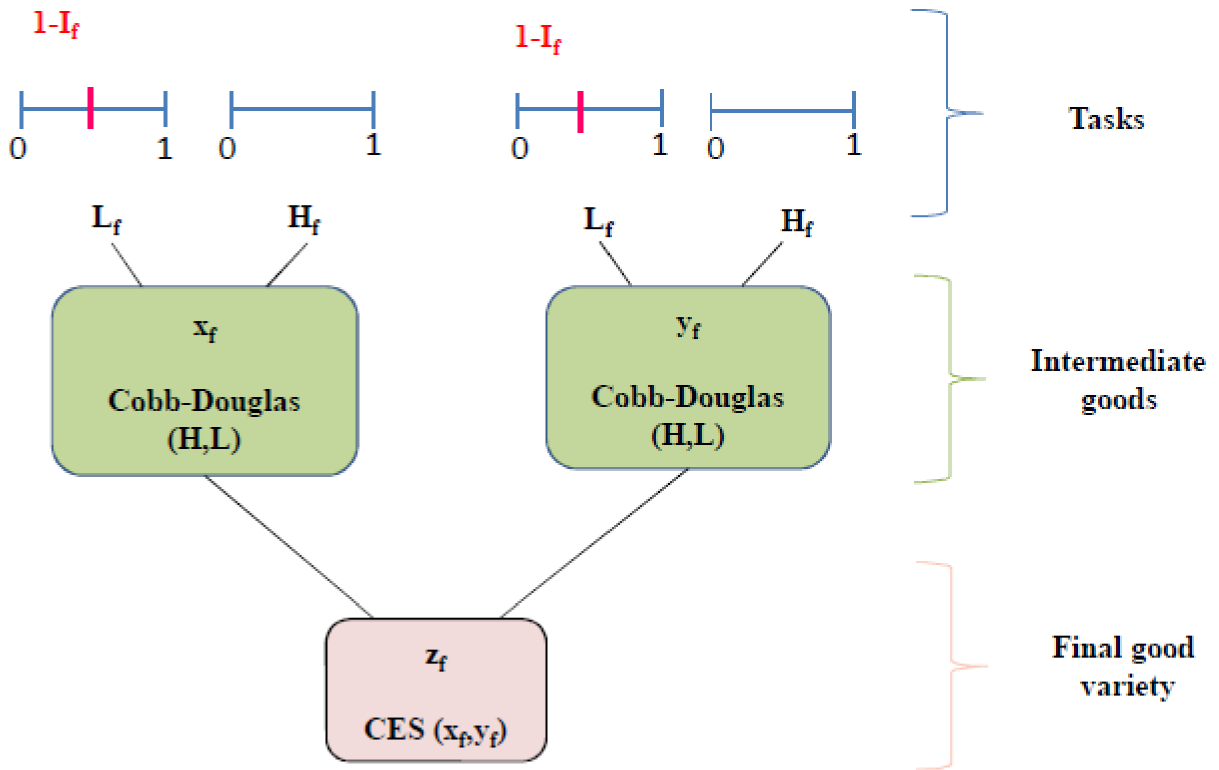
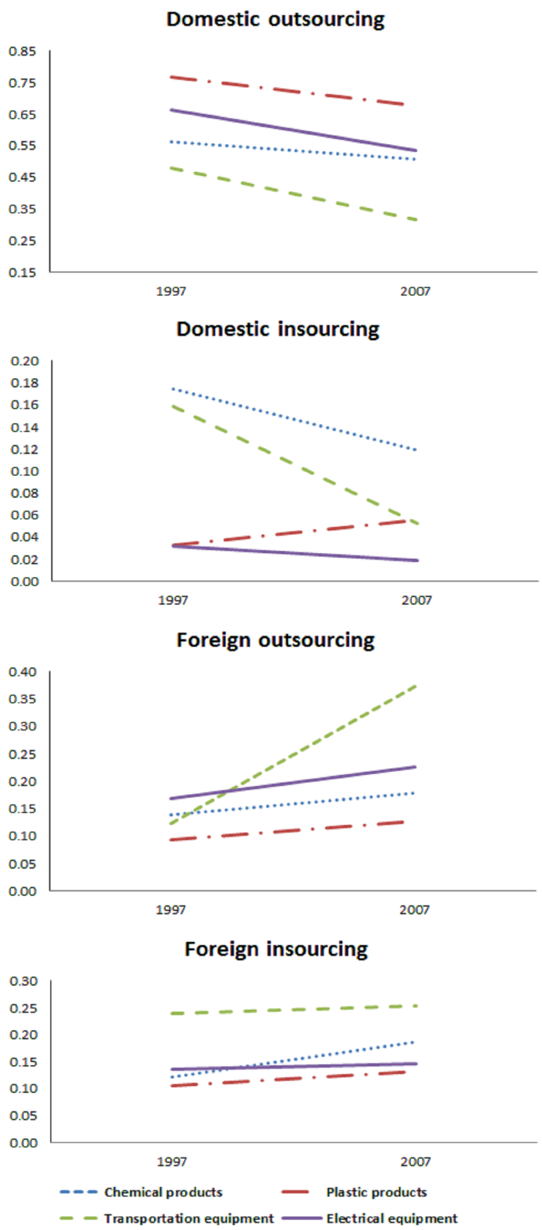
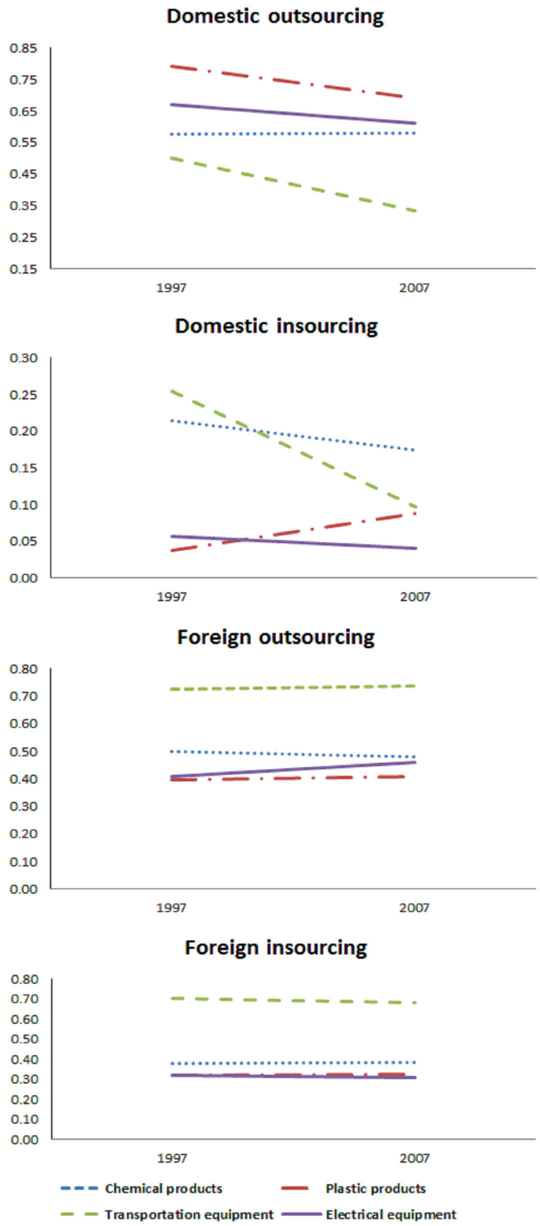


