Essays in Trade and Factor Markets

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ABSTRACT

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This dissertation examines the impact of globalization on firms’ organization, and documents how these organizational changes impact employment, efficiency and welfare in the domestic economy. In the first chapter, I study 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.

The second chapter proposes a new channel through which financial shocks affect firms – imported intermediate inputs – and investigates its empirical implications for firms' production decision in a panel of Hungarian firms and banks. In a model of liquidity-constrained heterogeneous firms, only the most productive firms import the higher productivity foreign intermediates because these firms are the only ones that can afford the necessary financing. In this model, a financial liberalization results in lower interest rates on bank loans that reduces the relative cost of imported intermediates, induces firms to become importers and leads continuing importers to import more. Thus capital market liberalization acts like trade liberalization. Using the last stage of Hungarian financial account liberalization in 2001 as a natural experiment, I find that, as predicted by the theory, firms whose banks were given access to new international sources of credit increased their intermediate import shares of production. Moreover, this increase was financed by the short-term liquidity arising from the liberalization. These findings support the hypothesis that positive credit supply shocks reduce the relative cost of imported intermediates, and induce firms to import and increase the share of imports in their intermediate input use.

The third chapter, co-authored with Richard Clarida, shows that the financial channel can substitute in a welfare-improving way for the trade channel in small open economies’ external
adjustment. Countries can adjust internationally through the trade and the financial channel. Gourinchas and Rey (2007) have shown that the financial channel can complement, or even substitute, for the traditional trade adjustment channel via a narrowing of the country’s current account imbalance. However, they only use a log linearization of a net foreign asset accumulation identity without reference to any specific theoretical model of international financial adjustment (IFA). In this chapter we calibrate the importance of IFA in a standard open economy growth model (Schmitt-Grohe and Uribe, 2003) with a well-defined steady state level of foreign liabilities. In this model there is a country specific credit spread which varies as a function of the ratio of foreign liabilities to gross domestic product. We find that allowing for an IFA channel results in a very rapid convergence of the current account to its steady state, relative to the no IFA case. While on the long term, all of the adjustment is via the IFA channel of forecastable changes in the cost of servicing debt and in appreciation of the real exchange rate. By contrast, in the no IFA case, current account adjustment by construction does all the work, and this adjustment is at a slow rate.
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Édesanyámnak és Édesapámnak

(To my Mom and Dad)
Chapter 1

Firm Reorganization, Chinese Imports, and US Manufacturing Employment

1.1 Introduction

Employment in US manufacturing has been declining for decades.\textsuperscript{1} The rise in imports from China, as a consequence of China’s joining the World Trade Organization (WTO) in 2001,\textsuperscript{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

\textsuperscript{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.

\textsuperscript{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.
markets that hosted these establishments. 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.

This paper uses the firm as the unit of analysis. Firms are bundles of establishments in the same or different industries, using multiple material input products to produce multiple output products. 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 exposed output industries, in which the US had a

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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.”
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. 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.

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7The 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.
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 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 occurred 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\textsuperscript{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 estimating the causal impact of increased Chinese imports in US output markets on US manufacturing firms’ employment. I quantify firms’ exposure by computing the

\textsuperscript{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.
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 manu-
facturing 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 ex-
posure, 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

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 lib-
eralization 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 firms’ activity. My findings strongly suggest that US manufac-
turing 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. 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.

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, productivity, innovation and R&D, and product scope and quality. 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

10A 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).
11Amiti and Konings (2007), and DeLoecker et al. (2015).
13Baldwin and Robert-Nicoul (2008), and Atkeson and Burstein (2010).
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 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 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). 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 chapter is organized as follows. Section 1.2 presents the methodology based on which I characterize firms’ organization. Section 1.3 presents the data and documents descriptive facts on US firms’ reorganization. Section 1.4 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 1.5 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

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16 For a more recent review of the literature see Bresnahan and Levin (2012) and Riordan (2008).
the US had a comparative advantage, and expand employment in these industries by taking advantage of the favorable cost shock induced by China. Section 1.6 documents empirical facts consistent with this mechanism. Section 1.7 concludes.

1.2 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 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

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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.
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. 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.

Firms, $f \in F_t$, are collections of establishments in the US under common ownership and control. 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.

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 $t$.

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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.
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 implies 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

\(^{24}\)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.
number of employees in the set of establishments that constitute the non-manufacturing activity within the firm, \( e \in E_{N,f,t} \):
\[
L_{N,f,t} = \sum_{e \in E_{N,f,t}} L_{e,f,t}
\] (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 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

\(^{26}\)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-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/
decomposed into employment in manufacturing, $L_{M,f,t}$, and non-manufacturing activities, $L_{N,f,t}$, within the firm:

$$L_{f,t}^M = L_{M,f,t}^M + L_{N,f,t}^N$$

(3)

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

$$L_{f,t}^N = L_{M,f,t}^N + L_{N,f,t}^N$$

(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 $t$, $\triangle L_{f,t}$, 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:

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

(5)

$$= \triangle L_{M,f,t} + \triangle L_{N,f,t}$$

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 employment within the same type of activity - i.e., manufacturing or non-manufacturing activities...
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. 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.

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

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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.
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 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 employment 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

\(^{32}\)This implies that in the two-stage least squares estimator of the effect of the shock on establishments, \(\hat{\beta}\), is an inconsistent estimator of the true effect, \(\beta\). 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 \(Z'\varepsilon\).
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.

1.3 Descriptive Evidence on Reorganization of US Firms

1.3.1 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 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

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\(^{33}\)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 classification, I stick to the sample period between 1997 and 2012 that allows me to use a consistent industrial classification over time.
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, 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 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 $t - 1$. Finally, I define the firm’s main manufacturing industry as the

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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 $\{t - 1, t\}$ pair. For instance, $t - 1$ is 1997 when the $\{1997, 2007\}$ years pair is considered.
manufacturing industry in which the firm has the largest number of employees.\textsuperscript{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 1.3) 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 industries, 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.\textsuperscript{39} The LBD contains information on the firm each establishment belongs to and the industrial classification of these establishments. I merge establishment-product

\textsuperscript{38}This definition is consistent with the definition of the main industry of the establishment used by the Census Bureau.

\textsuperscript{39}The Data Appendix includes detailed descriptions of the definitions and algorithms used to recover this information.
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 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 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) by using information about the country of origin of each

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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 50 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.

41 These five countries together account for about 70% of the international trade transactions of the US with the rest of the world.
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.\footnote{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}
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. 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. 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.

1.3.2 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, 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).

43 The Data Appendix discusses these datasets in detail.
firms that owned declining US manufacturing establishments not only eliminated jobs in manufacturing 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. 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 1.3, 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-manufacturing firms:

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

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:

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

$$= L^M_{M,t} + L^M_{N,t} + L^N_{M,t} + L^N_{N,t}$$

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, $L^N_{N,t}$, and non-manufacturing, $L^N_{M,t}$, activities by non-manufacturing firms.

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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.
aggregate employment in manufacturing, $L_{M,t}^N$, and non-manufacturing activities, $L_{M,t}^N$, 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, $\Delta L_{M,t}^M / L_{t-1}$, and (ii) non-manufacturing, $\Delta L_{N,t}^M / L_{t-1}$, activities of manufacturing firms, and (iii) adjustment due to changes in employment in manufacturing, $\Delta L_{M,t}^N / L_{t-1}$, and (iv) non-manufacturing, $\Delta L_{N,t}^N / L_{t-1}$, activities of non-manufacturing firms:

$$\frac{\Delta L_t}{L_{t-1}} = \frac{\Delta L_{M,t}^M}{L_{t-1}} + \frac{\Delta L_{N,t}^M}{L_{t-1}} + \frac{\Delta L_{M,t}^N}{L_{t-1}} + \frac{\Delta L_{N,t}^N}{L_{t-1}}$$

(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.\textsuperscript{45} This decomposition is based on the following accounting equation:

$$\frac{\Delta L_{N,t}^{M}}{L_{N,t}^{M}} = \sum_{n \in N} \frac{\Delta L_{n,t}^{M}}{L_{N,t}^{M}}$$  \hspace{1cm} (9)$$

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

\textsuperscript{45}Table 22 of the Data Appendix gives the list of these activities and the NAICS2 codes associated with them.
of employees greater than 5 percent.\textsuperscript{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 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.

\textsuperscript{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.
1.4 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.\footnote{For instance, Amiti and Freund (2010) documents the sectorial composition of this import growth.} 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.\footnote{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.}

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 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. 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.

1.4.1 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). 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 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 $t$, $\tilde{L}_{it}$, is defined as the sum

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49 This type of analysis is in line with the one used in Treffer (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).
of employment across establishments classified to manufacturing industry $i$ at time $t$ based on the largest activity within the establishment: $\bar{L}_{it} = \sum_{e \in M_{E}^{i}} L_{e,t}$, where $M_{E}^{i}$ 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, $L_{it} = \sum_{f \in M_{F}^{i}} L_{f,t}$, where $M_{F}^{i}$ 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, $L_{M,i,t} = \sum_{f \in M_{F}^{i}} L_{M,f,t}$, and non-manufacturing activities, $L_{N,f,t} = \sum_{f \in M_{F}^{i}} L_{N,f,t}$, 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:

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.
regression model:

\[
\Delta \log Y_{it} = \beta_0 + \beta_1 \text{Shock}_{it} + \beta_2 X_{i1997} + \varepsilon_{it}
\]

(10)

where \(\Delta \log Y_{it}\) is the log change in employment in manufacturing industry \(i\) from 1997 to 2007 defined in the alternative ways, \(\Delta \log L_{it}\). As industries with a larger increase in imports from China 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

\(^{52}\) 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.
total employment).54

$Shock_{it}$ measures the change in exposure to Chinese imports in manufacturing industry $i$ between 1997 and 2007. $\beta_1$ 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:

$$\Delta \log M^{CH,US}_{it} = \log M^{CH,US}_{i,2007} - \log M^{CH,US}_{i,1997}$$

where $M^{CH,US}_{i,t}$ is defined as the value of imports from China to the US in manufacturing industry $i$, 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’ wages55 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

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54Acemoglu 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.

55Hummels 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.
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).\footnote{Appendix provides more details on the institutional background of this liberalization.} 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:

\[
\Delta \log M_{i,t}^{\text{CH,OTH}} = \log M_{i,2007}^{\text{CH,OTH}} - \log M_{i,1997}^{\text{CH,OTH}}
\]

where \( M_{i,t}^{\text{CH,OTH}} \) 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.\footnote{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.} 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.

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:

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

(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:\(^{59}\)

\(^{58}\)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.
\[ \Delta IPR_{it}^{CH,OTH} = \frac{\Delta M_{it}^{CH,OTH}}{Y_{i,1997} + M_{i,1997} - X_{i,1997}} \]  

(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 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

\(^{60}\)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 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.
errors across industries within a given two-digit industry category.\textsuperscript{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 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 head-
quarter 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). 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 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.

1.4.2 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

64They document that at a more aggregated industry level, three-digit NAICS, employment in US industries that registered larger service offshoring went up between 1992 and 2000.
section. This consists of estimating the following regression model:

$$\frac{\Delta Y_{ft}}{L_{f,1997}} = \beta_0 + \beta_1 \text{Shock}_{ft} + \beta_2 X_{f,1997} + \varepsilon_{it} \quad (15)$$

where $\Delta Y_{ft}/L_{f,1997}$ 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, $L_{f,1997}$. $X_{1997}$ 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; 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 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. $\text{Shock}_{ft}$ 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, $\beta_1$ 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.

$^{65}$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 1.4.1., the main manufacturing industry in 1997 is the manufacturing industry within the firm with the largest number of employees in 1997.
I measure the China shock, $\text{Shock}_{ft}$, 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. 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:

$$\Delta W M^{CH,US}_{ft} = \sum_{e(i) \in I_{f,1997}} w_{e(i),f,1997} \Delta \log M^{CH,US}_{it}$$

(16)

where the weights, $w_{e(i),f,1997}$, are defined as described above and $\Delta \log M^{CH,US}_{it}$ 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:

$$\Delta WIPR^{CH,US}_{ft} = \sum_{e(i) \in E_{f,1997}} w_{e(i),f,1997} \Delta IPR^{CH,US}_{it}$$

(17)

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.
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 that firm \( f \) has in 1997.\(^{69}\) \( \Delta IPR^{US}_i \) 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

\[ w_{e(i),f,1997} = L_{e(i),f,1997} / \left( \sum_{e(i) \in E_{f,1997}} L_{e(i),f,1997} \right) \]

where \( L_{e(i),f,1997} \) is total employment by establishment \( e \), classified to industry \( i \), of firm \( f \) in 1997.

\(^{69}\)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.
measure (17) as:

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

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

$$\Delta WIPR_{ft}^{CH,OTH} = \sum_{e(i) \in E_{f,1997}} w_{e(i),f,1997} \Delta IPR_{it}^{CH,OTH}$$  \quad (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 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 $\beta_1$ 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 employ-
ment (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.\footnote{This finding is in line with the increasing importer wage premium documented by Koren and Csillag (2016) in the case of Hungarian workers.} 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

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of output prices, $price_{fept}^{output}$, 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.\footnote{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.}

$$\Delta \log (price_{fept}^{output}) = \gamma_0 + \gamma_1 Shock_{pt} + \gamma_e + \varepsilon_{fept}$$

where $\Delta \log (price_{fept}^{output})$ is the change in the price of output product $p$ produced in establishment $e$ owned by firm $f$ at time $t$, $\gamma_e$ 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 1.4.1. I use the same identification strategy and instrument the shock variable by using the same instrument as outlined in Section 1.4.1. Thus, $\gamma_1$ 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),\textsuperscript{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 manufacturing 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.

1.5 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 continuum of tasks performed by high- or low-skilled workers. Assembly

\textsuperscript{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.
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.
1.5.1 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, $j \in \{x, y\}$.

There are two labor skill types - low-skill, $L$, and high-skill, $H$ - 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.

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. In the rest of this section, I characterize the demand for varieties, firms’ production and offshoring technology, firms’ cost minimization, and profit maximization problem.

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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, 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.
1.5.1.1. 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:

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

(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 $f$:

$$z_f = \frac{Y}{P^{1-b} P_f}$$

(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 perfectly 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 $y$:

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

(23)

where $\varepsilon \in [0, \infty)$ is the elasticity of substitution 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.

---

$^{77}$ $\varepsilon < 1$ implies that intermediates $x$ and $y$ are complements in the production of $z$, while $\varepsilon > 1$ implies substitution between the two intermediates.
that combine low-skill, $L$, and high-skill, $H$, labor as factors of production:

\[ x_f = AL_{f,x}^{\alpha_x} H_{f,x}^{1-\alpha_x} \]  
\[ y_f = AL_{f,y}^{\alpha_y} H_{f,y}^{1-\alpha_y} \]  

where $\alpha_x$ and $\alpha_y$ 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 $i$. $\beta$ is a shift parameter that captures the technological characteristics of offshoring common across firms. $\gamma_f$ is an idiosyncratic component of the offshoring cost that captures the technological characteristics

---

\(^{78}\)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 $H_{f,j} = \int_0^1 H_{f,j} \, di$. 

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of offshoring specific to firm $f$, such that firms with lower $\gamma_f$ 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 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 $w(1 - I_f) + w^* \int_0^{I_f} \beta \gamma_f t(i) di$

### 1.5.1.2. 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:\(^83\)

$$w = \beta \gamma_f t(I_f) w^*$$

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

\(^{82}\)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.
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: \(^{84}\)

\[
\Omega(I_f) = 1 - I_f + \frac{\int_{I_f} I_f t(i)di}{t(I_f)} \tag{27}
\]

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

\[
\min_{\{L_{f,j}, H_{f,j}\}} \left\{ w \Omega(I_f) L_{f,j} + s H_{f,j} - c_{f,j} A L_{f,j}^{\alpha_j} H_{f,j}^{1-\alpha_j} \right\} \tag{28}
\]

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

\(^{84}\)This expression is derived by substituting in \( w(1 - I_f) + w * \int_{0}^{I_f} \beta t(i)di \) the expression of \( w^* \) given by (26).
case of firms with a lower firm specific component of the offshoring cost \((\gamma_f < \gamma_{f'})\), as these firms shift a larger set of L-tasks abroad in equilibrium, \((I_f > I_{f'})\).

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 \(y\):

\[
\begin{align*}
L_{f,j} &= \frac{\alpha_j \Omega(I_f)}{A} (w \Omega(I_f))^{\alpha_j - 1} s^{1 - \alpha_j} \\
H_{f,j} &= \frac{1 - \alpha_j}{A} (w \Omega(I_f))^{\alpha_j} s^{-\alpha_j}
\end{align*}
\] (31)

(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 \(f = 1, \ldots, F\) 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 \(z\), \(p_f = \left(\frac{Y}{P^{1-b}}\right)^{-\frac{1}{\varepsilon}} z_f^{-\frac{1}{\varepsilon}}\) with \(b > 1\),\(^{85}\) firm \(f\) solves the following profit maximization problem:

\[
\begin{align*}
\max_{\{x_f, y_f\}} \Pi_f &= \left(\frac{Y}{P^{1-b}}\right)^{-\frac{1}{\varepsilon}} \left[\gamma x_f^{\frac{\varepsilon-1}{\varepsilon}} + (1 - \gamma) y_f^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon(\varepsilon-1)}{\varepsilon(1-\varepsilon)}} - c_{f,x}x - c_{f,y}y
\end{align*}
\] (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:

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

\(^{85}\)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.
1.5.2 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.\textsuperscript{86} A decline in the cost of offshoring L-tasks in the model is equivalent to a reduction in parameter $\beta$. 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.\textsuperscript{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\textsuperscript{88} in the case of firm $f$ in response to a decline in $\beta$. Moreover, I derive predictions on how all these margins adjust in the case of a firm that is more exposed to a decline in $\beta$ (i.e., has a lower $\gamma_f$) relative to a less exposed firm (i.e., has a larger $\gamma_f$).

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

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

\textbf{Proof} See the Appendix.

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

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

\textsuperscript{86}One can think of the domestic country as the US, and the foreign country as China.

\textsuperscript{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.

\textsuperscript{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 $\hat{I}_f = dI_f/I_f$. 

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**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 $\beta$ 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 $\beta$ 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 $\beta$ declines if and only if $\varepsilon < b$:

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

\(^{(37)}\)

**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., $\varepsilon$). The intuition behind this is the following.

\(^{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.
The decline in $\beta$ 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 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.\textsuperscript{90} However, as the decline in $\beta$ 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 output expansion.