Figure 6: Weighted average material input product expenditure shares by sourcing type in four US manufacturing industries



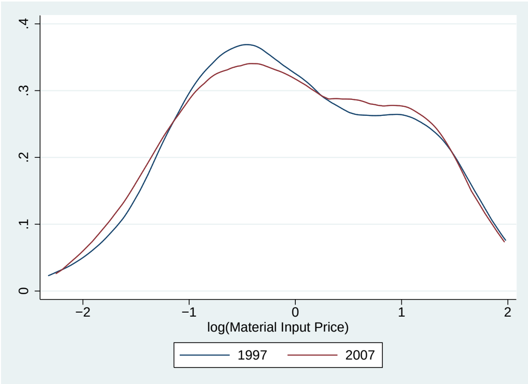
*Note:*The graphs contain the mean of the shares of material expenditure on the four types of sourcing relative to the total material expenditure on a particular material input product category within the firm weighted by the size of the product category within the firm and the size of the firm in the case of four manufacturing industries in the US. The weight of the product category within the firm is computed as the share of expenditure on the product category by the firm relative to the total material expenditure by firm. The weight of the firm in the cross section is computed as the share of the material expenditure by the firm relative to the sum of material expenditure across all the firms in the cross section. The sample contains the set of firms that manufacture and their material input products in each of the yearly cross sections. The sample are constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Figure 7: Average frequency of the choice of each type of sourcing of material input products by US firms in four US manufacturing industries



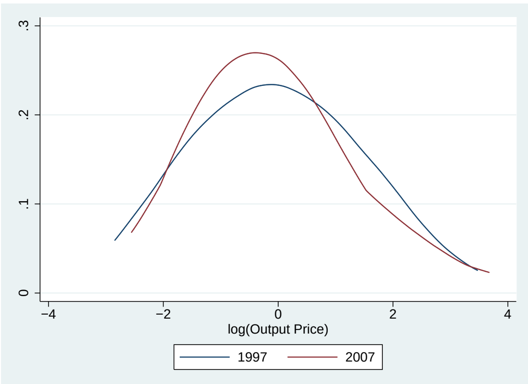
*Note:*The graphs contain the frequency of each of the four types of sourcing of material input product categories within the firm weighted by the size of the product category within the firm and the size of the firm in four US manufacturing industries. The weight of the product category within the firm is computed as the share of expenditure on the product category by the firm relative to the total material expenditure by firm. The weight of the firm in the cross section is computed as the share of the material expenditure by the firm relative to the sum of material expenditure across all the firms in the cross section. The sample contains the set of firms that manufacture and their material input products in each of the yearly cross sections. The sample are constructed by merging together the Census of Manufactures, the Longitudinal Foreign Trade Transactions Database, and the Longitudinal Business Database from the US Census Bureau at firm-product level. The material input product category is defined at six-digit NAICS level.

Figure 8: The distribution of material input costs in 1997 and 2007



*Note:*The sample is constructed by using the material trailer files in the Census of Manufactures from the US Census Bureau. The sample is constructed by keeping only the plant-product pairs present in both the 1997 and 2007 cross sections, and trimming the outliers above and below the 5th and 95th percentiles. Each observation at plant-product level is demeaned by the cross-product category average.

Figure 9: The distribution of output prices in 1997 and 2007



*Note:*The sample is constructed by using the output product trailer files in the Census of Manufactures from the US Census Bureau. The sample is constructed by keeping only the plant-product pairs present in both the 1997 and 2007 cross sections, and trimming the outliers above and below the 5th and 95th percentiles. Each observation at plant-product level is demeaned by the cross-product category average.

A.3 Data Appendix

This paper combines confidential microdata at firm, establishment and product level from the US Census Bureau with publicly available industry level data in order to construct the samples used in the analysis. I use establishment-product level data from the 1997, 2002, 2007, 2012 Census of Manufactures (CMF), establishment-firm level data from the 1997, 2002, 2007, 2012 Longitudinal Business Dataset (LBD) and firm-product-country of origin level of information on imports from the Longitudinal Foreign Trade Transaction Dataset (LFTTD). For some robustness checks, I also use establishment-product-origin-destination location information from the 1997, 2007 Commodity Flow Survey.

A.3.1 Confidential Microdata from the US Census Bureau.

A.3.1.1 Census of Manufactures[109]

The CMF covers the universe of US manufacturing establishments (i.e. plants). It contains information on the industrial classification of the establishment at NAICS6 and SIC4 industrial classification levels, the location of the establishment, production characteristics such as total number of employees, number of production workers, hours worked, wage bill, capital expenditure, material input expenditure, electricity bill, advertising expenditure, total sales, number of material input products used by the establishment and the number of output products produced by the establishment. Thus, the unit of observation is establishment in each cross section.

The US Census Bureau also collects value and quantity information on (i) the material input products used by the manufacturing establishment for the production of their output, and (ii) the products produced by the firm as output at 6-digit NAICS product classification level. These are included in the material input and output trailer files. Thus, in the case of the establishments included in the CMF, this information allows for defining a firm level input-output matrix at 6-digit product level that provides information on the value, quantity and price - defined as unit value obtained by dividing the value by quantity - of material inputs used by the firm and the output produced by the firm. The unit of observation in this case is the establishment-product pair in each cross section.

A.3.1.2 Longitudinal Business Dataset[110]

The LBD covers the universe of US establishments: all the manufacturing (plants) and non-manufacturing establishments in the US. It contains information on the industrial classification of each establishment at NAICS6 and SIC4 level, number of employees, total wage bill and the identifier of the firm that each establishment is owned by. Thus, the unit of observation is firm-establishment in each cross section.

[109] https://www.census.gov/econ/www/mancen.html
[110] https://www.census.gov/ces/dataproducts/datasets/lbd.html

A.3.1.3 Longitudinal Foreign Trade Transaction Dataset[111]

The Longitudinal Foreign Trade Transaction Dataset (LFTTD) is constructed based on customs declarations forms collected by U.S. Customs and Border Protection (CBP)[112]. The LFTTD contains information on the universe of import and export transactions of US firms: the value and quantity, the country of origin and destination, whether the transaction was a related party trade or arm's-length transaction at 10-digit Harmonized System (HS10) product level in each month of the year. I use the import files and aggregate from the monthly to the yearly the total value and quantities of each HS10 product imported by the firm from a given country, the value and the quantity of goods imported by the firm as arm's-length, respectively related party trade transactions. Thus, the unit of observtion is firm-product-country of origin in each cross section.

A.3.1.4 Commodity Flow Survey[113]

In the Commodity Flow Survey establishments report a randomly selected sample of 20-40 of their domestic shipments from a given week with zip-codes in the US characterizing the origin and the destination location. They provide the following information in the case of each shipment: product code - defined based on the Standard Classification of Transport Goods (SCTG)[114], value, weight, destination, and transportation mode. There are about 100,000 establishments sampled[115] in the CFS accounting for about 30% of the total number of manufacturing establishments in the US.

A.3.1.5 Merging and Cleaning the Census Datasets.

A.3.1.5.1 Merging LBD and CMF.

I merge the LBD and CMF in order to link the manufacturing establishments in the CMF to the firms that they belong to. The LBD contains the firm identifier and the establishment identifiers which are the Census File Numbers (CFN) and the LBD number (LBDNUM). There is a unique mapping between the CFN, that is the establishment identifier in the cross sections, and LBDNUM, the establishment identifier that is constructed by the Census Bureau and uniquely identifies the establishment over time. I merge the LBD and CMF in each year based on the CFN, while I link the cross section of establishments in years 1997, 2002 and 2007 based on the LBDNUM.

I remove all the establishments that have missing establishment identifier, all the establishments that have missing firm identifier in the merged LBD-CMF sample and the ones that have missing industrial classification. I also remove all the establishments that are registered as Administrative Record (AR). The CMF includes data on about 300,000 manufacturing establishments. The data in

[111] https://www.census.gov/ces/dataproducts/datasets/lfttd.html

[112] More information on the form based on which information on import transactions is collected: http://www.cbp.gov/sites/default/files/documents/CBP%20Form%207501_0.pdf

[113] https://bhs.econ.census.gov/bhs/cfs/

[114] At the five digits SCTG level there are 512 product categories.

[115] This is a random sampling method conducted by the Bureau of Transportation Statistics and US Census Bureau.

the case of the smallest plants, which represents roughly a third of the sample, is entirely imputed by the Census Bureau[116]. These are called AR plants. After these cleanings, about 30% of the total number of establishments included in the CMF are dropped. I also drop all the observations that has the flag indicating that the value was inputed. The CMF in 1997 is the only one that does not identify variables that value was imputed. Therefore, I do not exclude imputed observations in 1997.

I aggregate the merged LBD-CMF sample from the firm-establishment-product level to the firm-product level.

In the case of the analysis focusing on prices of outputs produced by the establishments and the cost of material inputs used by these establishments, I drop the establishment-product pairs which have missing quantities as prices are defined as the ratio between total value and quantity reported on the Census form. Also, I drop the NAICS6 product categories starting with 9, as these are auxiliary categories that the Census Bureau uses to allocate the values reported on the forms with missing NAICS6 code. In order to get the inflation adjusted price (i.e. prices comparable over time) I use the GDP deflator from FRED.

A.3.1.5.2 Merging LFTTD and CMF.

I take the LFTTD import files and remove all the transactions that do not have importer firm identifier or HS10 product code is missing. I use the concordance between NAICS6 and HS10 to get in the case of each HS product code the NAICS counterpart. As the HS10 code is a more disaggregated one than the NAICS6, I collapse the import files in each year (1997, 2002, 2007) to the firm-NAICS6 level. In order to get firm identifiers that are consistent with the LBD, I proceed as follows. The LFTTD records in the case of each import transaction the identifier of the US importer, ALPHA. This correspods to the firm identifier in the LBD in 1997. In 2002 and 2007, I construct the firm identifier based on the alpha such that it uniquely maps to the firm identifier in the LBD as follows. In the case of single establishment firms, the alphas in the LFTTD uniquely maps to the CFN in the LBD. I use this unique mapping to obtain firm identiers from the LBD that are consistent over time. In the case of multi-establishment firms, the firm identifier in the LBD is consistent with the ALPFA in the LFTTD augmented with four zeros in the end[117]. Using the firm identifier that is consistent over time, I merge the LBD-LFTTD sample in each year to the LBD-CMF sample at the firm - NAICS6 product level.

A.3.2 Publicly Available Data.

A.3.2.1 NBER-CES

[116] For more information see White et al. (2012) on http://www.nber.org/papers/w17816

[117] With other words, starting from 2002, the LFTTD files can be merged to the LBD files by constructig a new firm identifier that uniquely maps to the firm identifier in the LBD (the one to which the establishments are linked uniquely). This new firm identifier is equal to the CFN number in the case of single establishment firms and the ALPHA plus “0000” in the case of multi establishment firms. Once this new identifier is constructed both in the LBD and LFTTD, the two files can be merged.

The NBER-CES dataset[118] from the National Bureau of Economic Research (NBER) contains industry-level data on value of shipments, employment, payroll and other input costs, investment, capital stocks, TFP, and various industry-specific price indexes at the 4-digit 1987 SIC industries and 6-digit 1997 NAICS industries. I use data in years 1997, 2007 and 2012.

A.3.2.2 The United Nations Commodity Trade Statistics Database.

The United Nations Commodity Trade Statistics Database (UN Comtrade)[119] contains information on the import and export flows between the US and all the other coutnries in the world at 6-digit HS product level. I use this data set to construct information on the exports from China to the US and other eight major trading partners of China at 6-digit HS level in 1997, 2007 and 2012.

A.3.2.2 Concordance tables.

A.3.2.2.1 HS10-NAICS6-SIC4 concordances.

I use the concordances constructed by Pierce and Schott (2011)[120] that links the ten-digit Harmonized System (HS10) codes that classify products in U.S. international trade, and the SIC and NAICS industry codes that classify products in the domestic economic activity in the US in 1997, 2002, 2007 and 2012. This concordance allows for matching the LFTTD import files to the CMF material trailer files at 6-digit NAICS product level.

A.3.2.2.2 NAICS6-SIC4 Concordances.

As the classification of industries changed in 1997 from SIC to NAICS, I use concordance tables from the US Census Bureau that links the 4-digit SIC industries in 1987 to the 6-digit NAICS industries in 1997. These are available on the Census server and can be accessed from the secure Research Data Centers. I also use the import files from the concordances constructed by Pierce and Schott (2011) to link material input products defined at the NAICS6 level to SIC4 level. Moreover, from the same authors I use the export files to link the output products defined at the NAICS6 level to SIC4 level.

A.3.2.2.3 NAICS6 Concordances.

As the classification of industries changes over time in the sense as some product categories may disappear and others are added, I use concordance tables from the US Census Bureau that links 6-digit NAICS industries across years 1997, 2002, 2007 and 2012. These concordances are available on the

[118]For more details see the website: http://www.nber.org/nberces/

[119]http://comtrade.un.org/data/

[120]More information on these concordances are available here: http://www.justinrpierce.com/index_files/Pierce_Schott_JESM_2012.p
The zip files with the concordance tables can be downloaded from: http://www.justinrpierce.com/

Census server and can be accessed from the secure Research Data Centers or publicly available on the Census Bureau website[121].

A.3.3. Construction of the Samples and Variables Used in the Paper.

A.3.3.1. Construction of the Sourcing Information at the Firm Material Input Product level (CMF - Material and Product Trailer - LBD - LFTTD).

The CMF material trailer provides information on the material inputs used by manufacturing establishments in a given year at 6-digit NAICS product level, the value of the expenditure on each of these products and the quantity used. I call this the set of material input products used by the manufacturing establishment. The CMF output product trailer file contains information on the products produced by manufacturing establishments in a given year at 6-digit NAICS product level, the value and the quantity produced of each. I call this the set of output products produced by the manufacturing establishment. Table 1 below provides a list of these product categories at the broader three digit level to illustrate their nature.