**Proposition 4** If $I_f > 0$, then, as $\beta$ 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 $\varepsilon < 1$:

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

\textsuperscript{90}Thus, the condition on the elasticity of substitution between the final good varieties triggers the expansion in the output.
(ii) decreases relative to the equilibrium employment of high-skilled in the assembly of intermediate input $y$ if and only if $\varepsilon > 1$:

$$\hat{h}_{x,f} - \hat{h}_{y,f} < 0 \quad (39)$$

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 $\beta$ leads to a decline in the cost of production (Proposition 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 $\beta$, 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.\footnote{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.}

**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 $\beta$ declines:

$$\hat{I}_f > \hat{I}_{f'} > 0 \quad (40)$$

58
(ii) in equilibrium the cost of sourcing L-tasks by firm \( f \) declines more relative to firm \( f' \) as \( \beta \) declines:
\[
\hat{\Omega}_f < \hat{\Omega}_{f'} < 0
\]  
(41)

(iii) the equilibrium employment of high-skilled by firm \( f \) increases more relative to firm \( f' \) as \( \beta \) declines if and only if \( \varepsilon < b \):
\[
\hat{h}_f > \hat{h}_{f'} > 0
\]  
(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 \( \beta \) declines if and only if \( \varepsilon < 1 \):
\[
\hat{h}_{x,f} - \hat{h}_{y,f} > \hat{h}_{x,f'} - \hat{h}_{y,f'} > 0
\]  
(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 \( (\gamma_f) \) 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. \( \frac{\partial^2 t(I_f)}{\partial I^2_f} < 0 \)). This condition guarantees that the marginal cost of offshoring is decreasing in \( I_f \). This means that firms with a lower \( \gamma_f \) (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 \( \beta \). 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 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 1.4: increased offshoring to China led to an expansion of high-skilled employment by US manufacturing 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.

1.6 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 1.5 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.\textsuperscript{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

\textsuperscript{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.”
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 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.

1.6.1 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):

\[
\frac{Material_{fpt}}{Material_{fpt}} = \frac{Domestic \ material_{fpt}}{Material_{fpt}} + \frac{Foreign \ material_{fpt}}{Material_{fpt}}
\]  

(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:

\[
\frac{\text{Domestic material}_{fpt}}{\text{Material}_{fpt}} = \frac{\text{Domestic Insourcing}_{fpt}}{\text{Material}_{fpt}} + \frac{\text{Domestic Outsourcing}_{fpt}}{\text{Material}_{fpt}}
\]

(45)

\[
\frac{\text{Foreign material}_{fpt}}{\text{Material}_{fpt}} = \frac{\text{Foreign Insourcing}_{fpt}}{\text{Material}_{fpt}} + \frac{\text{Foreign Outsourcing}_{fpt}}{\text{Material}_{fpt}}
\]

(46)

I apply the decompositions in (45)-(46) to a data set that I construct on US manufacturing 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 1.3. The results of the decomposition are presented in 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

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\(^93\)The data appendix provides a detailed description of how this data set was constructed.

\(^94\)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.
production as about 10 percent of the materials are produced in-house in the US, 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. 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.

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 of choosing a particular sourcing type) and intensive margins (i.e., the share of spending on a particular sourcing type). By comparing sourcing

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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 occurred 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.
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 occurred 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:

\[ \Delta y_{fpt} = \alpha_0 + \alpha_1 \text{Shock}_{pt} + X_{f,1997} + \varepsilon_{fpt} \]  

where \( \Delta y_{fpt} \) is a vector with four components \( \Delta \frac{\text{Domestic Insourcing}}{\text{Material}_{fpt}} \), \( \Delta \frac{\text{Domestic Outsourcing}}{\text{Material}_{fpt}} \), \( \Delta \frac{\text{Foreign Insourcing}}{\text{Material}_{fpt}} \), and \( \Delta \frac{\text{Foreign Outsourcing}}{\text{Material}_{fpt}} \). Each of these components capture the change

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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.
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 1.5. $X_{f,1997}$ 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 as outlined in Section 1.4.

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.

$^{100}$Given the form of the specification in (24), $\alpha_1$ 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 entry 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).

$^{101}$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.

65
1.6.2 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, $\text{cost}_{i}^{\text{input}}$, 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.\textsuperscript{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.\textsuperscript{103}

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-

\textsuperscript{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.
\textsuperscript{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.
product pairs and on the entire sample:\footnote{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: \( cost_{fep}^{\text{input}} = \gamma_0 + \gamma_1 Shock_{pt} + \gamma_f + \gamma_p + \gamma_{e,t} + \varepsilon_{fep} \), where \( \gamma_f \) and \( \gamma_p \) control for variations in prices that are common over time in the case of a firm \( f \) and product \( p \) pair. \( \gamma_e \) contains establishment characteristics such as a set of industry fixed effects defined as the main output industry of the establishment.}

\[
\Delta cost_{fep}^{\text{input}} = \gamma_0 + \gamma_1 Shock_{pt} + \gamma_e + \varepsilon_{fep}
\]  

(48)

where \( \gamma_e \) 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 1.4. I use the same identification strategy and instrument the shock variable by using the same instrument as outlined in Section 1.4. Thus, \( \gamma_1 \) 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 \( \gamma_1 \) 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.

1.6.3 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 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:

\[
\frac{\Delta L^M_{ft}}{L_{f,1997}} = \beta_0 + \beta_1 \Delta \log \text{Material}_{ft} + \beta_2 X_{f,1997} + \varepsilon_{it} \tag{49}
\]

where \(\Delta L^M_{ft}/L_{f,1997}\) is the growth in manufacturing employment by firm \(f\) from 1997 to 2007, \(\Delta \log \text{Material}_{ft}\) 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 1.4.2. To identify variation in material expenditure over time due to the declining cost of sourcing induced by China, I instrument

\footnote{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.}
\( \Delta \log \text{Material}_{f, t} \) with the weighted average of the industry specific instrument defined in Section 1.4.1. 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. Thus, the two-stage least squares estimate of \( \beta_1 \) 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 \( \beta_1 \) 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 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

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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, \( w_{p,f,1997} = \frac{\text{Material}_{p,f,1997}}{\sum_{p \in P_{\text{input}} \text{f, 1997}}} \text{Material}_{f,1997} \). 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.
above: the firm level China shock measure from Section 1.4.2 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\textsuperscript{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 output 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.

### 1.7 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

\textsuperscript{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.
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’ 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 manufacturing 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 output 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 understanding of the sources of job creation 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.

A.1 Table Appendix
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 (%)

<table>
<thead>
<tr>
<th></th>
<th>Employment in manufacturing establishments</th>
<th>Employment in non-manufacturing establishments</th>
<th>Total employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing firm</td>
<td>-3.0</td>
<td>7.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Non-manufacturing firm</td>
<td>0.4</td>
<td>23.4</td>
<td>24.0</td>
</tr>
<tr>
<td>All firms</td>
<td>-2.6</td>
<td>30.6</td>
<td>28.0</td>
</tr>
</tbody>
</table>

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 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 activities between 1997 and 2007 by US manufacturing firms (%)

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

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 activities 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 activities 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 (%)

<table>
<thead>
<tr>
<th></th>
<th>Employment in manufacturing establishments</th>
<th>Employment in non-manufacturing establishments</th>
<th>Total employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firms that manufacture</td>
<td>-3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Firms that do not manufacture</td>
<td>0.7</td>
<td>23.3</td>
<td>24</td>
</tr>
<tr>
<td>All firms</td>
<td>-2.3</td>
<td>29.3</td>
<td>27</td>
</tr>
</tbody>
</table>

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

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

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 Comtrade 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

<table>
<thead>
<tr>
<th></th>
<th>Chinese import growth in the US</th>
<th>Total employment</th>
<th>Number of establishments</th>
<th>Payroll</th>
<th>Manufacturing employment</th>
<th>Non-manufacturing employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>1st stage 2SLS</td>
<td>0.158**</td>
<td>0.179**</td>
<td>0.378***</td>
<td>0.277**</td>
<td>0.217**</td>
<td></td>
</tr>
<tr>
<td>Chinese import growth in</td>
<td>(0.083)</td>
<td>(0.074)</td>
<td>(0.099)</td>
<td>(0.134)</td>
<td>(0.117)</td>
<td></td>
</tr>
<tr>
<td>other developed countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.45</td>
<td>0.44</td>
<td>0.35</td>
<td>0.38</td>
<td>0.56</td>
<td>0.42</td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Chinese import growth in the US</th>
<th>Manufacturing employment</th>
<th>Retail and wholesale</th>
<th>Transportation</th>
<th>Information services</th>
<th>Headquarters services</th>
<th>Professional services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td>1st stage 2SLS</td>
<td>0.082***</td>
<td>-0.072</td>
<td>-0.016</td>
<td>-0.014</td>
<td>0.020**</td>
<td>0.021**</td>
<td></td>
</tr>
<tr>
<td>Chinese import growth in</td>
<td>(0.025)</td>
<td>(0.055)</td>
<td>(0.013)</td>
<td>(0.020)</td>
<td>(0.014)</td>
<td>(0.009)</td>
<td></td>
</tr>
<tr>
<td>other developed countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.45</td>
<td>0.22</td>
<td>0.06</td>
<td>0.15</td>
<td>0.11</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Chinese import growth in the US</th>
<th>Number of production workers</th>
<th>Number of non-production workers</th>
<th>Number of manufacturing establishments</th>
<th>Number of hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese import growth in other developed countries (0.101)</td>
<td>0.747***</td>
<td>(0.101)</td>
<td>0.293***</td>
<td>(0.098)</td>
</tr>
<tr>
<td>Chinese import growth in the US (0.098)</td>
<td>(0.093)</td>
<td>(0.019)</td>
<td>0.039**</td>
<td>(0.122)</td>
</tr>
<tr>
<td>Observations</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.45</td>
<td>0.56</td>
<td>0.60</td>
<td>0.53</td>
</tr>
<tr>
<td>F-statistics</td>
<td>53.6</td>
<td>53.6</td>
<td>53.6</td>
<td>53.6</td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

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 constructed 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

<table>
<thead>
<tr>
<th>Weighted Chinese import growth in US firms’ US output industries</th>
<th>Total employment</th>
<th>Manufacturing employment</th>
<th>Non-manufacturing employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st stage 2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>Weighted Chinese import growth in other developed countries (0.040)</td>
<td>0.635***</td>
<td>(0.040)</td>
<td>0.019</td>
</tr>
<tr>
<td>Weighted Chinese import growth in US firms’ US output industries (0.068)</td>
<td>0.111***</td>
<td>(0.038)</td>
<td>-0.092**</td>
</tr>
<tr>
<td>Observations</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.98</td>
<td>0.35</td>
<td>0.21</td>
</tr>
<tr>
<td>F-stat</td>
<td>250.03</td>
<td>250.03</td>
<td>250.03</td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th></th>
<th>Retail-Wholesale</th>
<th>Headquarter services</th>
<th>Professional services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[4]</td>
<td>[2]</td>
<td>[3]</td>
</tr>
<tr>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td></td>
</tr>
<tr>
<td>Weighted Chinese import growth in US firms’ US output industries</td>
<td>-0.005</td>
<td>0.005**</td>
<td>0.002**</td>
</tr>
<tr>
<td>(0.015)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.58</td>
<td>0.40</td>
<td>0.37</td>
</tr>
<tr>
<td>F-stat</td>
<td>250.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th></th>
<th>Production workers</th>
<th>Non-production workers</th>
<th>Manufacturing wage</th>
<th>Production wage</th>
<th>Number of manufacturing establishments</th>
<th>Number of products</th>
</tr>
</thead>
<tbody>
<tr>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td></td>
</tr>
<tr>
<td>Weighted Chinese import growth in US firms’ US output industries</td>
<td>0.171**</td>
<td>-0.058</td>
<td>0.186**</td>
<td>0.274*</td>
<td>0.091***</td>
<td>0.090*</td>
</tr>
<tr>
<td>(0.084)</td>
<td>(0.059)</td>
<td>(0.088)</td>
<td>(0.171)</td>
<td>(0.021)</td>
<td>(0.070)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.16</td>
<td>0.15</td>
<td>0.472</td>
<td>0.29</td>
<td>0.15</td>
<td>0.45</td>
</tr>
<tr>
<td>F-stat</td>
<td>250.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>2002</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic insourcing</td>
<td>0.098</td>
<td>0.085</td>
<td>0.073</td>
</tr>
<tr>
<td>Domestic outsourcing</td>
<td>0.617</td>
<td>0.592</td>
<td>0.520</td>
</tr>
<tr>
<td>Foreign insourcing</td>
<td>0.143</td>
<td>0.162</td>
<td>0.176</td>
</tr>
<tr>
<td>Foreign outsourcing</td>
<td>0.142</td>
<td>0.161</td>
<td>0.231</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Share of imports from</th>
<th>1997</th>
<th>2002</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.100</td>
<td>0.108</td>
<td>0.118</td>
</tr>
<tr>
<td>China</td>
<td>0.013</td>
<td>0.024</td>
<td>0.044</td>
</tr>
<tr>
<td>Germany</td>
<td>0.034</td>
<td>0.035</td>
<td>0.034</td>
</tr>
<tr>
<td>Japan</td>
<td>0.069</td>
<td>0.051</td>
<td>0.051</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.055</td>
<td>0.049</td>
<td>0.046</td>
</tr>
<tr>
<td>Outsourcing from China</td>
<td>0.011</td>
<td>0.019</td>
<td>0.035</td>
</tr>
<tr>
<td>Insourcing from China</td>
<td>0.002</td>
<td>0.005</td>
<td>0.009</td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th></th>
<th>Chemical products</th>
<th>Plastic products</th>
<th>Transportation equipment</th>
<th>Electrical equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.060</td>
<td>0.069</td>
<td>0.093</td>
<td>0.095</td>
</tr>
<tr>
<td>China</td>
<td>0.010</td>
<td>0.042</td>
<td>0.006</td>
<td>0.045</td>
</tr>
<tr>
<td>Germany</td>
<td>0.077</td>
<td>0.044</td>
<td>0.037</td>
<td>0.042</td>
</tr>
<tr>
<td>Japan</td>
<td>0.059</td>
<td>0.033</td>
<td>0.070</td>
<td>0.059</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.024</td>
<td>0.037</td>
<td>0.054</td>
<td>0.036</td>
</tr>
<tr>
<td>Outsourcing from China</td>
<td>0.009</td>
<td>0.033</td>
<td>0.005</td>
<td>0.041</td>
</tr>
<tr>
<td>Insourcing from China</td>
<td>0.001</td>
<td>0.009</td>
<td>0.001</td>
<td>0.004</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Chemical products</th>
<th>Plastic products</th>
<th>Transportation equipment</th>
<th>Electrical equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make and buy</td>
<td>0.440</td>
<td>0.457</td>
<td>0.358</td>
<td>0.369</td>
</tr>
<tr>
<td>Make only</td>
<td>0.040</td>
<td>0.045</td>
<td>0.019</td>
<td>0.042</td>
</tr>
<tr>
<td>Buy only</td>
<td>0.520</td>
<td>0.498</td>
<td>0.623</td>
<td>0.589</td>
</tr>
<tr>
<td>Mixed sourcing</td>
<td>0.453</td>
<td>0.427</td>
<td>0.402</td>
<td>0.370</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic insourcing</td>
<td>0.481</td>
<td>0.235</td>
<td>0.246</td>
<td>0.436</td>
</tr>
<tr>
<td>in 1997</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic outsourcing</td>
<td>0.019</td>
<td>0.874</td>
<td>0.062</td>
<td>0.105</td>
</tr>
<tr>
<td>in 1997</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign insourcing</td>
<td>0.019</td>
<td>0.072</td>
<td>0.786</td>
<td>0.796</td>
</tr>
<tr>
<td>in 1997</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign outsourcing</td>
<td>0.025</td>
<td>0.084</td>
<td>0.535</td>
<td>0.535</td>
</tr>
<tr>
<td>in 1997</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th></th>
<th>dlog(Material Input Price)</th>
<th>log(Material Input Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Chinese import growth</td>
<td>-0.132***</td>
<td>-0.142***</td>
</tr>
<tr>
<td>in US firms’ input industries</td>
<td>(0.038)</td>
<td>(0.049)</td>
</tr>
<tr>
<td>Log Chinese imports</td>
<td></td>
<td>-0.357**</td>
</tr>
<tr>
<td>to US firms input industries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.02</td>
<td>0.07</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Material expenditure</th>
<th>Manufacturing employment</th>
<th>Production</th>
<th>Number of manufacturing</th>
<th>Number of products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>workers</td>
<td>establishments</td>
<td></td>
</tr>
<tr>
<td>1st stage</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>Change in log material expenditure</td>
<td>0.535** (0.235)</td>
<td>0.462* (0.279)</td>
<td>0.319** (0.193)</td>
<td>1.455* (0.920)</td>
</tr>
<tr>
<td>Weighted Chinese import growth in US firms</td>
<td>0.186*** (0.059)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observations: 60,000, R-squared: 0.04, 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 contains 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

<table>
<thead>
<tr>
<th>Manufacturing employment</th>
<th>Production workers</th>
<th>Number of manufacturing establishments</th>
<th>Number of products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted Chinese import growth in US firms input industries</td>
<td>0.070 (0.191)</td>
<td>0.087 (0.396)</td>
<td>0.079 (0.061)</td>
</tr>
<tr>
<td>Change in log material expenditure</td>
<td>-1.315 (2.972)</td>
<td>-2.619 (0.260)</td>
<td>-0.365 (6.016)</td>
</tr>
</tbody>
</table>

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.
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

1 - \( I_f \)

Tasks

Intermediate goods

Final good variety

\( L_f \)

\( H_f \)

\( x_f \)

Cobb-Douglas (H,L)

\( y_f \)

Cobb-Douglas (H,L)

\( z_f \)

CES (\( x_f, y_f \))
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


A.3.1 Confidential Microdata from the US Census Bureau.

A.3.1.1 Census of Manufactures\textsuperscript{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

\textsuperscript{109}https://www.census.gov/econ/www/mancen.html
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

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.

A.3.1.3 Longitudinal Foreign Trade Transaction Dataset

The Longitudinal Foreign Trade Transaction Dataset (LFTTD) is constructed based on customs declarations forms collected by U.S. Customs and Border Protection (CBP). 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 observation is firm-product-country of origin in each cross section.

A.3.1.4 Commodity Flow Survey

https://www.census.gov/ces/dataproducts/datasets/lbd.html
https://www.census.gov/ces/dataproducts/datasets/lfttd.html
More information on the form based on which information on import transactions is collected: http://www.cbp.gov/sites/default/files/documents/CPB%20Form%207501_0.pdf
https://bhs.econ.census.gov/bhs/cfs/
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)\textsuperscript{114}, value, weight, destination, and transportation mode. There are about 100,000 establishments sampled\textsuperscript{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 the case of the smallest plants, which represents roughly a third of the sample, is entirely imputed by the Census Bureau\textsuperscript{116}. These are called AR plants. After these cleanings, about 30\% of the total number of establishments included in the CMF

\textsuperscript{114}At the five digits SCTG level there are 512 product categories.
\textsuperscript{115}This is a random sampling method conducted by the Bureau of Transportation Statistics and US Census Bureau.
\textsuperscript{116}For more information see White et al. (2012) on http://www.nber.org/papers/w17816
are dropped. I also drop all the observations that has the flag indicating that the value was imputed. 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 corresponds 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 identifiers 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\textsuperscript{117}. Using the firm identifier that is

\textsuperscript{117}With other words, starting from 2002, the LFTTD files can be merged to the LBD files by constructig a
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

The NBER-CES dataset\textsuperscript{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)\textsuperscript{119} contains information on the import and export flows between the US and all the other countries 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)\textsuperscript{120} that links the ten-digit Harmonized System (HS10) codes that classify products in U.S. international trade, and the 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.