In order to characterize the firms' sourcing decision across the four types of sourcing (i.e. in-sourcing versus outsourcing domestically, or abroad), I use assumptions and definitions listed below that iterate through all the possible combinations by exclusion. In order to distinguish between foreign in-sourcing, VI_f, versus foreign outsourcing, OU_f, I use the CMF merged with LFTTD to document if the firm imports a particular product. Then, I use the related party trade versus arm's length transaction definition from the LFTTD to document if the import transaction is based on insourcing from a plant owned by the firm abroad or it is outsourcing as the product is procured from a independent supplier located abroad. Distinguishing between domestic outsourcing, OU_d, versus domestic insourcing, VI_d, (i.e. producing the input used by the firm in a plant owned by the firm which is located in the US) is more complicated as it involves iterating through all the following possible combinations by exclusion:

A. Single plant firm:

A.1. Foreign Sourcing occurs if Domestic material =0 and Import>0: ($VI_d = 0$, $OU_d = 0$, $OU_f = 1$, $VI_f = 1$) or if Domestic material >0 and Import>0, but Import>Domestic material:

A.1.i. Foreign outsourcing $(OU_f = 1)$: if import at arms' length >0 and import from related party$\geq$0

A.1.ii. Offshoring ($VI_{f=1}$): if import at arms' length$\geq$0 and import from related party$>$0

A.2. Domestic outsourcing: occurs if Domestic material >0 and Import=0: ($VI_d = 0$, $OU_d = 1$, $OU_f = 0$,$VI_f = 0$):

A.3. Domestic and Foreign Sourcing: occurs if Domestic material >0 and Import>0 but Import<Domestic material ($VI_d = 0$, $OU_d = 1$, $OU_f = 1$,$VI_f = 1$):

[121]https://www.census.gov/eos/www/naics/concordances/concordances.html

A.3.i. Foreign outsourcing $(OU_f = 1)$: if import at arms' length >0 and import from related party$\geq$0

A.3.ii. Offshoring $(VI_f = 1)$: if import at arms' length$\geq$0 and import from related party$>$0

A.3.iii. Domestic Outsourcing ($OU_d = 1$): if Domestic material-Import>0

B. Multi-plant firms:

B.1. Foreign Sourcing (FS) occurs if Domestic material =0 and Import>0: ($VI_d = 0$, $OU_d = 0$, $OU_f = 1$, $VI_f = 1$) or if Domestic material >0 and Import>0, but Import>Domestic material:

B.1.i. Foreign outsourcing $(OU_f = 1)$: if import at arms' length >0 and import from related party$\geq$0

B.1.ii. Offshoring $(VI_{f=1})$: if import at arms' length$\geq$0 and import from related party$>$0

B.2. Domestic outsourcing: occurs if Domestic material >0 and Import=0: ($VI_d = 1$, $OU_d = 1$, $OU_f = 0$,$VI_f = 0$):

B.2.i. Domestic outsourcing ($OU_d = 1$): if no plant within the firm that register the product as an output

B.2.ii. Domestic insourcing[122] ($VI_d = 1$): if there is a firm within the plant that produces this material

B.3. Domestic and foreign sourcing: occurs if Domestic material >0 and Import>0 but Import<Domestic material ($VI_d = 1$, $OU_d = 1$, $OU_f = 1$,$VI_f = 1$):

B.3.i. Domestic Outsourcing ($OU_d = 1$): if Domestic material-Import>0 and no plant within the firm that produces that good

B.3.ii. Domestic insourcing ($VI_d = 1$): if Domestic material-Import>0 and there is a plant within the firm that produces that good

[122] I also do two robustness checks. The first looks at the plant that produces in an industry upstream to the main industry of the plant that uses the product as material. The second looks at the plant that produces the input shiped to the zip code where the plant that uses it is located in line with the methodology in Atalay, Hortacsu, and Syversson (2013).

Table 21: Product categories based on the North American Industrial Classification at 3-digit level

NAICS-3 code	**Description**
311	Food Manufacturing
312	Beverage and Tobacco Product Manufacturing
313	Textile Mills
314	Textile Product Mills
315	Apparel Manufacturing
316	Leather and Allied Product Manufacturing
321	Wood Product Manufacturing
322	Paper Manufacturing
323	Printing and Related Support Activities
324	Petroleum and Coal Products Manufacturing
325	Chemical Manufacturing
326	Plastics and Rubber Products Manufacturing
327	Nonmetallic Mineral Product Manufacturing
331	Primary Metal Manufacturing
332	Fabricated Metal Product Manufacturing
333	Machinery Manufacturing
334	Computer and Electronic Product Manufacturing
335	Electrical Equipment, Appliance, and Component Manufacturing
336	Transportation Equipment Manufacturing
337	Furniture and Related Product Manufacturing
339	Miscellaneous Manufacturing

Table 22: Industry classification at 2-digit NAICS and SIC

NAICS-2	SIC-2	Description
11	01-09	Agriculture, Forestry, Fishing and Hunting
21	10-14	Mining, Quarrying, and Oil and Gas Extraction
22	49	Utilities
23	15-17	Construction
31-33	20-26, 28-39	Manufacturing
42	50-51	Wholesale Trade
44-45	52-57, 59	Retail Trade
48-49	40-47	Transportation and Warehousing
51	27, 48	Information
52	60-64	Finance and Insurance
53	65, 75, 72, 78, 79	Real Estate and Rental and Leasing
54	73, 87	Professional, Scientific, and Technical Services
55	67	Management of Companies and Enterprises
56	49, 73	Administrative, Support, Waste Management Services
61	82	Educational Services
62	80, 83	Health Care and Social Assistance
71	79	Arts, Entertainment, and Recreation
72	58, 70	Accommodation and Food Services
81	75, 76, 83, 86	Other Services (except Public Administration)
92	91-97	Public Administration

A.4 Computing the Real Values of the Variables in the China Shock Measure

The second measure I use to define the China shock is the change in Chinese import penetration ratio to US manufacutirng industries. This change in the import penetration ratio is defined as:

$$\Delta IPR_{it}^{CH,US} = \frac{\Delta M_{it}^{CH,US}}{Y_{i,1997} + M_{i,1997} - X_{i,1997}}$$

where $\Delta M_{it}^{CH,US}$ is the change in real imports from China to the US in manufacturing industry i between 1997 and 2007, defined as four digit SIC. $Y_{i,1997} + M_{i,1997} - X_{i,1997}$ is the size of the market in manufacturing industry i in the base year 1997 , and it is measured as the real value of shipments ($Y_{i,1997}$) plus the real value of net imports in industry i defined as the difference between total imports ($M_{i,1997}$) and exports ($X_{i,1997}$). As $\Delta IPR_{it}^{CH,US}$ is computed based on a the ten years difference in imports, all the values must be expressed in constant prices in order to ensure that the variation in the measure is not driven by the variation in inflation across sectors:

$$\Delta IPR_{it}^{CH,US} = \frac{\frac{M_{i2007}^{CH,US}}{P_{i,2007}} - \frac{M_{i1997}^{CH,US}}{P_{i,1997}}}{\frac{Y_{i,1997}}{P_{i,1997}} + \frac{M_{i,1997}}{P_{i,1997}} - \frac{X_{i,1997}}{P_{i,1997}}}$$

Thus, the values of net imports in the US, the value of shipments in the US and the imports from China to the US in 1997 has to be inflated to prices in 2007 or Chinese imports in 2007 must be deflated to 1997 prices. The previous literature chose to inflate the values in 1997 to 2007 prices. This means that we fix the base year to 2007 and use the price index to inflate nominal values with base year 2007. This implies the following import penetration measure in real values:

$$\Delta IPR_{it}^{CH,US} = \frac{M_{i2007}^{CH,US} - \frac{M_{i1997}^{CH,US}}{P_{i,1997}/P_{i,2007}}}{\frac{Y_{i,1997}}{P_{i,1997}/P_{i,2007}} + \frac{M_{i,1997}}{P_{i,1997}/P_{i,2007}} - \frac{X_{i,1997}}{P_{i,1997}/P_{i,2007}}}$$

As industry level price indices for import and exports are not available in the US, following Acemoglu et al. (2015), I inflate imports from China to the US, total imports and total exports by using the Personal Consumption Expenditure (PCE) index.[123] The PCE index is a measure of consumer inflation in the US and it is constant across industries. This means that $P_{i,1997}/P_{i,2007} = P_{1997}/P_{2007}$. The PCE in 1997 with 2007 base year was $P_{1997}/P_{2007} = 0.809$, which means that consumer prices in the US on average were lower by 20 percentage points relative to 2007. Thus, using this price index to compute the 1997 quantities of Chine imports and net imports in the US at 2007 prices assumes away potentially important price variations across industries, and results in quantities in 1997 evaluated at 1997 prices "scaled by a constant" instead of 2007 prices[124]. However, there are industry level price indices available in the NBER-CES database (i.e. the shipment price index) to compute the

[123]The Personal Consumption Expenditures (PCE) price index is produced by the U.S. Bureau of Economic Analysis (BEA). Despite differences in scope, weight, and methodology, the CPI and the PCE price index both measure inflation from the perspective of the consumer. PCE indices can be downloaded from FRED Economic Data of St. Louis Fed: https://fred.stlouisfed.org/series/PCEPI#0.

[124]Formally, what I aim to do is to bring $q_{i,1997}p_{i,1997}$to $q_{i,1997}p_{i,2007}$. Thus, we need a price index that gives the ratio between industry level prices in 1997 relative to industry level prices in 2007, i.e. $p_{i,1997}/p_{i,2007}$. The issue with the price index constant across industries, p_{1997}/p_{2007} is that we do not factor out the 1997 prices, $\frac{q_{i,1997}p_{i,1997}}{p_{1997}/p_{2007}} = q_{i,1997}p_{i,1997}\frac{p_{2007}}{p_{1997}}$.

value of shipment in the US at 2007 price. This producer price index exhibit a large variation across manufacturing industries in the US as Table A.4.1. reflects this[125].

Table A.4.1. Moments of the distribution of industry price index in 1997 with base year in 2007

1st pctile	5th pctile	50th pctile	95th pctile	99th pctile	Mean	St.dev
0.48	0.66	0.85	1.07	1.73	0.91	0.80

The industry that registered the largest increase in imports from China also experienced the largest decline in prices between 1997 and 2007 (i.e. $cov\left(\Delta M_{it}^{CH,US}, \frac{P_{i,2007}}{P_{i,1997}}\right) < 0$). Thus, by not factoring out these shifts in the price from the denominator of the shock measure leaves not only noise, and thus induces attenuation bias due to classical measurement error, but it induces a systhematic measurement error in the shock measure. This measurement error leads to downward bias in the point estimates because of the negative correlation between imports and prices. Therefore, in order to account for variation in prices across industries, I use the consistent price index where it is possible. The NBER-CES database contains industry specific US producer price index along with the nominal value of imports. Thus, I deflate the value of shipments in the US by using this industry specific producer price index. Table A.4.2. shows the implications of the choice of the price deflator when it is possible (i.e. in the case of the value of shipments) for the ranking of the China shock measured by the change in the Chinese import penetration ratio to US manufacturing industries. This table indicate that when the value of shipment is inflated by using the industry specific price index, the ranking of the shock changes substantially. This new ranking is consistent with the exposure of US manufacturing industries measured based on the growth rate in Chinese imports (i.e. the industries that registered the largest growth in Chinese imports were the household applience and furniture industries).

Table A.4.2. Changes in the ranking of the China shock under different Vship deflators

Ranking	PCE index deflated Vship	IPI deflated Vship
1	Oil and gas field machinery	Household cooking equipment
2	Waterproof outerwear	Computer storage devices
3	Games, toys	House furnishings
4	Luggage	Electric housewares and fans
5	Costume jewelry	Household vacuum cleaners

[125]Formally, as this price index exhibit variation across industries, i.e. $p_{i,1997}/p_{i,2007}$, it allows for evaluating the quantities shipped in the US at 2007 prices, $\frac{q_{i,1997}p_{i,1997}}{p_{i,1997}/p_{i,2007}} = q_{i,1997}p_{i,2007}$.

Note: The China shock, measured by the change in import penetration ratio from China to the US manufacturing industries between 1997 and 2007, is computed in line with the definition proposed by AADHP (2016). The calculations are based on the same data that these authors use, the NBER-CES publicly available SIC4 industry level data.

Table A.4.3. shows the implications of the choice of the price deflator when it is possible (i.e. in the case of the value of shipments) for the estimated impact of the China shock on the employment of manufacturing industries defined based on the establishment. More precisely, the table contains the two stage least square estimates of the coefficient on the China shock, measured as the change in the import penetration ratio, in the industry level employment regression model presented in Section 4.1. of the paper. The table indicate that when the statistically proper deflator is used the statistical significance of the coefficient on the change import penetartion measure vanishes. The estimates obtained based on the statistically consistently deflated import penetation ratio are the same in size with the estimates obtained based on the first measure of the China shock (i.e. the growth rate in Chinese imports). This finding indicate that there was no negative and statistically significant impact of Chinese imports on US manufacturing employment in industries defined based on establishments.

Table A.4.3. The effect of the China shock on the change in total employment by U.S. manufacturing industries between 1997 and 2007: two-stage least square estimates

	Vship deflated	Vship deflated	No normalization
	PCE Index	by Industry Price Index	
$\triangle IPR_{it}^{US,CH,PCE}$	-0.65**		
s.e.	(0.29)		
$\triangle IPR_{it}^{US,CH,IPI}$		-0.009	
s.e.		(0.26)	
$\triangle logM_{it}^{US,CH}$			-0.008
s.e.			(0.023)
R-squared	0.33	0.47	0.46

Table 23 presents the estimation results obtained based on the standard definition of the manufacturing industry. These demonstrate that whether the China shock is defined as the change in the import penetration ratio (Columns 1 and 2), or as the growth in imports (Columns 3 and 4), employment in more exposed industries did not fall relative to less exposed industries defined based on establishment type. The point estimates are close to zero, even when other control variables are not included in the regressions.[126]

A.5 Robustness Checks

[126]When the shock is defined as the change in the import penetration ratio, standard errors are large. This is not surprising, given the large standard deviation that the distribution of this measure of the shock exhibits relative to the mean. See Table 4 for descriptive statistics of the China shock measures.