\textsuperscript{118} For more details see the website: http://www.nber.org/nberces/
\textsuperscript{119} http://comtrade.un.org/data/
\textsuperscript{120} More information on these concordances are available here: http://www.justinrpierce.com/index_files/Pierce_Schott_JESM_2012.pdf. The zip files with the concordance tables can be downloaded from: http://www.justinrpierce.com/
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 Census server and can be accessed from the secure Research Data Centers or publicly available on the Census Bureau website\(^\text{121}\).

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


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

\(^{121}\text{https://www.census.gov/eos/www/naics/concordances/concordances.html}
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≥0

A.1.ii. Offshoring ($VI_f = 1$): if import at arms’ length≥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 \((VI_d = 0, OU_d = 1, OU_f = 1, VI_f = 1)\):

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

\(^{122}\)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 shipped 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

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

B.3.ii. Domestic insourcing ($V_{I_{d}} = 1$): if Domestic material-Import > 0 and there is a plant within the firm that produces that good
<table>
<thead>
<tr>
<th>NAICS-2</th>
<th>SIC-2</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>01-09</td>
<td>Agriculture, Forestry, Fishing and Hunting</td>
</tr>
<tr>
<td>21</td>
<td>10-14</td>
<td>Mining, Quarrying, and Oil and Gas Extraction</td>
</tr>
<tr>
<td>22</td>
<td>49</td>
<td>Utilities</td>
</tr>
<tr>
<td>23</td>
<td>15-17</td>
<td>Construction</td>
</tr>
<tr>
<td>31-33</td>
<td>20-26, 28-39</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>42</td>
<td>50-51</td>
<td>Wholesale Trade</td>
</tr>
<tr>
<td>44-45</td>
<td>52-57, 59</td>
<td>Retail Trade</td>
</tr>
<tr>
<td>48-49</td>
<td>40-47</td>
<td>Transportation and Warehousing</td>
</tr>
<tr>
<td>51</td>
<td>27, 48</td>
<td>Information</td>
</tr>
<tr>
<td>52</td>
<td>60-64</td>
<td>Finance and Insurance</td>
</tr>
<tr>
<td>53</td>
<td>65, 75, 72, 78, 79</td>
<td>Real Estate and Rental and Leasing</td>
</tr>
<tr>
<td>54</td>
<td>73, 87</td>
<td>Professional, Scientific, and Technical Services</td>
</tr>
<tr>
<td>55</td>
<td>67</td>
<td>Management of Companies and Enterprises</td>
</tr>
<tr>
<td>56</td>
<td>49, 73</td>
<td>Administrative, Support, Waste Management Services</td>
</tr>
<tr>
<td>61</td>
<td>82</td>
<td>Educational Services</td>
</tr>
<tr>
<td>62</td>
<td>80, 83</td>
<td>Health Care and Social Assistance</td>
</tr>
<tr>
<td>71</td>
<td>79</td>
<td>Arts, Entertainment, and Recreation</td>
</tr>
<tr>
<td>72</td>
<td>58, 70</td>
<td>Accommodation and Food Services</td>
</tr>
<tr>
<td>81</td>
<td>75, 76, 83, 86</td>
<td>Other Services (except Public Administration)</td>
</tr>
<tr>
<td>92</td>
<td>91-97</td>
<td>Public Administration</td>
</tr>
</tbody>
</table>
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 manufacturing industries. This change in the import penetration ratio is defined as:

\[
\Delta IPR_{it}^{CH,US} = \left( \frac{\Delta M_{it}^{CH,US}}{Y_{i,1997} + M_{i,1997} - X_{i,1997}} \right)
\]

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:

\[
\Delta IPR_{it}^{CH,US} = \left( \frac{M_{i,2007}^{CH,US} - M_{i,1997}^{CH,US}}{\frac{Y_{i,1997}}{P_{i,1997}} + \frac{M_{i,1997}}{P_{i,1997}} - \frac{X_{i,1997}}{P_{i,1997}}} \right)
\]

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:

\[
\Delta IPR_{it}^{CH,US} = \left( \frac{M_{i,2007}^{CH,US} - M_{i,1997}^{CH,US}}{\frac{Y_{i,1997}}{P_{i,1997}/P_{i,2007}} + \frac{M_{i,1997}}{P_{i,1997}/P_{i,2007}} - \frac{X_{i,1997}}{P_{i,1997}/P_{i,2007}}} \right)
\]

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.\textsuperscript{123} The PCE index is a measure of consumer inflation in the US and it is constant across industries. This means that \( \frac{P_{i,1997}}{P_{i,2007}} = \frac{P_{1997}}{P_{2007}} \). The PCE in 1997 with 2007 base year was \( \frac{P_{1997}}{P_{2007}} = 0.809 \), 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 China imports and net imports in the US at 2007 prices assumes away potentially important price

\textsuperscript{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.
variations across industries, and results in quantities in 1997 evaluated at 1997 prices “scaled by a constant” instead of 2007 prices\textsuperscript{124}. However, there are industry level price indices available in the NBER-CES database (i.e. the shipment price index) to compute the 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\textsuperscript{125}.

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

<table>
<thead>
<tr>
<th>1st pctile</th>
<th>5th pctile</th>
<th>50th pctile</th>
<th>95th pctile</th>
<th>99th pctile</th>
<th>Mean</th>
<th>St.dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.48</td>
<td>0.66</td>
<td>0.85</td>
<td>1.07</td>
<td>1.73</td>
<td>0.91</td>
<td>0.80</td>
</tr>
</tbody>
</table>

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 systematic 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 appliance and furniture industries).

\textsuperscript{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, $\frac{q_{i,1997}p_{i,1997}}{P_{1997}/P_{2007}} = q_{i,1997}p_{i,1997}/p_{i,2007}$.

\textsuperscript{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, $\frac{q_{i,1997}p_{i,1997}}{P_{1997}/P_{2007}} = q_{i,1997}p_{i,2007}$. 
Table A.4.2. Changes in the ranking of the China shock under different Vship deflators

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

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 1.4.1 of the paper. The table indicate that when the statistically proper deflator is used the statistical significance of the coefficient on the change import penetration measure vanishes. The estimates obtained based on the statistically consistently deflated import penetration 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

<table>
<thead>
<tr>
<th></th>
<th>Vship deflated</th>
<th>Vship deflated</th>
<th>No normalization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PCE Index</td>
<td>by Industry Price Index</td>
<td></td>
</tr>
<tr>
<td>$\Delta IPR_{it}^{US,CH,PCE}$</td>
<td>-0.65**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.e.</td>
<td>(0.29)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta IPR_{it}^{US,CH,IPI}$</td>
<td>-0.009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.e.</td>
<td>(0.26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \log M_{it}^{US,CH}$</td>
<td>-0.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.e.</td>
<td>(0.023)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.33</td>
<td>0.47</td>
<td>0.46</td>
</tr>
</tbody>
</table>

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.\textsuperscript{126}

### A.5 Robustness Checks

\textsuperscript{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

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

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

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dlog(Output Price)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Chinese import penetration ratio to the US</td>
<td>0.098***</td>
<td>0.169***</td>
</tr>
<tr>
<td></td>
<td>(0.045)</td>
<td>(0.092)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.01</td>
<td>0.09</td>
</tr>
</tbody>
</table>

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 paper. 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

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

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

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

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

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

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 constructed 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>
<thead>
<tr>
<th></th>
<th>Weighted change in the Chinese import penetration ratio to the US output industries of the US firms</th>
<th>Total employment</th>
<th>Manufacturing employment</th>
<th>Non-manufacturing employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>1st stage</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>Weighted change in the Chinese</td>
<td>1.061*** (0.063)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>import penetration ratio to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other developed countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted change in the Chinese</td>
<td>0.978 (0.816)</td>
<td>0.429</td>
<td>0.549</td>
<td></td>
</tr>
<tr>
<td>import penetration ratio to the</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US output industries of the US</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>firms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.99</td>
<td>0.35</td>
<td>0.20</td>
<td>0.49</td>
</tr>
<tr>
<td>p-value</td>
<td>282.67</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th></th>
<th>Retail-Wholesale</th>
<th>Headquarters services</th>
<th>Professional services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Weighted change in the Chinese import penetration ratio to other developed countries</td>
<td>0.286</td>
<td>0.335**</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>(0.202)</td>
<td>(0.182)</td>
<td>(0.187)</td>
</tr>
<tr>
<td>Observations</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.58</td>
<td>0.40</td>
<td>0.37</td>
</tr>
<tr>
<td>F-stat</td>
<td>282.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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 $\beta$ declines:

$$\hat{I}_f > 0$$  \hspace{1cm} (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 $dI_f = -\frac{\partial}{\partial \beta} \gamma_f \frac{t(I_f)}{I_f}$. Divide this equation through by $I_f$, and denote $\hat{I}_f \equiv \frac{dI_f}{I_f}$. As $\frac{\partial t(I_f)}{\partial I_f} > 0$ by assumption, then for any $I_f > 0$, $\frac{\partial t(I_f)}{\partial I_f} > 0$. As $t(I_f) > 0$, $\gamma_f \frac{t(I_f)}{I_f} > 0$. Dividing this through by $I_f$, $\hat{I}_f \equiv \frac{d\Omega(I_f)}{dI_f} \partial I_f \hat{I}_f = -\frac{\partial (\Omega(I_f))}{\partial I_f} \hat{I}_f$. As $\frac{\partial (\Omega(I_f))}{\partial I_f} > 0$ by assumption, then for any $I_f > 0$, $\frac{\partial (\Omega(I_f))}{\partial I_f} > 0$ and $t(I_f) > 0$. Thus, for any $\hat{\beta} < 0$ it results that $\hat{I}_f > 0$. \hspace{1cm} \square

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

$$\hat{\Omega}_f < 0$$  \hspace{1cm} (51)

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

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

$$\hat{h}_f > 0$$  \hspace{1cm} (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 $\hat{h}_{f,x}$ and $\hat{h}_{f,y}$ as the function of $\hat{\Omega}_f$:

$$\hat{h}_{f,y} = \frac{\alpha_x[(1-\varepsilon)\Delta_1+\Delta_2+\frac{\Delta_1}{\varepsilon}]^{-\frac{\varepsilon}{\varepsilon-1}}+\varepsilon\Delta_1\alpha_x}{\varepsilon-1} \hat{\Omega}_f$$

$$\hat{h}_{f,x} = \frac{\alpha_x[(1-\varepsilon)\Delta_2+\Delta_1+\frac{\Delta_2}{\varepsilon}]^{-\frac{\varepsilon}{\varepsilon-1}}+\varepsilon\Delta_2\alpha_y}{\varepsilon-1} \hat{\Omega}_f$$
\[ \Delta_1 f = \frac{\varepsilon-1}{\varepsilon} \left( \frac{\varepsilon(b-1)}{b(\varepsilon-1)} - 1 \right) \left( \frac{x - \varepsilon f_{x}^0}{y f_{x}^0} \right) \] and \[ \Delta_2 f = \frac{\varepsilon-1}{\varepsilon} \left( \frac{\varepsilon(b-1)}{b(\varepsilon-1)} - 1 \right) \left( \frac{\varepsilon f_{x}^0}{y f_{x}^0 + x f_{x}^0} \right) \]. 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 \( \hat{h}_f = s_{f,x} \hat{h}_{f,x} + s_{f,y} \hat{h}_{f,y} \) where \( s_{f,j,h} = \frac{h_{f,j}}{h_f} > 0 \) for \( j = \{x, y\} \).

\( \alpha_y \left[ (1-\varepsilon) \Delta_1 + \Delta_2 + \varepsilon - 1 \right] \Delta_1 \alpha_y < 0 \) and \( \alpha_x \left[ (1-\varepsilon) \Delta_1 + \Delta_2 + \varepsilon - 1 \right] \Delta_2 \alpha_y < 0 \) for any \( \varepsilon < b \). This together with \( \bar{\omega}_f < 0 \) (Proposition 2) implies that \( \hat{h}_{f,x} > 0 \) and \( \hat{h}_{f,y} > 0 \) for any \( \beta < 0 \). Thus, \( \hat{h}_f = s_{f,x} \hat{h}_{f,x} + s_{f,y} \hat{h}_{f,y} > 0 \) for any \( \beta < 0 \).

**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 \( \varepsilon < 1 \):

\[ \hat{h}_{x,f} - \hat{h}_{y,f} > 0 \] (53)

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

\[ \hat{h}_{x,f} - \hat{h}_{y,f} < 0 \] (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 \( h_{f,x} = H_{f,x} \), while in \( y \) is \( h_{f,y} = H_{f,y} \). Taking the logarithm of both sides and by applying the Implicit Function Theorem, the total differential of the expression becomes \( \hat{h}_{f,x} = \hat{H}_{f,x} + \hat{x} \), while \( \hat{h}_{f,y} = \hat{H}_{f,y} + \hat{y} \). 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: \( \hat{h}_{f,x} - \hat{h}_{f,y} = \hat{H}_{f,x} - \hat{H}_{f,y} + \hat{x} - \hat{y} \). Taking the logarithm of both sides and by applying the Implicit Function Theorem to (30), (32) and (34) we get \( \hat{H}_{f,x} - \hat{H}_{f,y} \) and \( \hat{x} - \hat{y} \) as functions of \( \bar{\omega}_f \) \( \hat{h}_{f,x} - \hat{h}_{f,y} = (1 - \varepsilon) (\alpha_x - \alpha_y) \bar{\omega}_f \) where \( \alpha_x < \alpha_y \) by assumption, \( \bar{\omega}_f < 0 \) 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 \( \beta \) declines:

\[ \hat{I}_f > \hat{I}_{f'} > 0 \] (55)

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

\[ \bar{\omega}_{f'} < \bar{\omega}_{f'} < 0 \] (56)

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(iii) the equilibrium employment of high-skilled by firm \( f \) increases more relative to firm \( f' \) as \( \beta \) 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 \( \beta \) 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 \( \beta \), the change in \( I_f \) is larger the lower \( \gamma_f \) is. By taking the cross-partial derivative of \( I_f \), we get

\[
\frac{\partial I_f}{\partial \beta} = -\frac{\gamma_f}{\beta} \frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}} \tag{36}
\]

By using the expression \( \frac{\partial I_f}{\partial \gamma_f} = -\frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}} \), the derivative simplifies to

\[
\frac{\partial^2 I_f}{\partial \beta \partial \gamma_f} = -\frac{t(I_f)}{\beta} \left( \frac{\partial^2 t(I_f)}{\partial I_f \partial I_f} \right) \tag{37}
\]

By using the expression \( \frac{\partial I_f}{\partial \gamma_f} = -\frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}} \), the derivative simplifies to

\[
\frac{\partial^2 I_f}{\partial \beta \partial \gamma_f} = -\frac{t(I_f)}{\beta} \left( \frac{\partial^2 t(I_f)}{\partial I_f \partial I_f} \right) \tag{37}
\]

Given the assumption on \( t(I_f) \) that \( \frac{\partial t(I_f)}{\partial I_f} > 0 \), \( \frac{\partial I_f}{\partial \gamma_f} = -\frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}} < 0 \) for any \( \gamma_f > 0 \), \( I_f > 0 \). Thus,

\[
\frac{\partial I_f}{\partial \beta} > 0 \text{ if and only if } \frac{t(I_f)}{\frac{\partial t(I_f)}{\partial I_f}} < 0. \text{ Which is equivalent with } \frac{\partial^2 t(I_f)}{\partial I_f \partial I_f} < 0. \text{ This implies}
\]

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 \( \hat{\beta} < 0 \). \( \square \)
Chapter 2

Does Financial Liberalization Promote Imports?

2.1 Introduction

A growing segment of the international trade literature has provided theoretical insight and empirical evidence about the way financial shocks shape firms' export decisions (Amiti and Weinstein, 2011; Feenstra et. al. 2012). However, there has been no empirical research investigating the implications of financial shocks for firms’ import decisions, despite the fact that a large and growing share of international trade transactions are intermediate input transactions\(^1\) and most exporting firms are importers too (Bernard et al. 2007; Amiti et al. 2013)^2.

This paper aims to fill this gap in the literature, both theoretically and empirically. We

\(^1\)Hummels, Ishii and Yi (2001), Yeats (2001), Feenstra and Hanson (1996) estimate that the share of imported intermediates increased from 5.3% of total U.S. intermediate purchases in 1972 to 11.6% in 1990, Campa and Goldberg (1997) find similar evidence for Canada and the UK. The two main lines of argument for the increasing share of intermediate input trade are: (1) firms prefer imported intermediate inputs over domestic inputs for their higher quality and better technological characteristics, which enhances the overall efficiency of production (for more details see Halpern et al., 2011 or Goldberg et al., 2010) (2) falling transportation costs (for more details see Hummels and Schaur, 2013).

\(^2\)Recently Amiti et al. (2013) has documented that most of the Belgian exporters are importers too, and that the largest exporters are the largest importers.
provide evidence that firms’ import decisions are affected by credit supply shocks, and we
document how firms’ choice between imported and domestic inputs is driven by their access
to external financing. We find that positive credit supply shocks loosen firms’ liquidity
constraints and cause firms to import more. We also find that this increase in imports can
be attributed to the increase in intermediate input imports, as financial liberalization reduces
the relative cost of buying intermediates from abroad. Thus, this is the first paper to show
that capital market liberalization can serve to lower trade costs which causes firms to buy
more imported intermediates.

The existing trade finance literature shows that exporters are more exposed to financial
shocks than non-exporters. The main argument is that exporters face a large time gap
between shipping the good and booking their sales revenue 3. During this time period,
exporters finance their working capital needs and ensure the continuity of their production
process by borrowing from financial institutions. Intuitively, this argument applies in the
case of importers too, especially in the case of intermediate input importers. For instance,
Hummels and Schaur (2013) show that firms importing their intermediate inputs need to hold
large inventories as a buffer stock due to the lengthy shipping time they face and to cover
depreciation such as spoilage or technological obsolescence. This suggests that importers
have at least as large liquidity needs as exporters because they have to finance not only
the goods in transit, but also these inventory holdings. Thus, analyzing the interaction of
import decisions and finance can provide new insights about the way firms’ access to bank
loans shapes firms’ cross border input sourcing decisions.