Table 23: The impact of the China shock on the change in log employment between 1997 and 2007 by US manufacturing industries: aggregation from the establishment

	(1)	(2)	(3)	(4)
Change in the Chinese import penetration ratio to the US	-0.009	0.005		
	(0.260)	(0.254)		
Change in log Chinese imports to the US			-0.008	-0.004
			(0.023)	(0.023)
Industry fixed effect	yes	yes	yes	yes
Industry characteristics in 1997	no	yes	no	yes
R-squared	0.47	0.47	0.46	0.47

Note: The outcome variable is defined by using the industry level employment reported in the NBER-CES in the case of 384 manufacturing industries. This variable is constructed by aggregation of the employment across establishments classified in the same industry in the micro data collected by the US Census Bureau (i.e. Census of Manufactures) and publicly available in the NBER-CES. The table reports two-stage least square estimates of the coefficient on the change in Chinese import penetration ratio, respectively on the growth rate of Chinese imports, defined and instrumented as described in the main text of the paper. All specifications include two-digit industry fixed effects, and initial year control variables such as capital and skill intensity. Estimates are weighted by employment in 1997. () contains standard errors that are clustered at two digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level

Table 24: The impact of the China shock on the change in the price of output products between 1997 and 2007

	dlog(Output Price)	
	(1)	(2)
Change in Chinese import penetration ratio to the US	0.098***	0.169***
	(0.045)	(0.092)
R-squared	0.01	0.09

Note: The outcome variables are expressed as the change between 1997 and 2007 in log output price. These variables are constructed by using the micro-data provided by the US Census Bureau in product trailer files of the Census of Manufactures in 1997, 2002 and 2007. The table reports two-stage least square estimates of the coefficient on the change in Chinese import penetration ratio defined and instrumented as described in the main text of the pape. Column 1 does not contain any fixed effects, Column 2 contains main output industry fixed effects. () contains standard errors that are clustered at the product level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 25: The impact of Chinese imports on the change in the size of US manufacturing industries between 1997 and 2007 - aggregation from the firm

	Change in the Chinese import penetration ratio to the US	Total employment	Number of establishments	Payroll	Manufacturing employment	Non-manufacturing employment
	(1)	(2)	(3)	(4)	(5)	(6)
	1st stage	2SLS	2SLS	2SLS	2SLS	2SLS
Change in the Chinese import penetration ratio to other developed countries	0.971***					
	(0.283)					
Change in the Chinese import penetration ratio to the US		0.165	-0.247	0.446*	0.203*	0.169
		(0.182)	(0.307)	(0.234)	(0.126)	(0.404)
Observations	384	384	384	384	384	384
R-squared	0.73	0.46	0.42	0.41	0.61	0.46
F-statistics	11.7					
p-value	0.00					

Note: N=384 industries defined at the SIC-4 level. The outcome variables are changes in the log of each variable between 1997 and 2007. They are constructed by aggregating firm level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the industry level based on the methodology and the definitions described in the main text. The table reports two-stage least square estimates of the coefficient on Chinese import penetration ratio, defined and instrumented as described in the main text of the paper. All specifications include the initial year control variables described in the main text and two-digit industry fixed effects. Estimates are weighted by employment in 1997. () contains standard errors that are clustered at two digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 26: The impact of Chinese imports on the growth of employment in manufacturing and non-manufacturing activities by US manufacturing industries between 1997 and 2007 - aggregation from the firm

	Change in the Chinese import penetration ratio to the US	Manufacturing	Retail and wholesale	Transportation	Information	Headquarter services	Professional services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	1st stage	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Change in the Chinese import penetration ratio to other developed countries	0.971***						
	(0.283)						
Change in the Chinese import penetration ratio to the US		0.125**	0.212	0.014	-0.050	-0.037	0.059**
		(0.052)	(0.258)	(0.026)	(0.051)	(0.027)	(0.033)
Observations	384	384	384	384	384	384	384
R-squared	0.73	0.30	0.06	0.14	0.15	0.19	0.20
F-statistics	11.7						
p-value	0.00						

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total industry level employment in 1997. These variables are constructed by aggregating firm level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the industry level based on the methodology and the definitions described in the main text. The table reports two-stage least square estimates of the coefficient on the change in Chinese import penetration ratio, defined and instrumented as described in the main text of the paper. All specifications include the initial year control variables described in the main text and two-digit industry fixed effects. Estimates are weighted by employment in 1997. () contains standard errors that are clustered at two digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 27: The impact of Chinese imports on the change in characteristics of manufacturing activity by US manufacturing industries between 1997 and 2007 - aggregation from the firm

	Change in the Chinese import penetration ratio to the US	Number of production workers	Number of non-production workers	Number of manufacturing establishments	Number of hours
	(1)	(2)	(3)	(4)	(5)
Change in the Chinese import penetration ratio to other developed countries	0.971***				
	(0.283)				
Change in the Chinese import penetration ratio to the US		0.107	-0.085	-0.016	0.077
		(0.152)	(0.117)	(0.033)	(0.141)
Observations	384	384	384	384	384
R-squared	0.45	0.64	0.46	0.58	0.61
F-statistics	11.7				
p-value	0.000				

Note: The outcome variables are constructed by aggregating firm level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database and Census of Manufactures, to the industry level based on the methodology and the definitions described in the main text. The outcome variables in column (1)-(4) are constracted as the change in production, respectively non-production workers between 1997 and 2007 relative to the total number of employees in 1997. The outcome variables in (5)-(8) are measured as the change in the log of the variable listed in the table between 1997 and 2007. The table reports two-stage least square estimates of the coefficient on Chinese import penetration ratio, defined and instrumented as described in the main text of the paper. All specifications include initial year control variables described in the main text and two-digit industry fixed effects. Estimates are weighted by employment in 1997. () contains standard errors that are clustered at two digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 28: The impact of Chinese imports to US output markets on US manufacturing firms' employment growth between 1997 and 2007

	Weighted change in the Chinese import penetration ratio to the US output industries of the US firms	Total employment	Manufacturing employment	Non-manufacturing employment
	(1)	(2)	(3)	(4)
	1st stage	2SLS	2SLS	2SLS
Weighted change in the Chinese import penetration ratio to other developed countries	1.061***			
	(0.063)			
Weighted change in the Chinese import penetration ratio to the US output industries of the US firms		0.978	0.429	0.549
		(0.816)	(0.443)	(0.516)
Observations	60,000	60,000	60,000	60,000
R-squared	0.99	0.35	0.20	0.49
F-stat	282.67			
p-value	0.00			

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total firm level employment in 1997. These variables are constructed by aggregating firm-establishment level information defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the firm level based on the methodology and the definitions described in the main text. The sample contains surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the weighted change in the import penetration ratio in the output industries of US firms, defined and instrumented as described in the main text of the paper. All specifications include initial year firm level control variables and four-digit industry fixed effects as described in the main text of the paper. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 29: The impact of Chinese imports to US output markets on US manufacturing firms' non-manufacturing employment growth between 1997 and 2007

	Retail-Wholesale	Headquarter services	Professional services
	(1)	(2)	(3)
	2SLS	2SLS	2SLS
Weighted change in the Chinese import penetration ratio to other developed countries	0.286	0.335**	0.025
	(0.202)	(0.182)	(0.187)
Observations	60,000	60,000	60,000
R-squared	0.58	0.40	0.37
F-stat	282.67		
p-value	0.00		

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total firm level employment in 1997. These variables are constructed by aggregating firm-establishment level information defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the firm level based on the methodology and the definitions described in the main text. The sample contains surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the weighted change in Chinese import penetration ratio in the US output industries of US firms, defined and instrumented as described in the main text of the paper. All specifications include initial year firm level control variables and four-digit industry fixed effects as described in the main text of the paper. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