We present a theory and derive predictions on the way changes in firms’ access to bank
loans affect their import decisions. Next, we test these predictions by using a dataset that
includes the balance sheets, international trade transactions and the banks of Hungarian
manufacturing firms. We use the last stage of Hungary’s financial account liberalization

3Ahn et al. (2011) and Amiti and Weinstein (2011) provide empirical evidence that negative liquidity
supply shocks in Japan accounted for the large drop in Japanese firms’ exports. Manova (2013) shows in a
structural framework that better financial institutions and a larger degree of financial development promote
trade through the channel of better access to trade finance.
as a natural experiment to identify credit supply shocks, and estimate the impact of the liberalization on Hungarian firms’ import and production decisions.

The theoretical model builds on Melitz (2003) with three main differences. First, besides labor, firms use intermediate inputs to produce the final good, which they can either purchase in the perfectly competitive domestic intermediate input market, or import. By building on Amiti et al. (2013), we assume that firms face a tradeoff when choosing the composition of intermediate inputs: imported intermediate inputs are more productive, but firms have to pay a fixed cost in order to acquire them. Second, we assume that a firm’s sales revenue does not cover its total cost if it imports the intermediate input. In particular, firms can cover only a constant fraction of the value of imported intermediates and the fixed cost of entering import markets, while the rest is financed by bank loans. There is a perfectly competitive financial sector in which banks borrow from international financial markets and provide loans to the firms. We assume that firms can refuse to pay the loan back to the bank with a given probability, in which case the bank can take away a constant fraction of the firm’s sales.  

This model provides theoretical predictions about the impact of changes in access to bank loans on firms’ trade decisions. As the interest rate at which banks borrow from international markerts falls (financial liberalization hereafter), firms can access bank loans at a lower cost. This has a series of consequences on their production and sales decisions.

First, financial liberalization promotes trade by increasing demand for imported intermediate inputs. As the cost of loans decreases, firms can acquire liquidity at a lower cost. This leads to a decrease in the relative cost of buying the more productive imported intermediate input. Thus, firms demand more bank loans and use this new source of liquidity to import more intermediate inputs. This leads to an increase in the material-cost-to-sales ratio and a decrease in the value-added-to-sales ratio. Consequently, the supply chain to which the firm belongs expands.

Second, as firms get access to more liquidity, they reallocate resources to the more pro-

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4Similar set of assumptions is used in Aghion et al. (2005) or Manova et al. (2014).
ductive imported intermediate inputs. Thus, the imported-intermediate-input-to-sales and import-to-sales ratios increase not only because firms buy more imported intermediate inputs, but also because they reduce the share of domestic intermediate inputs. This enhances the overall efficiency of firms’ production. Consequently, the effect of financial liberalization on firms’ production outcomes and on the size of the supply chain is amplified by the presence of imported intermediate inputs in the production process.

Finally, we show that as a consequence of financial liberalization, more firms enter the import market and buy the more productive imported intermediate input. Thus, the model predicts entry into the import market generated by the positive credit supply shock.

We test these predictions on a dataset that includes information on the balance sheets, international trade transactions and the banks of Hungarian manufacturing firms over the period 1998 - 2002. The main argument for using this dataset is that the last stage of the Hungarian financial account liberalization - implemented in 2001 in preparation of Hungary joining the European Union (EU) - provides a source of exogenous variation in credit supply which can be used as a natural experiment to quantify the way relaxed credit constraints shape production and sales decisions at the firm level. After liberalization, banks had access to cheaper refinancing from international markets than the domestic interbank market. As a consequence, banks expanded their loan portfolio and offered loans to the firms at a lower interest rate, which then translated into an expansion in firms’ production activity.

The financial account in Hungary was fully liberalized in June 2001 when domestic banks were allowed to conduct financial transactions on international capital markets without any legal restrictions. Thus, this liberalization had a differential impact across firms banking with domestic banks and those banking with foreign banks. This allows us to identify the impact of the positive financial shock on firms’ production decisions by comparing average changes in different real economic and financial outcomes across the two groups of firms5.

5This methodology is similar to the one proposed by Khwaja and Mian (2008) for identifying the impact of bank liquidity shocks on the health and loan supply of banks in Pakistan, and later adopted by Amiti and Weinstein (2011).
Thus, we use a difference-in-difference approach in order to quantify the impact of financial account liberalization on Hungarian firms’ real and financial outcomes. This provides the empirical test of the theoretical predictions.

The results provide support for the theory. First, they indicate that Hungarian manufacturing firms banking only with domestic banks in 2001 registered an increase in the material-cost-to-sales ratio by 3 percentage points relative to the control firms; also their short-term-loan-to-sales and short-term-loan-to-materials ratios increased by 4 and 8 percentage points, respectively, relative to firms banking with foreign banks. This provides empirical evidence of the theoretical prediction that as a response to positive liquidity shocks, firms buy more inputs and, thus, become vertically more specialized. Second, the estimation results suggest that the increase in the material-cost-to-sales ratio is almost exclusively generated by the 2 percentage points increase in imports, which can be attributed to the increase in intermediate input imports. This result provides empirical support for the theoretical prediction that financial liberalization has a particularly important impact on the intensive margin of imports: financial liberalization reduces the relative cost of importing intermediates as firms become less liquidity constrained and, consequently, substitute imported intermediates for domestic intermediates. Moreover, we find that the probability of becoming an intermediate input importer increased more in the case of firms banking with domestic banks relative to the control group. This evidence supports the theoretical prediction that the positive liquidity shock, resulted from financial liberalization, generates import market entry.

Finally, we quantify the point estimates by using a simple gravity equation with the elasticity of substitution equal to three and find that, as a consequence of financial liberalization: (1) imported intermediate inputs increased by 9.66 percentage points, (2) the increase in intermediate input imports is equivalent to a 22 percent tariff cut in the case of firms banking with domestic banks, and a 3.5 percent tariff reduction in the case of the whole sample, (3) the predicted probability of becoming an intermediate input importer increased by 6.6
percentage points, while the number of firms importing intermediates increased by 5 percent.

This paper is related to three strands of recent literature. First, it relates to the growing literature on the interaction between finance and export decisions of firms, which shows that exporters are more exposed to financial shocks. Amiti and Weinstein (2011) and Paravasini et al. (2012) provide the first micro level empirical evidence on the impact of credit supply shocks on firms’ export performance by using linked bank-firm datasets. This paper focuses on the import side instead. However, it uses the methodology proposed in Amiti and Weinstein (2011) in order to quantify the impact of credit supply shocks on firms’ import decisions by using a bank-firm-customs dataset.

Moreover, several theory papers, such as Chaney (2013), Feenstra et al. (2011) or Manova (2013), attempt to formalize the idea that exporters need more financing and model exporters’ financing needs by introducing liquidity constraints in heterogeneous firm models. These models differ in their assumptions about the competition in the banking sector. For example, Feenstra et al. (2011) assumes monopoly in the banking sector, while Manova (2013) or Chaney (2013) work with a perfectly competitive banking sector. Following this literature we also use a perfectly competitive banking sector, but we assume that firms are liquidity constrained when they are importing the intermediate input. Thus, this paper is the first one which considers the impact of credit supply shocks on import decisions both theoretically and empirically.

Second, our paper contributes to the structural empirical work on the relationship between firm import intensity and firm productivity. We closely follow the structural work of Halpern et al. (2011) - who estimate the impact of imports on Hungarian firms’ total factor productivity, and Amiti et al. (2013) - who study the interaction between import intensity and markup variability, as well as the productivity effect of imported intermediate inputs. Similarly to these papers, we assume that firms face a trade-off when choosing the type of intermediate inputs: imported intermediate inputs are more costly as firms have to pay a fixed cost of entering import markets, but the imported intermediate has higher productiv-
ity than domestic intermediates. However, for the first time in this literature, we go a step further and analyze how this trade-off is driven by financial shocks.

Finally, this paper is related to the literature which attempts to explain the rapid growth of trade in intermediate goods and offshoring. Most of this literature focuses on technological and informational determinants of firms’ offshoring and vertical specialization decisions such as specialization between routines (Grossman and Rossi-Hansberg, 2006, 2008), complementarity of production processes (Baldwin and Venables, 2010) or the time dimension of offshoring (Hummels and Schaur, 2013; Kim and Shin, 2013). However, to our knowledge, the only paper that considers finance as a determinant of firms’ offshoring decision is Kim and Shin (2013). By using a representative agent general equilibrium model, they show that a firm’s production process gets longer with offshoring, due to the time taken for transport of the intermediate good. Consequently, firms’ inventory holdings expand since they hold inventory for each part of the production chain plus the inventories in transit. They show that, if firms’ inventories are financed by bank loans, tighter credit conditions cause firms to shorten their supply chains and restrict their offshoring activity, which results in a lower aggregate trade volume. Our paper is complementary in that we generalize a similar idea in a heterogeneous firm general equilibrium model, and by using micro data, provide direct empirical estimates of the impact of credit supply shocks on firms’ vertical specialization decisions.

The rest of the chapter is organized as follows. Section 2.2 presents the theory. Section 2.3 presents the data and the experiment we use to empirically test the theoretical predictions. Section 2.4 concludes.
2.2 Model

2.2.1 Basic Setup

This section presents the theoretical framework which is used to assess the impact of financial liberalization on firms’ production decisions. We assume that the world consists of a large number of symmetric countries and an international capital market. Each country has three sectors: an intermediate input sector, a final good sector, and a financial intermediary sector. The final good sector is characterized by monopolistic competition and increasing returns to scale. The intermediate input sector is characterized by perfect competition and constant returns to scale. Finally, banks in the perfectly competitive financial intermediary sector decide whether to lend the money they raise from the international capital market to the firms, or to invest it in an outside option. The return on the outside option is normalized to the international interest rate, which is exogenous to each country. The international financial market is populated by investors endowed with liquidity which they pull together and lend it to the banks in each country at the international interest rate.

2.2.2 Consumers

In each country, consumers derive utility from the consumption of differentiated goods, \( \omega \in \Omega \). Their utility function takes the standard CES form:

\[
U = \left( \int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}
\]

(1)

where \( q(\omega) \) denotes the quantity of differentiated variety \( \omega \), and the elasticity of substitution between varieties is assumed to be \( \sigma > 1 \).

Maximizing (1) subject to the standard budget constraint yields consumers’ demand
\( q(\omega) \) for variety \( \omega \in \Omega \), and the aggregate price index of differentiated goods \((P)\):

\[
q(\omega) = \frac{Y}{P} \left( \frac{p(\omega)}{P} \right)^{-\sigma} 
\]

\[
P = \left( \int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}
\]

where \( Y \) is total income. We also assume that labor supply is perfectly inelastic, and the hourly wage is normalized to 1 in all countries.

### 2.2.3 Production

#### 2.2.3.1 Intermediate inputs

Intermediate input producers in each country are characterized by a constant returns to scale technology and use only labor as input. That is, their technology is linear: \( X^i = L^i \), where \( i = D \) denotes the input produced domestically and \( i = F \) denotes the input produced in foreign countries. \( L^i \) is the labor used for the production of the intermediate inputs in country \( i \) and \( X^i \) is the amount of intermediate inputs produced in country \( i \). By perfect competition, symmetry across countries and the fact that wages are normalized to 1, the equilibrium price of intermediate inputs in each country is equal to the marginal cost of producing one additional unit of input, i.e. \( p^D = p^F = 1 \).

We assume that domestic final good producers have to pay the fixed cost \( f_M \) in order to import the input produced in foreign countries. But we also assume that this imported foreign input has a larger productivity, \( a > 1 \), than the input produced and purchased from the domestic market. These are standard assumptions in the literature\(^6\) and generate a trade-off that final good producers face while making their input sourcing decision.

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\(^6\)See Amiti et al. (2014), Koren et al. (2011).
2.2.3.2 Final goods

Each variety in each country is produced by a single, specialized final good producer firm which takes intermediate input prices and wages as given. These firms have to pay a sunk cost of entry, $f_e$, in order to learn their productivity, $\varphi$, that is distributed Pareto with cumulative distribution function $G(\varphi) = 1 - \frac{\varphi^k}{\varphi^m}$. This assumption induces heterogeneity across final good producers. Firms exit at an exogenous rate $\delta$ in each period.

Firm $\varphi$ uses labor, $L(\varphi)$, intermediate inputs, $X(\varphi)$ and a Cobb-Douglas (C-D, hereafter) production technology with intermediate input share $\phi \in (0, 1)$ to produce quantity $y(\varphi)$ of the final good:

$$y(\varphi) = \varphi X(\varphi)^\phi L(\varphi)^{1-\phi}$$

We assume that $X(\varphi)$ is a combination of domestic intermediate inputs, $X^D(\varphi)$, and foreign imported intermediate inputs, $X^F(\varphi)$, aggregated by a constant elasticity of substitution (CES, hereafter) function:

$$X(\varphi) = \left[ X^D(\varphi)^{\frac{\xi}{1+\xi}} + a^{\frac{\xi}{1+\xi}} X^F(\varphi)^{\frac{1+\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}}$$

where $a > 1$ measures the productivity advantage of the imported intermediate input. We assume that the elasticity of substitution $1 + \xi > 1$, which implies that the two types of intermediate inputs are imperfect substitutes.

Domestic production entails a fixed cost $f$, while exporting entails a fixed cost $f_x$. Exporters incur iceberg trade costs such that $\tau$ units of the final good are needed to be shipped to ensure that one unit arrives at the destination.

To generate the link between finance and imports in the model, we assume that final good producers that import intermediate inputs are liquidity constrained. Thus, these firms can

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7This set of assumptions is consistent with Melitz (2003).
8This distinction between the types of inputs rationalizes the idea that imported inputs are useful both for their productivity advantages and for love of variety reasons.
9This assumption ensures that the production is possible without the use of imported inputs, and is consistent with Amiti et al. (2014).
only finance a fraction $\rho \in [0, 1)$ of the total cost of their imported intermediates, while the rest is borrowed from the banks in the financial intermediation sector at interest rate $r(\varphi)$. This set of assumptions generates the demand for bank loans in the model. The assumption that firms need external financing in the form of bank loans to cover the $1-\rho$ fraction of the import market entry fixed cost, $f_M$, and the value of foreign input purchases, implies the link between finance and firms’ import market entry decision (extensive margin of import hereafter), and finance and firms’ foreign input demand decision (intensive margin of import hereafter).

We assume that firms may choose to refuse the re-payment of their bank loans in order to avoid interest payment with probability $1-\eta$. This assumption rationalizes the idea that borrowing is costly, since there is a risk of default characterized by probability $\eta$. In addition, we assume that banks hedge themselves against this risk by threatening the firms that, in case of the refusal of the payment, the bank takes away the firms’ sales revenue. These probabilities, as well as the firm’s productivity $\varphi$, are known by the bank. This is the simplest way to rationalize the idea of collateral in a heterogeneous firms model and get analytically tractable comparative statics results. Another way would be to assume that the bank requires the firm to collateralize some fixed assets, which are transferred back to the firm after the repayment of the loan. Following Manova (2013), this latter idea can be theoretically rationalized by assuming that the bank takes away a constant fraction of the firm’s fixed costs as collateral. However, these assumptions would imply an interest rate that is a non-linear function of productivity. Thus, derivatives in the comparative statics analysis could not be analytically signed when changes in financial parameters are considered.

As a result of the previously outlined cost structure, there can be four types of firms in this economy: (i) firms using the domestic intermediate input only, and selling on the domestic market, (ii) firms using both domestic and imported intermediate inputs, and selling on the domestic market, (iii) firms using the domestic intermediate input, and selling on both the domestic and foreign markets, (iv) firms using both domestic and imported intermediate
inputs, and selling both on the domestic and foreign markets.

Based on these assumptions, the total cost $TC^1(\varphi)$ of the domestic producer using the domestic intermediate input only is:

$$TC^1(\varphi) = wL(\varphi) + p^DX^D(\varphi) + f$$

where $wL(\varphi)$ is the total cost of labor, $L(\varphi)$ is the number of workers employed, and $p^DX^D(\varphi)$ is the total cost of domestic intermediate inputs, where $p^D$ and $X^D(\varphi)$ are the unit price and the quantity of the domestic input.

Similarly, the total cost, $TC^2(\varphi)$, faced by the domestic producer using both domestic and imported intermediate inputs is:

$$TC^2(\varphi) = wL(\varphi) + p^DX^D(\varphi) + \rho(p^FX^F(\varphi) + f_M) + f + \eta(1 + r(\varphi))C(\varphi)$$

where $C(\varphi)$ is the bank loan demanded by the firm and paid back to the bank with probability $\eta$, while the corresponding interest is $r(\varphi)C(\varphi)$. $p^FX^F(\varphi)$ is the total cost of intermediate inputs imported by the firm, while $p^F$ and $X^F(\varphi)$ are the price and the quantity of imported intermediate inputs.

By assumption, the total loan demanded by the firm must cover the fraction of the total imported intermediate input cost which the firm cannot finance from its own resources. This constraint generates the demand for credit in the model and captures the key idea that capital market liberalization has a particularly big impact on firms’ import decisions both on the extensive margin - as bank loans are required to cover some fixed cost of imports, $(1 - \rho)f_M$, and on the intensive margin - as the firm needs bank loans to cover some part of the total imported inputs cost, $(1 - \rho)p^FX^F(\varphi)$:

$$C(\varphi) \geq (1 - \rho)(p^FX^F(\varphi) + f_M)$$
The total cost of exporting, $TC_x^1(\varphi)$, for a firm which enters the export market and uses only the domestic intermediate inputs is:

$$TC_x^1(\varphi) = \tau(wL_x(\varphi) + p^D X_x^D(\varphi)) + f_x$$

(8)

where $\tau(wL_x(\varphi) + p^D X_x^D(\varphi))$ is the total cost of labor and domestic intermediate inputs used by the exporter augmented by the iceberg trade cost, and the index $x$ denotes the exporter firm.

Finally, the total cost of exporting, $TC_x^2(\varphi)$, for a firm which enters the export market and uses both intermediate inputs is:

$$TC_x^2(\varphi) = \tau(wL_x(\varphi) + p^D X_x^D(\varphi)) + \rho(\tau p^F X_x^F(\varphi) + f_M) + \eta (1 + r(\varphi)) C(\varphi) + f_x$$

(9)

where $\tau p^F X_x^F(\varphi)$ is the total cost of the imported intermediate inputs, and $\rho(\tau p^F X_x^F(\varphi) + f_M)$ is the value of the imported intermediate inputs and importing fixed cost financed from the firm’s own resources. $C(\varphi)$ is the bank loan contracted by the exporter and paid back to the bank with probability $\eta$, while the corresponding interest is $r(\varphi)C(\varphi)$. The total loan demanded by the exporter must cover the fraction of the imported input costs which the firm cannot finance from its own resources. Thus, the bank loan demanded by the exporter must satisfy the following inequality:

$$C(\varphi) \geq (1 - \rho)(\tau p^F X_x^F(\varphi) + f_M)$$

(10)

2.2.4 Financial Intermediation Sector

Banks in the financial intermediation sector are profit maximizing agents. They raise liquidity from the international capital market at the exogenously given interest rate $r^*$ which we
do not model here for simplicity\textsuperscript{10}. Banks can choose between two investment opportunities: provide loans to firms in the final good sector and earn interest $r(\varphi)$, or invest their liquidity in the outside option that has return normalized to $r^*$. Banks set their loan supply by taking into account that firms can refuse payment with probability $1-\eta$. As we assume that banks operate in a market characterized by perfect competition, the representative bank’s profit from the loan provided to the firm with productivity $\varphi$ is given by:

$$\pi^B(\varphi) = \eta (1 + r(\varphi)) C^S(\varphi) - C^S(\varphi)(1 + r^*) \quad (11)$$

where $C^S(\varphi)$ is the amount of loans supplied by the bank to the firm at interest $r(\varphi)$.

By the perfect competition assumption in the banking sector, free entry drives the banks’ profit to zero and the equilibrium interest rate is given by:

$$\eta (1 + r(\varphi)) C^S(\varphi) = C^S(\varphi)(1 + r^*) \quad (12)$$

Thus, the interest rate at which banks finance the firms’ domestic and export production activity is always above the rate at which they borrow from the international financial market\textsuperscript{11}, $r^*$:

$$1 + r(\varphi) = \frac{1 + r^*}{\eta} \quad (13)$$

As $\eta \to 1$, $r(\varphi)$ approach $r^*$, and the risk premium applied by the bank shrinks to zero.

\textbf{2.2.5 Firms’ Optimization Problem}

We solve for final good producer firms’ input demand and output price in two steps. First, we determine how much labor, intermediate inputs and bank loans each firm demands conditional on its output $y(\varphi)$, and what is the cost minimizing composition of intermediate

\textsuperscript{10}Since we assume that the world consists of a large number of symmetric countries, none of the countries can individually alter the equilibrium interest rate on the international financial market. Thus, the exogenous world interest rate assumption is meaningful in this setup.

\textsuperscript{11}This follows from the fact that the probability with which firms commit to repay their loans is $\eta \in (0, 1)$.
inputs. Second, we solve for the price of the final good by maximizing profits subject to the quantity demanded by the consumer and the total cost derived from the first step\(^{12}\).

### 2.2.5.1 Cost minimization

Domestic producers minimize total cost (14) subject to their production technology (15), the intermediate inputs demanded (16) and the external financing constraint (17), by taking wages (\(w\)), intermediate input prices (\(p^D, p^F\)) and the interest rate, \(r(\varphi)\), as given:

$$
\begin{align*}
\min_{\{L(\varphi), X(\varphi), X^D(\varphi), X^F(\varphi), C(\varphi)\}} & \quad TC(\varphi, y(\varphi)) = wL(\varphi) + p^D X^D(\varphi) + \rho(p^F X^F(\varphi) + f_M) + \\
& \quad + \eta (1 + r(\varphi)) C(\varphi) + f \\
\text{s.t.} & \quad y(\varphi) = \varphi X(\varphi)^{\phi} L(\varphi)^{1-\phi} \\
& \quad X(\varphi) = \left[ X^D(\varphi)^{\frac{\xi}{1 + \xi}} + a^{\frac{1}{1 + \xi}} X^F(\varphi)^{\frac{\xi}{1 + \xi}} \right]^{\frac{1 + \xi}{\xi}} \\
& \quad C(\varphi) \geq (1 - \rho)(p^F X^F(\varphi) + f_M)
\end{align*}
$$

Exporters choose their input demand similarly to domestic producers: they minimize total cost (18) subject to the production technology (19), demand for intermediate inputs (20) and the external financing constraint (21), by taking wages (\(w\)), intermediate input prices (\(p^D, p^F\)) and the interest rate, \(r(\varphi)\), as given:

$$
\begin{align*}
\min_{\{L_x(\varphi), X_x(\varphi), X^D_x(\varphi), X^F_x(\varphi), C_x(\varphi)\}} & \quad TC_x(\varphi, y_x(\varphi)) = \tau(wL_x(\varphi) + p^D X^d_x(\varphi)) + \rho \left( \tau p^F X^F_x(\varphi) + f_M \right) + \\
& \quad + \eta (1 + r(\varphi)) C(\varphi) + f_x
\end{align*}
$$

\(^{12}\)Appendix A.1 contains the detailed derivation of the solution to the cost minimization and profit maximization problems.
\[ s.t. \]
\[ y_x(\varphi) = \varphi X_x(\varphi)^\phi L_x(\varphi)^{1-\phi} \]
\[ X_x(\varphi) = \left[ X_D^x(\varphi)^{\frac{\xi}{1+\xi}} + a^{\frac{\xi}{1+\xi}} X_F^x(\varphi)^{\frac{\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}} \]
\[ C(\varphi) \geq (1-\rho)(\tau p^F X_F^x(\varphi) + f_M) \]

Solutions to these cost minimization problems are presented in Appendix A.1, Section 1. Since using the imported intermediate input entails a fixed cost \( f_M \), there will be firms which find it optimal to use the domestic intermediate input only. In the case of these firms \( X_F^x(\varphi) = 0 \) and \( C(\varphi) = 0 \). Therefore, there can be four types of firms with the following total cost functions conditional on output:

1. firms using the domestic intermediate input and selling their product on the domestic market have total cost \( TC_1^1(y(\varphi)) \) with marginal cost of production \( \frac{1}{\varphi \Psi} \):

\[ TC_1^1(y(\varphi)) = \frac{1}{\varphi \Psi} y(\varphi) + f \]

where \( \Psi \equiv \phi^\phi (1-\phi)^{1-\phi} \in (0,1) \), since \( \phi \in (0,1) \) by assumption.

2. firms using imported and domestic intermediate inputs, and selling their product on the domestic market have total cost \( TC_2^2(y(\varphi)) \) with marginal cost of production \( \frac{1}{\varphi \Psi b^\phi} \):

\[ TC_2^2(y(\varphi)) = \frac{1}{\varphi \Psi b^\phi} y(\varphi) + ((1 + r^*) (1 - \rho) + \rho) f_M + f \]

where \( b \equiv \left[ 1 + \frac{a}{(1+r^*)(1-\rho)+\rho} \right]^\frac{1}{\xi} \). The marginal cost of a firm using the imported intermediate is lower than the marginal cost of a firm using the domestic intermediate only, i.e. \( \frac{1}{\varphi \Psi} > \frac{1}{\varphi \Psi b^\phi} \)\(^{13}\). This follows from the fact that \( b^\phi > 1 \)\(^{14}\) due to the productivity advantage provided by the imported intermediate (\( a > 1 \)) and the firms' love of variety implied by the CES intermediate input aggregator. Intuitively, this means that using the imported intermediate

\(^{13}\)This result is consistent with Amiti and Davis (2011).

\(^{14}\)Appendix A.1, Section 1 shows that this inequality holds.
enhances the overall efficiency of production.

(3) exporter firms using the domestic intermediate input only have the following total cost of exporting:

\[ TC^1_x(y_x(\varphi)) = \frac{\tau}{\varphi \Psi} y_x(\varphi) + f_x \]  

(24)

where the marginal cost of production \( \frac{\tau}{\varphi \Psi} \) is always greater than the marginal cost of producing for the domestic market by using the domestic input only, \( \frac{1}{\varphi \Psi} \). This results from the fact that \( \tau > 1 \) by assumption\(^{15}\). Moreover, this marginal cost is always greater than the marginal cost of domestic producers that use both inputs, i.e. \( \frac{\tau}{\varphi \Psi} > \frac{1}{\varphi \Psi b \phi} \). This follows from the fact that \( b \phi \tau > 1 \) since \( \tau > 1 \) and \( b \phi > 1 \).

(4) firms using both imported and domestic inputs, and exporting their product, have the following total cost of exporting:

\[ TC^2_x(y_x(\varphi)) = \frac{\tau}{\varphi \Psi b \phi} y_x(\varphi) + ((1 + r^*) (1 - \rho) + \rho) f_M + f_x \]  

(25)

where the marginal cost of producing an additional unit of the final good for export is lower than the one in the case of exporters using the domestic input only: \( \frac{\tau}{\varphi \Psi b \phi} < \frac{\tau}{\varphi \Psi} \), since \( b \phi > 1 \).

2.2.5.2 Price setting

Domestic producers set their prices by maximizing their profits subject to the quantity demanded and the cost minimizing choice of inputs:

\[
\text{max}_{\{p^1(\varphi), y^1(\varphi)\}} \left\{ y^1(\varphi)p^1(\varphi) - TC^1(y(\varphi)) \right\} \quad \text{s.t.} \quad y^1(\varphi) = \frac{Y}{P} \left( \frac{p^1(\varphi)}{P} \right)^{-\sigma} 
\]  

(26.1)

\[
\text{max}_{\{p^2(\varphi), y^2(\varphi)\}} \left\{ \eta y^2(\varphi)p^2(\varphi) - TC^2(y(\varphi)) \right\} \quad \text{s.t.} \quad y^2(\varphi) = \frac{Y}{P} \left( \frac{p^2(\varphi)}{P} \right)^{-\sigma} 
\]  

(26.2)

where (26.1) describes the optimization problem of firms using the domestic intermediate input only, and (26.2) describes the optimization problem of firms using both the imported

\(^{15}\)This result is consistent with any monopolistic competition model with labor as the only factor of production.
and the domestic intermediate input. $TC^i(\cdot)$ is the minimum cost of production conditional on output, as described in (22) and (23).

Similarly, exporters set their export prices by maximizing profits from export sales conditional on export demand:

$$\max \{ p_1^1(\varphi)y_1^1(\varphi) - TC_x^1(\varphi) \} \quad \text{s.t.} \quad y_1^1(\varphi) = \frac{Y_x}{P_x} \left( \frac{p_x^1(\varphi)}{P_x} \right)^{-\sigma} \quad (27.1)$$

$$\max \{ \eta p_2^1(\varphi)y_2^1(\varphi) - TC_x^2(\varphi) \} \quad \text{s.t.} \quad y_2^1(\varphi) = \frac{Y_x}{P_x} \left( \frac{p_x^2(\varphi)}{P_x} \right)^{-\sigma} \quad (27.2)$$

By the monopolistic competition assumption, final good producers are small relative to the size of the economy. Thus they take aggregate prices ($P$) and income ($Y$) as given, and charge a constant markup over the marginal cost such that the price of varieties sold on the domestic market by a firm that uses only the domestic input $p_1^1(\varphi)$, and the price charged by a firm that uses both the domestic and the imported intermediate inputs $p_2^1(\varphi)$ are\textsuperscript{16}:

$$p_1^1(\varphi) = \frac{\sigma}{\sigma - 1} \frac{1}{\varphi \Psi}$$

$$p_2^1(\varphi) = \frac{\sigma}{\sigma - 1} \frac{1}{\varphi \Psi b^\phi} \quad (28.1)$$

The heterogeneity in the productivity of imported intermediates relative to domestic intermediates ($a > 1$) and the presence of imperfect financial contracting, $\eta \in (0, 1)$, lead to heterogeneity in the marginal cost at which firms using the imported intermediate produce a given variety relative to firms using the domestic intermediate only. This generates a relative price differential across the two groups of firms equal to $1/\eta b^\phi$. Thus, importers set a lower price for their product if $\eta b^\phi > 1$. This happens if the probability of repaying the loan ($\eta$) is large and the efficiency gain from using the imported intermediate input ($a$) is large relative to the cost of the bank loan\textsuperscript{17}.

Similarly, exporters price their products by setting a constant markup over the marginal cost. Hence, exporters using the domestic intermediate input only charge price $p_x^1(\varphi)$, while

---

\textsuperscript{16}The optimal quantities supplied by domestic firms and exporters, and the corresponding revenues are presented in Appendix A.1, Section 2.

\textsuperscript{17}In this case, both $\eta$ and $b^\phi$ is large such that $\eta b^\phi > 1$. 
exporters using both types of inputs charge $p^2_x(\varphi)$:

$$p^1_x(\varphi) = \frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi \Psi}$$  \hspace{1cm} $$p^2_x(\varphi) = \frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi \Psi \eta b^\phi}$$  \hspace{1cm} (28.2)

where $p^1_x(\varphi) > p^2_x(\varphi)$ if $\eta b^\phi > 1$.

The assumptions that countries are identical and trade costs are symmetric imply that the price index $(P, P_x)$ and the expenditure level $(Y, Y_x)$ are the same in all countries. Thus, the profits of firms from domestic sales depending on whether they use only the domestic intermediate input, $\pi^1(\varphi)$, or both inputs, $\pi^2(\varphi)$, are:

$$\pi^1(\varphi) = \frac{Y}{\sigma P^{1-\sigma}} \left( \frac{1}{\sigma - 1} \varphi \Psi \right)^{1-\sigma} - f$$  \hspace{1cm} (29.1)

$$\pi^2(\varphi) = \frac{\eta Y}{\sigma P^{1-\sigma}} \left( \frac{1}{\sigma - 1} \varphi \Psi \eta b^\phi \right)^{1-\sigma} - ((1 + r^*) (1 - \rho) + \rho) f_M - f$$  \hspace{1cm} (29.2)

Firms’ profits from exporting depending on whether they use the domestic intermediate input only, $\pi^1_x(\varphi)$, or both inputs, $\pi^2_x(\varphi)$, are equal to:

$$\pi^1_x(\varphi) = \frac{(N - 1) Y}{\sigma P^{1-\sigma}} \left( \frac{1}{\sigma - 1} \varphi \Psi \right)^{1-\sigma} - f_x$$  \hspace{1cm} (30.1)

$$\pi^2_x(\varphi) = \frac{\eta (N - 1) Y}{\sigma P^{1-\sigma}} \left( \frac{1}{\sigma - 1} \varphi \Psi \eta b^\phi \right)^{1-\sigma} - ((1 + r^*) (1 - \rho) + \rho) f_M - f_x$$  \hspace{1cm} (30.2)

2.2.5.3 Productivity cutoffs.

The firm’s exporting and importing decisions depend on its productivity draw. We define cutoff productivities $\varphi^1, \varphi^2, \varphi^3, \varphi^1_x, \varphi^2_x, \varphi^3_x$ and focus on two potential equilibrium sorting patterns that are consistent with the data. In case (i), firms with productivity draw $\varphi < \varphi^1$ decide to exit the market. Firms with $\varphi \in (\varphi^1, \varphi^1_x)$ stay in the market, produce and sell on
the domestic market by using the domestic intermediate input only. Firms with \( \varphi \in (\overline{\varphi}_x, \overline{\varphi}_x^1) \) export by using the domestic intermediate input only, and firms with \( \varphi > \overline{\varphi}_x^2 \) sell on the domestic market and export by using both domestic and imported intermediate inputs. The three cutoff productivities \( \{\overline{\varphi}_x^1, \overline{\varphi}_x^1, \overline{\varphi}_x^2\} \) are pinned down by the following system of equations\(^{18}\):

\[
\begin{align*}
\pi^1(\overline{\varphi}_x^1) &= 0 \quad \text{(31.1)} \\
\pi^1(\overline{\varphi}_x^1) &= \pi^1(\overline{\varphi}_x^1) + \pi^1_x(\overline{\varphi}_x^1) \quad \text{(31.2)} \\
\pi^1(\overline{\varphi}_x^2) + \pi^1_x(\overline{\varphi}_x^2) &= \pi^2(\overline{\varphi}_x^2) + \pi^2_x(\overline{\varphi}_x^2) \quad \text{(31.3)} \\
fe &= [G(\overline{\varphi}_x^2) - G(\overline{\varphi}_x^1)]\sum_{t=0}^{\infty}(1 - \delta)^t \left\{ \frac{1}{\sigma}E[q^1(\varphi)] - f \right\} + \\
&\quad + [G(\overline{\varphi}_x^2) - G(\overline{\varphi}_x^1)]\sum_{t=0}^{\infty}(1 - \delta)^t \left\{ \frac{N-1}{\sigma}E[q_x^1(\varphi)] - f_x \right\} + \\
&\quad + [1 - G(\overline{\varphi}_x^2)]\sum_{t=0}^{\infty}(1 - \delta)^t \left\{ \frac{1}{\sigma}E[q^2(\varphi)] - f - ((1 + r^*) (1 - \rho) + \rho)f_M \right\} \\
&\quad + [1 - G(\overline{\varphi}_x^2)]\sum_{t=0}^{\infty}(1 - \delta)^t \left\{ \frac{N-1}{\sigma}E[q_x^2(\varphi)] - f_x \right\} \quad \text{(31.4)}
\end{align*}
\]

where equation (31.1) is the zero profit condition for producing for the domestic market such that firms with productivity draw \( \overline{\varphi}_x^1 \) are indifferent between selling on the domestic market and exiting. Equation (31.2) states that firms with productivity draw \( \overline{\varphi}_x^1 \) are indifferent between producing by using only domestic intermediates, and selling on the domestic market, and producing by using only domestic intermediates, and selling on both domestic and export markets. Equation (31.3) states that firms with \( \overline{\varphi}_x^2 \) are indifferent between producing for both the domestic and export markets by using the domestic intermediate input only, and producing for both markets by using both types of inputs. Equation (31.4) is the free entry condition which guarantees that entering firms make an expected profit that covers the sunk cost of entry, \( f_e \).

\(^{18}\)Appendix A.1, Section 3 outlines the detailed algebra for deriving these cutoffs and the parameter restrictions under which this sorting occurs.
The solution to the system of equations (31.1) - (31.4) takes the form:

\[
(\varphi^1)^k = \Delta_1 + \Delta_2 \left( \frac{\eta^\sigma b^{\phi(\sigma-1)} - 1}{((1 + r^*) (1 - \rho) + \rho) f_M} \right)^\frac{k-(\sigma-1)}{\sigma-1} \{ \Delta_3 \eta^\sigma b^{\phi(\sigma-1)} + \Delta_4 \} \tag{32}
\]

where

\[
\Delta_1 = \frac{\varphi_{m}^h}{\delta f_{e}} (N-1) \left( (1 + (N-1) f_{x}) \frac{\eta}{(N-1) f_{x}} \right)^\frac{k-(\sigma-1)}{\sigma-1} \Delta_3 \eta^\sigma b^{\phi(\sigma-1)} + \Delta_4 \tag{33}
\]

\[
\Delta_2 = \frac{\varphi_{m}^h}{\delta f_{e}} \left( \frac{k-(\sigma-1)}{\eta(N-1)(k-(\sigma-1))} \right), \quad \Delta_4 = \frac{\varphi_{m}^h}{\delta f_{e}} \left( \frac{N-1(k-(\sigma-1))-k}{(N-1)(k-(\sigma-1))} \right) \tag{34}
\]

Equation (33) shows that the larger the fixed cost of entering the export market, \( f_{x} \) or the larger the iceberg trade cost \( \tau \) is, the higher the export cutoff is. Thus, fewer firms enter export markets. This result is in line with Melitz (2003). In addition, this model has predictions about the extensive margin of importing. Equation (35) shows that the larger the gross fixed cost of entering the import market, \((1 + r^*) (1 - \rho) + \rho) f_M\), relative to the fixed cost of exporting, \( f_{x} \), the larger the export-import cutoff, \( \varphi_{x}^3 \), is. Thus, the share of firms that use the imported intermediate and export their product is lower. Moreover, (33)-(35) indicate that the case (i) productivity cutoff ranking, \( \varphi_{x}^1 < \varphi_{x}^2 < \varphi_{x}^3 \), occurs in equilibrium when the fixed cost of entering import markets is large relative to the fixed cost of entering export markets, and also the fixed cost of entering export markets is large relative to the fixed cost of entering the domestic market.