Table 30: The impact of Chinese imports to US output markets on US manufacturing firms' manufacturing activity between 1997 and 2007

	Production workers	Non-production workers	Manufacturing wage	Production wage	Number of manufacturing establishments	Number of products
	(1)	(2)	(3)	(4)	(5)	(6)
	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Weighted change in the Chinese import penetration ratio to the US output industries of the US firms	0.202	0.631	5.681*	4.286**	0.501*	1.648**
	(0.891)	(0.609)	(3.320)	(1.842)	(0.258)	(0.845)
Observations	60,000	60,000	60,000	60,000	60,000	60,000
R-squared	0.17	0.15	0.59	0.28	0.15	0.46
F-stat	282.67					
p-value	0.00					

Note: The outcome variables are expressed as the change between 1997 and 2007 in employment related to the activities listed in the table relative to the total firm level employment in 1997. These variables are constructed by aggregating firm-establishment level observations defined based on the micro-data provided by the US Census Bureau in the Longitudinal Business Database, to the firm level based on the methodology and the definitions described in the main text. The sample contains surviving US manufacturing firms. The table reports two-stage least square estimates of the coefficient on the weighted change in Chinese import penetration ratio in the US output industries of US firms, defined and instrumented as described in the main text of the paper. All specifications include initial year firm level control variables and four-digit industry fixed effects. Estimates are weighted by firm level employment in 1997. () contains standard errors clustered at four digit industry level. *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 significance level.

A.6 Theory Appendix

Proposition 1 If $I_f > 0$, then in equilibrium the set of L-tasks offshored by firm f increases as β declines:

$$\hat{I}_f > 0 \tag{50}$$

Proof Condition (26) must hold in equilibrium. Taking the logarithm of both sides and by applying the Implicit Function Theorem, the total differential of the expression becomes $dI_f = -\frac{d\beta}{\beta}\gamma_f \frac{t(I_f)}{\frac{\partial t(I)}{\partial I_f}}$. Divide this equation equation through by I_f, and denote $\hat{I}_f \equiv \frac{dI_f}{I_f}$. As $\frac{\partial t(i)}{\partial i} > 0$ by assumption, then for any $I_f > 0$, $\frac{\partial t(I_f)}{\partial I_f} > 0$, $\gamma_f > 0$ and $t(I_f) > 0$, $-\gamma_f \frac{t(I_f)}{I_f \frac{\partial t(I_f)}{\partial I_f}} < 0$. Thus, for any $\hat{\beta} < 0$ it results that $\hat{I}_f > 0$.■

Proposition 2 If $I_f > 0$, then in equilibrium the cost of sourcing L-tasks by firm f declines as β declines:

$$\hat{\Omega}_f < 0 \tag{51}$$

Proof Using the Implicit Function Theorem and the Leibniz integral rule, the total differential of the expression below (27) becomes $d\Omega(I_f) = -\frac{\int_0^{I_f} t(i)di}{\left(t(I_f)\right)^2}\frac{\partial t(I_f)}{\partial I_f} dI_f$. Dividing this through by $I_f\Omega(I_f)$, $\hat{\Omega}_f \equiv \frac{d\Omega(I_f)}{\Omega(I_f)} = -\frac{\int_0^{I_f} t(i)di}{\left(t(I_f)\right)^2}\frac{\partial t(I_f)}{\partial I_f}\frac{I_f}{\Omega_f}\hat{I}_f$. As $\frac{\partial t(i)}{\partial i} > 0$ by assumption, then for any $I_f > 0$, $\frac{\partial t(I_f)}{\partial I_f} > 0$ and $t(I_f) > 0$. Thus, $\frac{\int_0^{I_f} t(i)di}{(t(i))^2}\frac{\partial t(I_f)}{\partial I_f}\frac{I_f}{\Omega_f} > 0$. Proposition 1 $\hat{I}_f = -\frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f} I_f}\hat{\beta} > 0$. Therefore, $\hat{\Omega}_f = \frac{\int_0^{I_f} t(i)di}{t(I_f)}\frac{1}{\Omega_f}\hat{\beta} < 0$ for any $\hat{\beta} < 0$.■

Proposition 3 If $I_f > 0$, $\alpha_x < \alpha_y$, then the equilibrium employment of high-skilled by firm f increases as β declines if and only if $\varepsilon < b$:

$$\hat{h}_f > 0 \tag{52}$$

Proof By taking the logarithm of both sides of the first order conditions resulted from the profit maximization problem in (33) and applying the Implicit Function Theorem, I solve for $\hat{x}_f$ and $\hat{y}_f$ as the function of $\hat{\Omega}_f$. By taking the logarithm of both sides of (32) and applying the Implicit Function Theorem, I derive $\hat{H}_{f,x}$ and $\hat{H}_{f,y}$ as the function of $\hat{\Omega}_f$. Using these, the following expression gives $\hat{h}_{f,y}$and $\hat{h}_{f,x}$ as the function of $\hat{\Omega}_f$: $\hat{h}_{f,y} = \frac{\alpha_y\left[(1-\varepsilon)\Delta_1+\Delta_2+\frac{\varepsilon-1}{\varepsilon}\right]+\varepsilon\Delta_1\alpha_x}{\frac{\varepsilon-1}{\varepsilon}\left(\frac{\varepsilon(1+b)}{b(\varepsilon-1)}-1\right)-\frac{1}{\varepsilon}}\hat{\Omega}_f$ and $\hat{h}_{f,x} = \frac{\alpha_x\left[(1-\varepsilon)\Delta_2+\Delta_1+\frac{\varepsilon-1}{\varepsilon}\right]+\varepsilon\Delta_2\alpha_y}{\frac{\varepsilon-1}{\varepsilon}\left(\frac{\varepsilon(b-1)}{b(\varepsilon-1)}-1\right)-\frac{1}{\varepsilon}}\hat{\Omega}_f$ where $\Delta_{1f} = \frac{\varepsilon-1}{\varepsilon}\left(\frac{\varepsilon(b-1)}{b(\varepsilon-1)}-1\right)\left(\frac{x_f^{\frac{\varepsilon-1}{\varepsilon}}}{y_f^{\frac{\varepsilon-1}{\varepsilon}}+x_f^{\frac{\varepsilon-1}{\varepsilon}}}\right)$ and $\Delta_{2f} = \frac{\varepsilon-1}{\varepsilon}\left(\frac{\varepsilon(b-1)}{b(\varepsilon-1)}-1\right)\left(\frac{y_f^{\frac{\varepsilon-1}{\varepsilon}}}{y_f^{\frac{\varepsilon-1}{\varepsilon}}+x_f^{\frac{\varepsilon-1}{\varepsilon}}}\right)$. By taking the logarithm of both sides of the expression $h_f = h_{f,x} + h_{f,y}$, and applying the Implicit Function Theorem, I derive$\hat{h}_f = s_{f,x,h}\hat{h}_{f,x} + s_{f,y,h}\hat{h}_{f,y}$ where $s_{f,j,h} = \frac{h_{f,j}}{h_f} > 0$ for $j = \{x, y\}$. $\frac{\alpha_y\left[(1-\varepsilon)\Delta_1+\Delta_2+\frac{\varepsilon-1}{\varepsilon}\right]+\varepsilon\Delta_1\alpha_x}{\frac{\varepsilon-1}{\varepsilon}\left(\frac{\varepsilon(1+b)}{b(\varepsilon-1)}-1\right)-\frac{1}{\varepsilon}} < 0$ and $\frac{\alpha_x\left[(1-\varepsilon)\Delta_2+\Delta_1+\frac{\varepsilon-1}{\varepsilon}\right]+\varepsilon\Delta_2\alpha_y}{\frac{\varepsilon-1}{\varepsilon}\left(\frac{\varepsilon(b-1)}{b(\varepsilon-1)}-1\right)-\frac{1}{\varepsilon}} < 0$ for any $\varepsilon < b$. This together with$\hat{\Omega}_f < 0$ (Proposition 2) implies that $\hat{h}_{f,x} > 0$ and $\hat{h}_{f,y} > 0$ for any $\hat{\beta} < 0$. Thus, $\hat{h}_f = s_{f,x,h}\hat{h}_{f,x} + s_{f,y,h}\hat{h}_{f,y} > 0$ for any $\hat{\beta} < 0$■

Proposition 4 If $I_f > 0$, $\alpha_x < \alpha_y$ and $b > 1$ then the equilibrium employment of high-skilled by firm f in the assembly of intermediate input x (i) increases relative to the equilibrium employment of high-skilled in the assembly of intermediate input y if and only if $\varepsilon < 1$:

$$\hat{h}_{x,f} - \hat{h}_{y,f} > 0 \tag{53}$$

(ii) decreases relative to the equilibrium employment of high-skilled in the assembly of intermediate input y if and only if $\varepsilon > 1$:

$$\hat{h}_{x,f} - \hat{h}_{y,f} < 0 \tag{54}$$

and (iii) there is no effect if $\varepsilon = 1$.

Proof By definition the total employment of high-skilled at firm f in x is $h_{f,x} = H_{fx}x$, while inx is $h_{f,y} = H_{fy}y$. Taking the logarithm of both sides and by applying the Implicit Function Theorem, the total differential of the expression becomes $\hat{h}_{f,x} = \hat{H}_{fx} + \hat{x}$, while $\hat{h}_{f,y} = \hat{H}_{fy} + \hat{y}$. Thus, the change in the employment of high-skilled at firm f in x relative to the employment of high-skilled at firm f in y is: $\hat{h}_{f,x} - \hat{h}_{f,y} = \hat{H}_{fx} - \hat{H}_{fx} + \hat{x} - \hat{y}$. Taking the logarithm of both sides and by applying the Implicit Function Theorem to (30), (32) and (34) we get $\hat{H}_{fx} - \hat{H}_{fx}$ and $\hat{x} - \hat{y}$ as functions of$\hat{\Omega}_f$ $\hat{h}_{f,x} - \hat{h}_{f,y} = (1-\varepsilon)(\alpha_x - \alpha_y)\hat{\Omega}_f$ where $\alpha_x < \alpha_y$ by assumption, $\hat{\Omega}_f < 0$ by Proposition 2. Thus, (i) for $\varepsilon < 1$, $\hat{h}_{f,x} - \hat{h}_{f,y} > 0$ for any $\hat{\beta} < 0$, (ii) for $\varepsilon > 1$, $\hat{h}_{f,x} - \hat{h}_{f,y} < 0$ for any $\hat{\beta} < 0$, and (iii) for $\varepsilon = 1$, $\hat{h}_{f,x} - \hat{h}_{f,y} = 0$ for any $\hat{\beta} < 0$■

Proposition 5 If $I_f > 0$, $I_{f'} > 0$, $\gamma_f < \gamma_{f'}$, and $\frac{\partial^2 t(I)}{\partial I_f \partial I_f} < 0$, then (i) the equilibrium set of L-tasks offshored by firm f expands more relative to firm f' as β declines:

$$\hat{I}_f > \hat{I}_{f'} > 0 \tag{55}$$

(ii) in equilibrium the cost of sourcing L-tasks by firm f declines more relative to firm f' as β declines:

$$\hat{\Omega}_{f'} < \hat{\Omega}_{f'} < 0 \tag{56}$$

(iii) the equilibrium employment of high-skilled by firm f increases more relative to firm f' as β declines if and only if $\varepsilon < b$:

$$\hat{h}_f > \hat{h}_{f'} > 0 \tag{57}$$

(iv) the relative equilibrium employment of high-skilled by firm f in the assembly of intermediate input x increases more relative to firm f' as β declines if and only if $\varepsilon < 1$:

$$\hat{h}_{x,f} - \hat{h}_{y,f} > \hat{h}_{x,f'} - \hat{h}_{y,f'} > 0 \tag{58}$$

Proof We want to show that $\frac{\partial^2 I_f}{\partial\beta\partial\gamma_f} > 0$. This condition ensures that, for any decline in β, the change in I_f is larger the lower γ_f is. $\frac{\partial I_f}{\partial\beta} = -\frac{\gamma_f}{\beta}\frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}}$ based on the proof of Proposition 1. By taking the cross-partial derivative of I_f, we get $\frac{\partial I_f}{\partial\beta\partial\gamma_f} = -\frac{\gamma_f}{\beta}\frac{\partial I_f}{\partial\gamma_f}\left[1 - \frac{t(I_f)\frac{\partial^2 t(I)}{\partial I_f\partial I_f}}{\left(\frac{\partial t(I)}{\partial I_f}\right)^2}\right] - \frac{1}{\beta}\frac{t(I_f)}{\frac{\partial t(I)}{\partial I_f}}$. By using the expression $\frac{\partial I_f}{\partial\gamma_f} = -\frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}\gamma_f}$, $\frac{\partial I_f}{\partial\beta\partial\gamma_f}$ simplifies to $\frac{\gamma_f}{\beta}\frac{\partial I_f}{\partial\gamma_f}\left[\frac{t(I_f)\frac{\partial^2 t(I)}{\partial I_f\partial I_f}}{\left(\frac{\partial t(I)}{\partial I_f}\right)^2}\right]$. Given the assumption on $t(I_f)$ that $\frac{\partial t(I_f)}{\partial I_f} > 0$, $\frac{\partial I_f}{\partial\gamma_f} = -\frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}\gamma_f} < 0$ for any $\gamma_f > 0$, $I_f > 0$. Thus, $\frac{\partial I_f}{\partial\beta\partial\gamma_f} > 0$ if and only if $\frac{t(I_f)\frac{\partial^2 t(I)}{\partial I_f\partial I_f}}{\left(\frac{\partial t(I)}{\partial I_f}\right)^2} < 0$. Which is equivalent with $\frac{\partial^2 t(I)}{\partial I_f\partial I_f} < 0$. This implies implies that $\hat{I}_f > \hat{I}_{f'} > 0$ and, thus, $\hat{\Omega}_f < \hat{\Omega}_{f'} < 0$ for any $\gamma_f < \gamma_{f'}$ and $\hat{\beta} < 0$. As $\hat{\Omega}_f < \hat{\Omega}_{f'} < 0$, by the proof of Proposition 3 it follows that $\hat{h}_f > \hat{h}_{f'} > 0$ and, by the proof of Proposition 4 it follows that $\hat{h}_{x,f} - \hat{h}_{y,f} > \hat{h}_{x,f'} - \hat{h}_{y,f'} > 0$ for any $\hat{\beta} < 0$■