In the case (ii) productivity ranking, \( \varphi_{x}^2 < \varphi_{x}^3 \), firms with productivity draw \( \varphi < \varphi_{x}^2 \) decide to exit the market. Firms with \( \varphi \in [\varphi_{x}^2, \varphi_{x}^3] \) stay in the market, produce and sell on the domestic market by using the domestic intermediate input only. Firms with \( \varphi \in [\varphi_{x}^3, \varphi_{x}^3] \)
stay in the market, produce and sell on the domestic market only by using both domestic and imported intermediate inputs. Firms with $\varphi > \overline{\varphi}^3$ sell on both the domestic and export markets, and use both types of inputs. The three cutoff productivities $\{\overline{\varphi}^2, \overline{\varphi}^3, \overline{\varphi}_x^3\}$ are pinned down by the following system of equations:

\[
\begin{align*}
\pi^1(\varphi^2) &= 0 \quad (36.1) \\
\pi^1(\varphi^3) &= \pi^2(\varphi^3) \quad (36.2) \\
\pi^2(\varphi^3) &= \pi^2(\varphi^3_x) + \pi^2_x(\varphi^3_x) \quad (36.3) \\
\end{align*}
\]

\[
f_e = [G(\varphi^3) - G(\varphi^2)]\sum_{t=0}^{\infty}(1 - \delta)^t \left\{ E \left[ \frac{1}{\sigma} q^1(\varphi) - f \right] \right\} + \\
+ [1 - G(\varphi^3)]\sum_{t=0}^{\infty}(1 - \delta)^t \left\{ E \left[ \frac{1}{\sigma} q^2(\varphi) - f - ((1 + r^*)(1 - \rho) + \rho) f_M \right] \right\} + \\
+ [1 - G(\varphi^3_x)]\sum_{t=0}^{\infty}(1 - \delta)^t \left\{ E \left[ \frac{N - 1}{\sigma} q^2_x(\varphi) - f_x \right] \right\} 
\]

where equation (36.1) is the zero profit condition for entering the domestic market such that firms with productivity draw $\varphi^2$ are indifferent between selling on the domestic market and exiting. Equation (36.2) states that firms with productivity draw $\varphi^3$ are indifferent between using only domestic intermediate inputs and selling on the domestic market, and using both inputs and selling on the domestic market. Equation (36.3) states that firms with productivity $\varphi^3_x$ are indifferent between producing for the domestic market by using both intermediate inputs, and producing for both markets by using both types of inputs. Equation (36.4) is the free entry condition.

The solution to the system of equations (36.1) - (36.4) is given by:

\[
(\varphi^2)^k = \Delta_5 + \Delta_6 \frac{\eta^\sigma b^\delta(\sigma - 1) - 1}{[(1 + r^*)(1 - \rho) + \rho) f_M]^{\kappa - (\sigma - 1)}} \frac{\kappa}{\sigma - 1} \\
+ \Delta_7 \frac{b^\delta k}{[(1 + r^*)(1 - \rho) + \rho) f_M + f_x]^{\kappa - (\sigma - 1)}} \left\{ \frac{k(1 + r^*) (1 - \rho) + \rho) f_M + f_x}{f_x \eta (k - (\sigma - 1))} - 1 \right\} 
\]

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where \( \Delta_5 = \frac{\varphi_k}{\delta f_e} f^k \frac{1}{k-1}, \Delta_6 = \frac{\varphi_k}{\delta f_e} f^k \frac{1}{k-2}, \Delta_7 = f (N-1) \frac{\varphi_k}{\delta f_e} \frac{1}{k-1} \).

\[
\frac{\varphi_3}{\varphi_2} = \left( \frac{(1+r^*) (1-\rho) + \rho}{f (\eta^\sigma b^\sigma (\sigma-1) - 1)} \right)^{\frac{1}{\sigma-1}} \tag{38}
\]

\[
\frac{\varphi_3}{\varphi_2} = \left( \frac{(1+r^*) (1-\rho) + \rho}{f (N-1) \eta^\sigma b^\sigma (\sigma-1)_{\sigma-1}} \right)^{\frac{1}{\sigma-1}} \tag{39}
\]

\[
\frac{\varphi_3}{\varphi_2} = \left( \frac{((1+r^*) (1-\rho) + \rho) f_M + f_x}{f (N-1) \eta^\sigma b^\sigma (\sigma-1)_{\sigma-1}} \right)^{\frac{1}{\sigma-1}} \tag{40}
\]

Equation (38) shows that the larger the fixed cost of entering the import market, \((1+r^*)(1-\rho) + \rho\), relative to the fixed cost of entering the domestic market, the higher the import cutoff. Thus, firms with productivity draw below \(\varphi_3\) enter the domestic market and use the domestic input only, while firms with productivity draw above \(\varphi_3\) enter the domestic market and use both types of inputs. Moreover, based on equation (40), if the gross fixed cost of entering the export market and using both types of inputs, \(((1+r^*)(1-\rho) + \rho) f_M + f_x\), is large relative to the gross fixed cost of entering the domestic market only and using both types of inputs, \(((1+r^*)(1-\rho) + \rho) f_M\), then only firms with large enough productivity draws (i.e. above \(\varphi_3\)) enter the export market. Thus, equations (37)-(40) indicate that the case (\(ii\)) productivity cutoff ranking \(\varphi_2 < \varphi_3 < \varphi_3\), occurs in equilibrium when the fixed cost of entering import markets is low relative to the fixed cost of entering both export and import markets.

### 2.2.6 Financial Liberalization

In this section we report a series of theoretical implications of financial liberalization for firms’ import decisions. Financial liberalization is equivalent to a decrease in the exogenously given interest rate at which banks in the financial intermediation sector borrow from international financial markets (i.e. \(r^*\) falls). As a consequence of financial liberalization, banks can raise liquidity at a lower cost. This implies that banks raise more liquidity at \(r^*\) from abroad as they have the incentive to lend it to the firms at an interest rate above \(r^*\). The liquidity
constrained firms will demand more bank loans and use this new source of liquidity to import more inputs from abroad as a lower cost of borrowing external funds relaxes their liquidity constraint. Thus, financial liberalization is similar to trade liberalization because it reduces the relative cost of imported intermediates. The total impact of financial liberalization considered in this section consists of adjustments on the intensive and extensive margins of production.

2.2.6.1 Financial liberalization and the intensive margin of imports

How does financial liberalization affect firms’ import decisions? We show that financial liberalization promotes imports as it provides firms better access to bank loans. Both the intensive and the extensive margins of imports contribute to the increase in trade.

First, we look at how an exogenous decrease in the international interest rate (i.e. lower \( r^* \)) impacts firms’ intermediate input purchases conditional on entry. As \( r^* \) decreases, banks in the domestic financial intermediary sector can raise liquidity from the international financial market at a lower cost, and, thus, the interest rate at which they lend money to domestic firms decreases. This relaxes final good producers’ liquidity constraints as they can borrow from the banks at a lower cost to finance their imported intermediate purchases. Thus, final good producers buy more imported intermediate inputs which generates an increase in the total material costs. Since final good producers are characterized by CD technology, for a given increase in the intermediate input purchases, firms demand more labor and their sales revenue increases. Value added, defined as the difference between total sales and total material costs, increases but less than sales revenues because the latter incorporates both the labor and the intermediate input costs. Thus, the material-costs-to-sales ratio increases and, consequently, the value-added-to-sales ratio decreases. The following proposition and corollary summarize this idea.

**Proposition 1** (Material-to-sales ratio) Given the assumptions \( \sigma > 1, \phi \in (0, 1), \rho \in (0, 1), \eta \in (0, 1), a > 1 \) and all else constant, the material-to-sales ratio \((MS)\) increases as
the cost of bank loans decreases, $\frac{dMS}{dr^*} < 0$.

**Proof:** See Appendix A.1, Section 6.

**Corollary 1** (*Value-added-to-sales ratio*) Given the assumptions $\sigma > 1$, $\phi \in (0, 1)$, $\rho \in (0, 1)$, $\eta \in (0, 1)$, $a > 1$ and all else constant, the value-added-to-sales ratio ($VAS$) decreases as the cost of bank loans decreases, $\frac{dVAS}{dr^*} > 0$.

**Proof:** See Appendix A.1, Section 6.

Intuitively, as a result of a positive credit supply shock, firms become vertically more specialized as they buy more intermediate inputs from abroad, so they expand their supply chains internationally. This is consistent with the findings in Kim and Shin (2013). In a representative agent general equilibrium model, they show that credit supply shocks increase firms’ incentive to conduct more offshoring activity. Thus, the supply chain that these firms belong to expands as a response to positive credit supply shocks.

The expansion in the supply chain is amplified by the higher efficiency of imported intermediate inputs in the firm’s production process. The intuition is as follows: as firms get access to more liquidity, they re-optimize, and given their CES technology of combining the two types of inputs, they reallocate resources to the more productive imported intermediate input. Consequently, the share of imported to domestic intermediate inputs increases not only because firms spend more on the imported intermediate inputs, but also because firms reduce the share of the domestic intermediate inputs\(^{19}\). Thus, firms importing the intermediate input experience an increase in their material-cost-to-sales and their sales-to-value-added ratios relative to firms using the domestic intermediate input only. Thus, there is also heterogeneity in the impact of financial liberalization across firms using the domestic input only and firms using both types of inputs. This result is summarized in Proposition 3.

**Proposition 2** (*Heterogeneity*) Given the assumptions $\sigma > 1$, $\phi \in (0, 1)$, $\rho \in (0, 1)$, $\eta \in (0, 1)$, $a > 1$ and all else constant, the material-cost-to-sales and the value-added-to-

\(^{19}\)In the firms’ optimization problem, this is captured by the imported to domestic intermediate input ratio $X^F(\varphi)/X^D(\varphi) = a/((1 + r^*)(1 - \rho) + \rho)^{1+\xi}$ (for more details see Appendix A.1, Section 1). One can easily notice that as $r^*$ decreases, $X^F(\varphi)/X^D(\varphi)$ increases and this increase is greater the larger $a$ is.
sales ratios of importers increase relative to the firms using the domestic intermediate input, as the cost of bank loans decreases, \[|\frac{dMS_2}{dr^*}| < |\frac{dMS_1}{dr^*}| \quad \text{and} \quad |\frac{dVAS_2}{dr^*}| < |\frac{dVAS_1}{dr^*}|.\]

**Proof:** See Appendix A.1, Section 6.

### 2.2.6.2 Financial liberalization and the extensive margin of imports

Second, we consider how an exogenous change in the international interest rate affects the extensive margin of firms’ production decisions. In particular, we show that as a result of an exogenous decline in the international interest rate, more firms enter the import market and buy the more productive imported intermediate input. The intuition is as follows. As \(r^*\) decreases, firms can borrow at a lower interest rate. Thus, firms with productivity slightly below the import cutoff face a lower cost of importing the more efficient foreign intermediate. These firms’ net profit, when using both imported and domestic intermediates, becomes larger than the net profit when using the domestic intermediate input only. Thus, they decide to start importing intermediate inputs and the share of importer firms increases both under case (i) and case (ii) productivity rankings. This result is summarized in Proposition 5.

**Proposition 3 (Productivity cut-offs)** Given the assumptions \(\sigma > 1, \phi \in (0, 1), \rho \in (0, 1), \eta \in (0, 1), a > 1\) and all else constant, the productivity cutoffs of importing decrease as the cost of bank loans decreases both under case (i) productivity ranking, \(\frac{d\psi_2}{dr^*} > 0\), and case (ii) productivity ranking, \(\frac{d\psi_3}{dr^*} > 0\) and \(\frac{d\psi_1}{dr^*} > 0\).

**Proof:** See Appendix A.1, Section 6.

Moreover, financial liberalization does not only affect firms’ import decisions, but it also drives firms’ domestic market entry. This latter effect goes through the aggregate price index. Since imported intermediate inputs are more productive in the final good producers’ production process than domestic intermediates, new entrant importer firms’ marginal cost goes down as the consequence of financial liberalization. Thus, these firms can produce a given variety at a lower marginal cost. This is translated into lower final good prices and a
lower aggregate price index. Consequently, the financial liberalization considered generates a selection of the least efficient firms out of the market as firms with productivity slightly above the domestic entry productivity cutoff register negative profits and exit. Thus, a financial liberalization in the form of an exogenous decline in the world interest rate is equivalent to a trade liberalization in the form of an exogenous decline in the iceberg trade cost, which has been widely studied in the framework of the heterogeneous firm model considered in this paper too.

2.3 Empirical Evidence

In this section we test the predictions of the theory summarized in Proposition 1 - 3 by using a dataset over the period 1998-2002 that includes the balance sheets, international trade transactions and the banks of the Hungarian manufacturing firms. I use the last stage of capital market liberalization in Hungary as a natural experiment to identify exogenous variation in the credit supply. This liberalization generated a positive liquidity shock to banks, and had a differential impact across domestic and foreign owned banks. Thus, by using a difference-in-difference (DiD) approach, I document the change in the ratios of a series of production and financial variables to sales or to material costs for firms doing business with domestic banks relative to firms doing business with foreign banks. I also investigate the heterogeneous impact of the credit supply shock across importer and non-importer firms by estimating the impact of the shock on the import-to-sales and the imported-intermediate-input-to-sales ratios in addition to the previously listed variables.

First, I describe the data sources. Next, I discuss the identification strategy and present the historical background of the last stage of the Hungarian financial account liberalization. Finally, I present the reduced form regression models and discuss the estimation results.
2.3.1 Data Sources

To take the theory to the data we need a dataset with four key ingredients\textsuperscript{20}. First, we need firm level information on sales, material costs, number of employees, short term debt, short term bank loans, payables, receivables and the industry each firm belongs to. These come from a comprehensive data set that contains the balance sheets of Hungarian firms collected by the Hungarian Fiscal Authority at yearly frequency and covers the universe of Hungarian firms with double-entry bookkeeping.

Second, we need information on the import transactions of these firms. Thus, we link the balance sheet dataset to the Hungarian Customs Data, collected by the Hungarian Customs Authority. This covers the universe of international trade transactions conducted by Hungarian firms. The data are reported at the firm level for each product classified at the 8-digit combined nomenclature (CN) product code level and country of origin/destination. We use the value of import and export transactions from this dataset.

Third, to establish the link between the credit supply shock and the firm level variables, we need information on the commercial banks that each Hungarian firm banked with. These are documented from a dataset collected by a Hungarian private data provider. This dataset contains firm identifiers and the checking account numbers that these firms opened at commercial banks in any given year. Each bank account number consists of eighteen or twenty-four numbers. The first three of these numbers is called the GIRO code which is the unique bank identifier assigned to each bank by the Hungarian National Bank (MNB). We use the GIRO tables published by MNB to identify the name of the bank.

Finally, to identify the effect of the credit supply shock on firm level production variables, we explore the differential impact that the financial account liberalization had across domestic and foreign owned banks. Information on Hungarian banks’ ownership comes from a yearly panel constructed by using annual reports of the Hungarian Banking Association, Hungarian Fiscal Authority, Hungarian Financial Supervisory Authority and MNB. This

\textsuperscript{20}Appendix A.2 presents detailed description of each source of the dataset.
bank panel contains information on balance sheet variables and the ownership structure (i.e. domestic, foreign or state owned banks) of all the commercial banks that operated in Hungary over the 1992-2011 period.

We construct our dataset by linking the balance sheet data to the customs data based on the firm identifiers. This is linked to the bank account numbers based on the unique firm identifiers and to the bank panel based on the unique bank identifiers. The unit of observation is firm-bank-year in the case of the balance sheet variables, while it is firm-bank-year-product-origin/destination country in the case of the import transactions. We restrict our sample to manufacturing firms, and exclude the state owned banks from the analysis.

The sample period is restricted to 1998-2002 for two reasons. First, the consolidation and privatization of the Hungarian banking sector had been mainly finished by the end of 1998, such that there were no major entries and takeovers from 1998. The structure of the Hungarian banking sector was stable over this period, with 27 commercial banks being present on average and more than 70% of the overall capitalization of the Hungarian banking sector coming from the 9 biggest banks. Second, the integration of Hungary to the EU in 2004 led to the fall of borders between Hungary and other member countries. As a consequence, most of the administrative barriers to trade between Hungary and other EU member countries vanished. Thus, the sales and the input decisions of firms conducting international trade transactions were potentially driven by this effect starting from 2003.

Finally, the liberalization of the Hungarian current and financial account was implemented in consecutive stages between 1990-2001. The current account was almost fully liberalized by 1997. The last stage of financial account liberalization was implemented in 2001 as a prerequisite for the accession of Hungary to the EU. Thus, starting the sample in 1998, financial liberalization can be isolated from current account liberalization.

The data indicates that the main variables of interest exhibit significant variations across

\[\text{year 2003 is omitted from the sample.}\]
the type of bank firms did business with. This is captured by the average ratios of the main variables of interest in the case of a balanced sample of firms over the period 1998-2003 reported in Table 1.1. Firms banking with domestic banks only are similar on average to firms banking with foreign banks only. The summary statistics also suggest that firms banking with both foreign and domestic banks are substantially different from the other two groups: these firms are bigger, have more external financing per unit of sales, use more material per unit of sales and register a lower value-added-to-sales ratio. Table 1.2 in Appendix A.3 reports the descriptive statistics for the main variables of interest in the case of importer firms and the overall sample.

2.3.2 Estimation

2.3.2.1 The Hungarian financial account liberalization

The identification of the causal effect of the change in credit supply on the production and external financing variables of Hungarian manufacturing firms comes from the differential impact that the financial liberalization in Hungary had on firms banking with domestic banks relative to firms banking with foreign banks.

Hungary had to liberalize its capital account by the time of joining the EU, as the free movement of capital has been one of the major principles of the EU. Thus, in June 2001, the Hungarian government decided to fully liberalize the financial account as part of the negotiations concerning the access of the country to the EU\textsuperscript{22}. As a consequence of this liberalization, Hungarian banks were allowed to borrow from or lend to international financial markets in any currency of their choice, and without any legal restrictions. The deregulation of financial transactions was followed by significant financial inflows to Hungary.

The liberalization had a differential impact on domestic banks’ ability to raise liquidity

\textsuperscript{22}This is also stipulated in Articles 56 to 60 of the EC Treaty. According to the Treaty, all restrictions on the capital flows between EU member countries, and between EU member countries and third countries are prohibited. For more institutional details on the Hungarian capital account liberalization see Arvai (2005) and Varela (2013).
relative to the foreign owned banks. Before liberalization, domestic banks could obtain financ- 
ing from domestic savings or through refinancing from the domestic interbank market. These methods of raising liquidity were relatively expensive given the speculative transac-
tions conducted by foreign banks to exploit the interest rate differential between Hungary 
and their country of origin. However, foreign owned banks had the option to refinance 
from abroad even before liberalization by using different accounting practices which allowed 
them to raise capital from their international headquarters. Free access to the international 
financial markets provided new sources of refinancing for domestic banks, which had not 
been accessible for them before liberalization. This in turn was translated into an increase 
in bank lendings to households and firms. Thus, firms banking with domestic banks, and 
especially those firms that were more dependent on external financing, benefited more from 
the liberalization.

There are two reasons why this liberalization episode can be considered exogenous and unexpected. First, no other reform occurred in Hungary in the 1998 - 2002 period which could potentially bias the effect of the last stage of the financial account liberalization. The current account had been liberalized by 1997 and the privatization of the Hungarian banking sector had ended by 1998. Second, the decision concerning the implementation of this liberalization was unexpected mainly because the European Commission admitted Hungary to the EU only in 2003 with integration in May 2004. Thus, one can regard the shock as an unexpected positive liquidity shock.

We exploit this liberalization episode as the source of exogenous variation in credit supply that generated a positive liquidity shock to the firms banking with domestic banks relative to those banking with foreign banks. The data set allows for grouping the firms in three categories based on the type of the bank they do business with: (1) firms banking with domestic banks only \(DBonly_i\) (2) firms banking with foreign banks only \(FOnly_i\), and (3) firms banking with both foreign and domestic banks \(DFboth_i\). Descriptive statistics reported in Table 1.1, Appendix A.3 confirm that firms banking with domestic banks only
are similar in terms of their average characteristics to firms banking with foreign banks only. Thus, to completely isolate the effect of the liquidity shock generated by the financial account liberalization, I define as control group the group of firms banking with foreign banks only, while the treatment group consists of firms banking with domestic banks only. Another rationale behind this choice of control and treatment groups is that foreign banks had been able to refinance their activity from foreign financial markets through their headquarters even before the reform was implemented. Thus, one would expect that giving direct access of foreign banks to international financial markets would have no significant impact on their liquidity constraints. However, the liquidity constraint of the domestic banks was relaxed by letting them refinance at a lower interest rate from international markets. As a consequence, these banks could expand their balance sheet by increasing their loan portfolio.

By using a difference-in-difference (DiD) approach, I identify the causal impact of the positive liquidity shock on Hungarian firms’ production and financial variables to sales or to material costs ratios. In order to isolate the impact of liberalization, I restrict the pre-liberalization period to 2000\textsuperscript{23}, and the post-liberalization period to 2002. As a robustness check, I use the 1998-2000 period as a placebo period and check whether differences in trends across the treated and control firms drive my results.

2.3.2.2 Reduced form test

The theory generates a series of theoretical predictions about the way financial liberalization affects firms’ production decisions. In particular, financial liberalization promotes trade by increasing demand for intermediate inputs. As the interest rate on loans decreases, firms can borrow at a lower cost. Thus, they can demand more bank loans and use this new source of liquidity to purchase more intermediate inputs, in particular imported interme-

\textsuperscript{23}This could be restrictive since we would want to compare how the trend of different firm level real variables changed over time in case of the treatment group relative to the control group. However, since the last stage of liberalization was unexpected, one can assume that there were no pre-adjustments in the firms’ production decisions. Thus, considering 2000 only can be a well enough proxy to characterize pre-treatment differences across the two groups of firms.
diates. This leads to an increase in the material-cost-to-sales ratio and, consequently, a decrease in the value-added-to-sales ratio as summarized in Proposition 1 and Corollary 1. We use a difference-in-difference approach to test this hypothesis. We estimate the reduced form equation (41) to quantify the average effect of the financial account liberalization on the materials-to-sales and the value-added-to-sales ratio, as well as the payables, short term loan\(^{24}\), and receivables to materials, respectively to sales ratios\(^{25}\) \((y_{it})\) of Hungarian manufacturing firms:

\[
y_{i,2002} - y_{i,2000} = \tau_0 + \tau_1 DBonly_{i,2001} + \tau_2 \ln(empl_{i,2001}) + \tau_3 \Delta \ln(empl_{i,t}) + \gamma_{ind,2001} + \varepsilon_{it} \tag{41}
\]

where \(i\) accounts for the firm, \(t\) is time and \(ind\) is the four-digit industry the firm belongs to. \(y_{i,2002} - y_{i,2000}\) is the change in \(y_i\) over the 2000-2002 period where year 2000 is the pre-liberalization period and year 2002 is the post-liberalization period. \(DBonly_{i,2001}\) is a dummy variable equal to 1 if firm \(i\) did banking with domestic bank only in year 2001 when the liberalization was implemented. \(\gamma_{ind,2001}\) represents a set of four-digit level industry fixed effects that controls for variation common to firms within a narrowly defined industry. \(\ln(empl_{i,2001})\) is the log of the total number of employees a firm had in 2001 and it controls for the variation in the scale of production across firms in the year of liberalization. \(\Delta \ln(empl_{i,t})\) is the change in the number of employees from 2000 to 2002, and it controls for the variation in the scale of production across firms and over time. \(\tau_1\) identifies by how much on average variable \(y_i\) changes from 2000 to 2002 in the case of treated firms relative to the control firms.

Based on Propositions 1 and 2, we hypothesize that firms buy more materials per unit of sales as they get less credit constrained which is consistent with an increase in their materials-to-sales ratios. Thus, we expect that the materials-to-sales ratio increases on average in the case of firms banking with domestic banks relative to those banking with foreign banks,

\(^{24}\)Payables are a proxy for non-financial sector intermediated loans, while short term loans are bank loans contracted by firms with maturity less than one year.

\(^{25}\)The definition of these variables is presented in Appendix A.2.
while the value-added-to-sales ratio decreases. This hypothesis is consistent with \( \tau_1 > 0 \) in the case of materials-to-sales ratios in our reduced form equation, and \( \tau_1 < 0 \) in the case of the value-added-to-sales ratio.

If the effect of financial liberalization goes through the intermediate input channel and the accumulation of the additional stock of intermediate inputs is financed by bank loans, or trade credit from the supplier of the intermediate input, we expect to see that the short-term-loan-to-materials and the short-term-loans-to-sales ratios of the treated firms increase relative to the control group (i.e. \( \tau_1 > 0 \)). The expected signs of the payables-to-sales and receivables-to-sales ratios are ambiguous. Firms can use the new sources of liquidity to buy more inputs and build up inventories, or they can use these new bank loans to replace trade credit obtained from suppliers. Thus, it can be the case that the payables-to-sales, the receivables-to-sales and payables-to-materials ratios decrease in response to the liquidity shock. However, as financial liberalization relaxes the liquidity constraint of firms, it can also be the case that firms start to receive more trade credit from their suppliers and provide more trade credit to their clients. In this case, we expect that the payables and receivables per unit of sales increase.

Second, our theory predicts that, conditional on entry to the import market, firms re-allocate resources to the more productive imported intermediate inputs as they get access to more liquidity. Therefore, conditional on entry to the import market, firms’ import-to-domestic-intermediate-input ratio increases because firms buy more imported intermediate inputs. This enhances the efficiency of firms’ production and induces an additional decrease in the value-added-to-sales ratio as summarized in Proposition 2. Consequently, the effect of the financial liberalization on firms’ production outcomes and on the size of the supply chain is amplified by the presence of imported intermediate inputs in the production process.

To test this hypothesis, we classify firms as importers and non-importers. Then, we estimate the reduced form equation (41) by restricting the sample to importer firms. Importers are defined as firms that registered positive import purchases in the year of liberalization.
Based on the predictions of the theory, we expect that the import-to-sales ratio increases, on average, in the case of treated firms relative to the control firms (i.e. \( \tau_1 > 0 \)). We also hypothesize that this increase in the import-to-sales ratio is driven by the increase in intermediate input imports since firms use the new source of liquidity to buy the more productive imported inputs. Thus, we expect that the imported-intermediate-input-to-sales ratio increases (i.e. \( \tau_1 > 0 \)). Also, the size of the estimates is expected to be similar to the one we obtain in the case of the import-to-sales ratio. If the effect of the financial liberalization on the firms’ production decisions acts through the channel of more productive imported inputs, as predicted by the theory, we expect to see a larger impact on importers’ value-added-to-sales ratio than the one estimated from the overall sample.

Finally, as summarized in Proposition 3, the theory also predicts that there is an entry to the import market as the consequence of the financial liberalization. To test this prediction, we estimate the following probability model:

\[
\text{Imp}_i = \theta_0 + \theta_1 DBonly_{it,2001} + \theta_2 \ln(empl_{i,2001}) + \theta_3 \Delta \ln(empl_{i,t}) + \gamma_{ind,2001} + \varepsilon_{it} \quad (42)
\]

where \( \text{Imp}_i \) is an indicator variable of import market entry. This takes value of one if firm \( i \) was not an importer in the pre-liberalization year 2000 but became an importer in the post-liberalization year 2002, and zero otherwise. All the other variables are defined as described previously in the case of equation (41). First we estimate (42) by using an OLS estimator. If there is an entry in the import market as a consequence of financial liberalization, then we expect that on average a larger share of firms banking with domestic banks only became importers relative to firms banking with foreign banks only. Thus, we expect \( \theta_1 > 0 \). We also estimate a probit model by assuming that the probability of becoming an importer, \( P(I_{2002} > 0|I_{2000} = 0) \), can be modeled by a normal distribution. In this case we expect that on average the probability of becoming an importer is larger in the case of firms banking with domestic banks only relative to firms banking with foreign banks only.
2.3.3 Results

We estimate the reduced form equations (41) and (42) on a balanced panel of manufacturing firms covering years 1998 - 2002. We perform a robustness check showing that the results also hold for alternative definitions of the control group and if we control for the export status of the firms. We also conduct a placebo test to show that there were no significant differences in the trend of the control and treated firms before the liberalization. All the errors are clustered at four-digit industry level.

2.3.3.1 The impact of financial liberalization

The data support the main prediction of our theory. Tables 2.1 - 2.3 in Appendix A.3 report the baseline estimates of $\tau_1$ by considering the whole sample. The dependent variables are defined as changes between 2000 and 2002 in the real and financial ratios, shown in the first row of the table.

The results reported in Table 2.1 provide the empirical support for our theoretical predictions summarized in Proposition 1 and Corollary 1. The point estimates of $\tau_1$ in columns (1) and (2) of Table 2.1 indicate that conditional on the firm size, the change in the scale of production and the industry the firms belonged to, the material cost per unit of sales increased on average by 0.027, while the value added per unit of sales decreased on average by 0.022 in the case of firms banking with domestic banks only relative to firms banking with foreign banks only. This supports our theoretical predictions that firms experience an expansion in their backward linkages by buying more intermediate inputs as they get less liquidity constrained.

To empirically test the mechanism highlighted by the model, we need to check if firms hit by the liquidity shock contract more bank loans and if they use these new sources of liquidity to finance the increase in their material purchases. First, we estimate model (41) by using as dependent variables the short-term-loan-to-sales ratio to test if firms hit by the positive liquidity shock borrow more from the banks. The estimation results in Table 2.2, column (1)
and (2), indicate that firms banking with domestic banks register, on average, an increase in their short term loans per unit of sales by 0.039. This result provides empirical support to our theoretical prediction that firms hit by the positive credit supply shock contract more short term bank loans. Columns (3) - (6) of Table 2.2 indicate that the point estimates of $\tau_1$ are not statistically significant when the dependent variables considered are the payables, respectively the receivables-to-sales ratios. These results suggest that the Hungarian financial account liberalization had no direct impact on trade credit provided by the suppliers of the firms banking with domestic banks only relative to firms banking with foreign banks only.

Second, we estimate model (41) by using as dependent variable the short-term-loan-to-material costs ratio to test if firms, hit by the positive liquidity shock, use this new source of liquidity to buy more intermediate inputs in the form of materials. The estimation results in Table 2.3, columns (1) and (2), indicate that firms banking with domestic banks registered an increase in their short term loans per unit of material costs by 0.084. Our theory does not address the issue of non-financial sector intermediated loans and their substitutability with bank loans, but we have to check that the new material purchases are not financed by trade credit from the firms’ supplier. The idea is that the credit supply shock relaxes the liquidity constraint of all the constrained firms in the economy. Thus, it can be the case that firms use the new bank loans to repay liabilities to their suppliers which would reduce the account payables on their balance sheet. Columns (3) and (4) in Table 2.3 shows that firms banking with domestic banks only registered a small decrease in their payables per unit of material purchases relative to the treatment group. These results indicate that the financial liberalization had a particularly big impact on the financial sector intermediated loans and liquidity. Overall, the data support our main theoretical prediction that a financial liberalization, which loosens firms’ liquidity constraint, induces firms to borrow more from the banks in order to finance their intermediate input purchases.

The data also support the theoretical predictions that the financial liberalization impacts firms through the channel of imported intermediate inputs. As firms get access to more li-
uidity, they import more by reallocating resources to the more productive imported intermediate inputs. Thus, we expect that these firms’ import-to-sales and imported-intermediate-input-to-sales ratios increase, while their domestic-intermediate-input-to-sales ratio does not change or decreases. To test this hypothesis, we estimate model (41) by restricting data to the sample of firms that registered positive imports in 2001. We report the estimation results in Tables 3.1 - 3.3 in Appendix A.3.

The estimation results in Table 3.1 indicate that firms banking with domestic banks only import more relative to the firms banking with foreign banks only, as their import-to-sales ratio increases by 0.016 on average. Columns (3) and (4) indicate that the increase in total imports is mostly coming from the increase in imported intermediate inputs, as the treated firms’ imported-intermediate-input-to-sales ratio increases by 0.017 on average relative to the control firms. Moreover, the point estimates reported in columns (5) and (6) show that the financial liberalization had no impact on firms’ domestic intermediate purchases per unit of sales. These results provide empirical support for our theoretical predictions that firms import more intermediate inputs if they have better access to bank loans.

Similarly to the baseline results, the data support the theoretical prediction that importers hit by the liquidity shock contracted more short term bank loans to finance the increased intermediate input imports. The estimation results suggest that importers hit by the positive liquidity shock contracted 0.027 more short term loans per unit of sales (Table 3.2), and 0.042 more short term loans per unit of material (Table 3.3) than firms banking with foreign banks. However, the liquidity shock generated by the financial liberalization had no impact on the Hungarian importer firms’ payables and receivables per unit of sales, or material. This result reinforces the findings documented from the whole sample of firms: the last stage of Hungarian financial account liberalization provided a positive liquidity shock to the Hungarian firms through a better availability of the banking sector intermediated loans. Thus, these results provide evidence to the theoretical predictions that importer firms hit by the positive liquidity shock borrowed more from banks and used this new source of liquidity
to import more intermediate inputs.

Finally, our theory predicts that financial liberalization generates entry to the import market as firms just below the import market entry cutoff productivity find it profitable to import the intermediate inputs. To test this prediction we estimate the reduced form model in (42). The estimation results reported in Table 4, Appendix A.3, columns (1) and (2), suggest that the share of firms that were banking with domestic banks only and became importers after the liberalization is larger relative to the share of firms that became importers in the control group. The probit estimates reported in columns (3) and (4) indicate that the probability of becoming an importer in the post-liberalization period is larger in the case of firms banking with domestic banks only relative to the control firms. These results provide empirical support for our theoretical predictions that financial liberalization impacts the extensive margin of imports as firms hit by the positive liquidity shock decide to enter the import market and import some of their intermediate inputs.

In conclusion, these results indicate that Hungarian firms banking with domestic banks expanded their intermediate import activity relative to firms banking with foreign banks as financial liberalization allowed them to access more outside short term financing. Thus, we can conclude that the estimation results outlined in this section provide evidence for our theoretical predictions that positive credit supply shocks loosen firms’ liquidity constraints and cause firms to import more intermediate inputs. Based on our theoretical predictions and the empirical evidences outlined in this section, we can also conclude that financial liberalization can serve to lower international trade costs because it reduces the relative cost of imported intermediate inputs.

By doing a back of the envelope calculation based on a simple gravity equation with elasticity of substitution assumed to be equal to 3, the estimated 2 percentage point increase in the imported intermediate to import ratio is equivalent to 9.66 percentage point increase in intermediate inputs, a 22 percent tariff cut in the case of firms banking with domestic banks, and a 3.5 percent tariff cut in the case of the whole sample. These results indicate that
the liquidity shock generated by the financial liberalization had a differential impact across
the treated and control firms. Moreover, the point estimates predict a 6.6 percentage point
increase in the probability of becoming an intermediate input importer, while the number
of firms importing increases by 5 percent as a consequence of the liberalization.

### 2.3.3.2 Robustness check

In this section we present a series of robustness checks that show that our identification
strategy and estimation results are robust to alternative definitions of the treatment group,
there are no past differences in the average trends of treated and control firms, and that there
are no systematic differences in the impact of financial liberalization across importer-exporter
and importer-non-exporter firms.

Table 5, in Appendix A.3, shows that our results are robust to alternative definitions of
the treatment group. A large group of Hungarian firms did banking with both domestic and
foreign banks during the sample period. Since we expect that these firms could get short
term bank loans easier from their foreign owned banks than from their domestic owned
banks even before the liberalization, their presence in the estimation sample could cause
downward bias, and we would underestimate the impact of financial liberalization. To verify
this, we re-estimate equation (41) by redefining the treatment group by adding to the group
of firms banking with domestic banks only the group of firms that did banking with both
domestic and foreign banks. The signs of the point estimates of $\tau_1$ support the theoretical
predictions and are consistent with the ones obtained in the case of the baseline specification.
However, the size of the point estimates are lower relative to the ones obtained in the baseline
specification. This suggests that our results are robust to alternative specifications of the
treatment group, while the presence of the firms with the mixed group of banks biases the
results downward.

Our identification strategy relies on the assumption that treated and control firms on
average exhibited a similar trend of evolution in the dependent variables of interest before
the liberalization. To verify that the data support this assumption, we define the placebo period as the years 1998-2000 that is the three years window exactly before the 2000-2002 period considered in the baseline estimation. We estimate the following regression model:

\[ y_{i,2000} - y_{i,1998} = \gamma_0 + \gamma_1 \text{Dom}_{only} + \gamma_2 \ln(\text{empl}_{i,2001}) + \gamma_{ind,2001} + \varepsilon_{it} \]  

where \( y_{i,2000} - y_{i,1998} \) is the three years difference in the value-added-to-sales and material-cost-to-sales ratios, as well as short-term-loans-to-material-cost, import-to-sales and imported-intermediate-input-to-sales ratios.

In Table 6, Appendix A.3 we report the placebo difference-in-difference estimates. The point estimates of \( \gamma_1 \) are not statistically significant. This provides support to our identification assumption that the group of firms banking with domestic bank only and the group of firms banking with foreign bank only exhibited a similar trend on average before the liberalization. These results combined with results reported in the previous section provide the evidence that the Hungarian financial liberalization, on average, had a differential impact on the trend of firms banking with domestic bank only relative to firms banking with foreign banks only.

Finally, we show that the Hungarian financial liberalization had a differential impact across exporter and non-exporter firms banking with domestic banks in the case of the whole sample, but it had no differential impact across the group of exporter and non-exporter importers banking with domestic banks. We estimate the following regression model:

\[ y_{i,2002} - y_{i,2000} = \eta_0 + \eta_1 \text{DB only}_{i,2001} + \eta_2 \text{DB only,Exporter}_{i,2001} + \eta_3 \text{Exporter}_{i,2001} + \eta_4 \text{X} + \varepsilon_{it} \]  

where \( \text{Exporter}_{i,2001} \) is a dummy variable that takes a value of one if the firm was an exporter in 2001 and \( \text{DB only,Exporter}_{i,2001} \) is an interaction term between the exporter dummy and the banking with domestic banks only dummy. Vector X contains other explanatory variables such as the number of employees, the change in the number of employees from 2000 to 2002.

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and a set of industry fixed effects defined at four-digit level.

We hypothesize that if the financial liberalization had a differential impact across exporter and non-exporter firms banking with domestic banks only relative to the control group, then estimated $\eta_2$ and $\eta_3$ are jointly significantly different from zero when we estimate (44) on the overall sample of firms. The estimation results reported in Table 7.1, Appendix A.3 in the appendix verify this hypothesis. The size of the point estimates and the F-statistics on the joint significance test of $\eta_2$ and $\eta_3$ indicate that indeed exporter firms banking with domestic banks benefited more from the financial liberalization relative to the non-exporters. These results are in line with the findings of the papers that study the link between firms’ export decisions and financial markets, and that document that exporter firms are more affected by financial shocks than non-exporters.

In Table 7.2, Appendix A.3 in the appendix, we report the point estimates of $\eta$ on the sample restricted to the group of firms that were importers in 2001. The point estimates of $\eta_2$ and $\eta_3$ are not jointly significantly different from zero. These results indicate that the Hungarian financial liberalization had no differential impact across exporter and non-exporter importers. This is mainly due to the fact that about 80% of the Hungarian importer firms were exporters too in 2001.

2.4 Conclusions

Despite the fact that a large and growing share of international trade transactions are intermediate input transactions and most exporting firms are importers too, there has been no empirical research investigating the implications of financial shocks for firms’ import decisions. This paper fills this gap in the literature. We present a model and derive theoretical predictions on the way changes in firms’ access to bank loans affect their import decisions. Next, we test these predictions by using a dataset that includes the balance sheets, international trade transactions and the banks of Hungarian manufacturing firms. We use the last
stage of Hungary’s financial account liberalization as a natural experiment to identify credit supply shocks, and estimate the impact of the liberalization on Hungarian firms’ import and production decisions.

We provide evidence that firms’ import decisions are affected by credit supply shocks, and we document how firms’ choice between imported and domestic inputs is driven by their access to external financing. We find that positive credit supply shocks loosen firms’ liquidity constraints and cause firms to import more. We also find that the increase in imports can be attributed to the increase in intermediate input imports (i.e. 9.66 percentage point), as financial liberalization reduces the relative cost of buying intermediates from abroad. Thus, this is the first paper to show that capital market liberalization can serve to lower trade costs on intermediates, which causes firms to buy more of the more productive imported intermediates. The increase in the intermediate inputs is equivalent to a 22 percent tariff cut in the case of firms banking with domestic banks, and a 3.5 percent tariff reduction in the case of the whole sample.

Moreover, we find that the probability of becoming an intermediate input importer increased more in the case of firms banking with domestic banks relative to the control group. This evidence supports the theoretical prediction that the positive liquidity shock, resulted from financial liberalization, generates import market entry. The predicted probability of becoming an intermediate input importer increased by 6.6 percentage points, while the number of firms importing intermediates increased by 5 percent.

Our results have a number of implications for future research. In particular, these results provide the first empirical evidence that there is a link between financial and trade liberalization: financial liberalization can have a similar impact on firms’ import decisions as the impact of trade liberalization in form of a input tariff cut widely studied in the international trade literature.
A.1 Theory Appendix

1. Cost minimization

1.1. Domestic producers:

Domestic producers solves the following cost minimization problem:

\[
\min_{\{L(\phi), X(\phi), X^d(\phi), X^F(\phi)\}} \{ wL(\phi) + p^D X^D(\phi) + C(\phi)(1 + r(\phi)) \eta + \rho \left( p^F X^F(\phi) + f_M \right) + f \} \tag{1}
\]

\[
s.t. \quad y(\phi) = \varphi X(\phi)^{\phi} L(\phi)^{1-\phi} \tag{2}
\]

\[
X(\phi) = \left[ X^d(\phi)^{\frac{\xi}{1-\xi}} + a^{\frac{1}{1-\xi}} X^F(\phi)^{\frac{\xi}{1-\xi}} \right]^{\frac{1+\xi}{\xi}} \tag{3}
\]

\[
C(\phi) \geq (1 - \rho)(p^F X^F(\phi) + f_M) \tag{4}
\]

In equilibrium, since bank loans are costly, firms do not demand more credit than the total cost of imported intermediate inputs that they cannot finance from their own resources. Thus, (4) is binding.

The corresponding Lagrangean:

\[
\mathcal{L}(\phi) = \{ wL(\phi) + p^D X^D(\phi) + (\eta (1 + r(\phi)) (1 - \rho) + \rho) \left( p^F X^F(\phi) + f_M \right) + f \} \tag{5}
\]

\[
+ \lambda \left( y(\phi) - \varphi X(\phi)^{\phi} L(\phi)^{1-\phi} \right) + \chi \left( X(\phi) - \left[ X^d(\phi)^{\frac{\xi}{1-\xi}} + a^{\frac{1}{1-\xi}} X^F(\phi)^{\frac{\xi}{1-\xi}} \right]^{\frac{1+\xi}{\xi}} \right)
\]

The first order conditions (FOCs, hereafter) are:
\[ [L(\phi)] : wL(\phi) = \lambda(1 - \phi)y(\phi) \quad (6) \]

\[ [X(\phi)] : \chi X(\phi) = \lambda\phi y(\phi) \quad (7) \]

\[ [X^D(\phi)] : \left[ p^D - \chi \left( \frac{X(\phi)}{X^D(\phi)} \right)^{\frac{1+\xi}{\xi}} \right] X^D(\phi) = 0 \quad X^D(\phi) \geq 0 \quad (8) \]

\[ [X^F(\phi)] : \left[ \left( \eta (1 + r(\phi))(1 - \rho) + \rho \right)p^F - \chi \left( \frac{aX(\phi)}{X^F(\phi)} \right)^{\frac{1+\xi}{\xi}} \right] X^F(\phi) = 0 \quad X^F(\phi) \geq 0 \quad (9) \]

\[ [\lambda] : \lambda \left[ y(\phi) - \varphi X(\phi) \phi L(\phi)^{1-\phi} \right] = 0 \quad \lambda \leq 0 \quad (10) \]

\[ [\chi] : \chi \left[ X(\phi) - \left[ X^d(\phi)^{\frac{1+\xi}{\xi}} + a^{\frac{1+\xi}{\xi}} X^F(\phi)^{\frac{1+\xi}{\xi}} \right] \right] = 0 \quad \chi \leq 0 \quad (11) \]

By combining (7) and (8), equation (12) results:

\[ p^D X(\phi) = \lambda\phi y(\phi) \left( \frac{X(\phi)}{X^d(\phi)} \right)^{\frac{1+\xi}{\xi}} \quad (12) \]

By combining (7) and (9), equation (13) results:

\[ \left( \frac{p^D a^{\frac{1+\xi}{\xi}}}{\left( \eta (1 + r(\phi))(1 - \rho) + \rho \right)p^F} \right)^{\frac{1+\xi}{\xi}} = \left( \frac{X^F(\phi)}{X^d(\phi)} \right) \quad (13) \]

By using the expression from (13) and the definition of X(\phi) in (3), we get:

\[ X(\phi) = X^d(\phi) \left[ 1 + a^{\frac{1}{\xi}} \left( \frac{X^F(\phi)}{X^d(\phi)} \right)^{\frac{\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}} \]

\[ X(\phi) = X^d(\phi) \left[ 1 + \frac{a}{\left( \eta (1 + r(\phi))(1 - \rho) + \rho \right)} \left( \frac{p^D}{p^F} \right)^{\frac{\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}} \]

\[ \frac{X(\phi)}{X^d(\phi)} = \left[ 1 + \frac{a}{\left( \eta (1 + r(\phi))(1 - \rho) + \rho \right)} \left( \frac{p^D}{p^F} \right)^{\frac{\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}} \quad (14) \]
From (7) and (8), and substituting (13) it follows:

\[
p^D X(\varphi) = \lambda \phi y(\varphi) \left[ 1 + \frac{a}{(\eta(1+r(\varphi))(1-\rho)+\rho)} \left( \frac{p^D}{p^F} \right)^\xi \right]^{\frac{1}{\xi}}
\]

Thus, the resulting intermediate input demand is given by equation (15) when firms buy only domestic intermediate input, and (16) if firms buy both domestic and imported intermediate input:

\[
p^D X(\varphi) = \lambda \phi y(\varphi) \quad \text{if } X^F(\varphi)=0 \tag{15}
\]

\[
p^D X(\varphi) = \lambda \phi y(\varphi) b \quad \text{if } X^F(\varphi)>0 \tag{16}
\]

where \( b = \left[ 1 + \frac{a}{(\eta(1+r(\varphi))(1-\rho)+\rho)} \left( \frac{p^D}{p^F} \right)^\xi \right]^{\frac{1}{\xi}} \) since \( \frac{a}{(\eta(1+r(\varphi))(1-\rho)+\rho)} \left( \frac{p^D}{p^F} \right)^\xi > 0 \) whenever \( X^F(\varphi)>0 \). Based on equations (6), (7) and (8), we can express \( L(\varphi) \) and \( X(\varphi) \) as function of \( y(\varphi) \) and \( \lambda \) as follows:

\[
L(\varphi) = \lambda y(\varphi)(1-\phi) \frac{1}{w} \tag{17}
\]

\[
X(\varphi) = \lambda y(\varphi) \frac{\phi b}{p^D} \tag{18}
\]

By using (17) and (18), and plugging it into the production function (2), we can derive the Lagrange multiplier \( \lambda \):

\[
y(\varphi) = \varphi X(\varphi)^\phi L(\varphi)^{1-\phi} = \lambda y(\varphi) \varphi \left( \phi^\phi(1-\phi)^{1-\phi} \right) \left( \frac{b}{p^D} \right)^\phi \left( \frac{1}{w} \right)^{1-\phi}
\]

Collecting terms and dividing through by \( y(\varphi) \), \( \lambda \) becomes:

\[
\lambda = \frac{(p^D)^\phi w^{1-\phi}}{\varphi \Psi b^\phi} \tag{19}
\]
Thus, the minimum cost function, $TC(\lambda; y(\varphi))$, associated to producing $y(\varphi)$ is obtained by plugging (17), (18) and (19) into the objective function:

$$TC(\lambda; y(\varphi)) = wL(\varphi) + p^D X^D(\varphi) + (\eta (1 + r(\varphi)) (1 - \rho) + \rho) (p^FX^F(\varphi) + f_M) + f$$

which based on whether the firm imports intermediates ($X^F(\varphi)>0$) or not ($X^F(\varphi)=0$), can take the following two forms:

**Case 1:** If $X^F(\varphi)=0$:

$$TC^1(\lambda; y(\varphi)) = wL(\varphi) + p^D X^D(\varphi) + f = \lambda y(\varphi)(1 - \phi) + \lambda y(\varphi)\phi + f = \lambda y(\varphi) + f$$

$$TC^1(y(\varphi)) = \frac{1}{\varphi} \left( \frac{p^D}{\Psi} w^{1-\phi} \right) y(\varphi) + f$$

By using the assumptions on the market structure and technology in the intermediate input sector (i.e. perfect competition, linear technology and labor is the only factor of production), and wages are normalized to 1 (i.e. $p^D = w \equiv 1$), the minimum total cost of a domestic producer, $TC^1(y(\varphi))$, using only domestic intermediate input for the production of quantity $y(\varphi)$ is given by:

$$TC^1(y(\varphi)) = \frac{1}{\varphi} \Psi y(\varphi) + f \quad (20)$$

**Case 2:** If $X^F(\varphi)>0$:

By multiplying and dividing the intermediate input quantities by $X(\varphi)$:
\[ TC^2(\lambda; y(\varphi)) = wL(\varphi) + p^D X^D(\varphi) + (\eta(1 + r(\varphi))(1 - \rho) + \rho)(p^F X^F(\varphi) + f_M) + f \]

\[ = wL(\varphi) + p^D X(\varphi) \frac{X^D(\varphi)}{X(\varphi)} + (\eta(1 + r(\varphi))(1 - \rho) + \rho)p^D X(\varphi) \frac{X^D(\varphi)}{X(\varphi)} \frac{p^F X^F(\varphi)}{p^D X^D(\varphi)} \]

\[ + \eta(1 + r(\varphi))(1 - \rho) + \rho) f_M + f \]

By substituting for \( p^D X(\varphi), \frac{X^D(\varphi)}{X(\varphi)} \) and \( \frac{p^F X^F(\varphi)}{p^D X^D(\varphi)} \), and taking \( y(\varphi) \) out as a common factor we get:

\[ TC^2(\lambda; y(\varphi)) = \lambda y(\varphi) \left\{ (1 - \phi) + \phi \frac{1}{y^2} \right\} + (\eta(1 + r(\varphi))(1 - \rho) + \rho) f_M + f \]

\[ TC^2(y(\varphi)) = \left( \frac{p^D}{\varphi \Psi b^e} \right)^{\phi} w^{1-\phi} y(\varphi) + (\eta(1 + r(\varphi))(1 - \rho) + \rho) f_M + f \]

By using the assumptions on the market structure and technology in the intermediate input sector (i.e. perfect competition, linear technology and labor is the only factor of production) and wages are normalized to 1 (i.e. \( p^D = p^F = w \equiv 1 \)), the minimum total cost of a firm using both imported and domestic intermediate input for production of \( y(\varphi) \) is given by:

\[ TC^2(y(\varphi)) = \frac{1}{\varphi \Psi b^e} y(\varphi) + (\eta(1 + r(\varphi))(1 - \rho) + \rho) f_M + f \quad (21) \]

1.2. Exporters: Exporters’ cost minimization problem is similar to the domestic producers’ cost minimization problem with the only difference that exporters’sales is subject to an iceberg trade cost (i.e. in order to get one unit to the final destination they have to
produce and ship \( \tau \) units):

\[
\min_{\{L_x(\varphi), X_x(\varphi), X^d_x(\varphi), X^F_x(\varphi), C^D_x(\varphi)\}} TC_x(\varphi, y_x(\varphi)) = \tau w L_x(\varphi) + \tau p^D X^d_x(\varphi) + \rho \left( \tau p^F X^F_x(\varphi) + f_M \right) + f_x + \eta (1 + r(\varphi)) C^D_x(\varphi)
\]

(22)

\[
s.t. \quad y_x(\varphi) = \varphi X_x(\varphi)^{\phi} L_x(\varphi)^{1-\phi} \tag{23}
\]

\[
X_x(\varphi) = \left[ X^d_x(\varphi)^{\frac{\xi}{1+\xi}} + a^{\frac{1}{1+\xi}} X^F_x(\varphi)^{\frac{\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}} \tag{24}
\]

\[
C_x(\varphi) \geq (1 - \rho) (\tau p^F X^F_x(\varphi) + f_M) \tag{25}
\]

As bank loans are costly, exporters will demand bank loans equal to the amount of total cost they cannot finance from own resources. Thus, the constraint in equation (25) is binding. By plugging \( C_x(\varphi) \) into the objective function, the exporters’ cost minimization problem becomes:

\[
\min_{\{L_x(\varphi), X_x(\varphi), X^d_x(\varphi), X^F_x(\varphi)\}} \left\{ \tau w L_x(\varphi) + \tau p^D X^d_x(\varphi) + \tau (\eta(1 + r(\varphi))(1 - \rho) + \rho) p^F X^F_x(\varphi) \right. \]

\[
\left. + (\eta(1 + r(\varphi))(1 - \rho) + \rho) f_M + f_x \right\} \tag{26}
\]

\[
s.t. \quad y_x(\varphi) = \varphi X_x(\varphi)^{\phi} L_x(\varphi)^{1-\phi} \tag{27}
\]

\[
X_x(\varphi) = \left[ X^d_x(\varphi)^{\frac{\xi}{1+\xi}} + a^{\frac{1}{1+\xi}} X^F_x(\varphi)^{\frac{\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}} \tag{28}
\]

The corresponding Lagrangean is:
\[ \mathcal{L} = \{ \tau w L_x(\varphi) + \tau p^D X^d_x(\varphi) + \tau (\eta (1 + r(\varphi)) (1 - \rho) + \rho) p^F X^F_x(\varphi) \\
+ (\eta (1 + r(\varphi)) (1 - \rho) + \rho) f_M + f_x \} \]
+ \lambda_x (y_x(\varphi) - \varphi X_x(\varphi) \phi L_x(\varphi)^{1-\phi})
+ \chi_x \left( X_x(\varphi) - \left[ X^d_x(\varphi)^{\frac{\xi}{\xi + \tau}} + a \frac{\xi}{\xi + \tau} X^F_x(\varphi)^{\frac{\xi}{\xi + \tau}} \right]^{\frac{\tau + \xi}{\xi + \tau}} \right) \]

Similarly to equations (15) and (16) in the case of the domestic producer, the exporters’ intermediate input demand is characterized by equations (30) if exporters use only domestic intermediate inputs, and by equation (31) if exporters use both domestic and imported intermediate inputs:

\[ \tau p^D X_x(\varphi) = \lambda_x \phi y_x(\varphi) \quad i f \quad X^F_x(\varphi) = 0 \] (30)
\[ \tau p^D X_x(\varphi) = \lambda_x \phi y_x(\varphi) b \quad i f \quad X^F_x(\varphi) > 0 \] (31)

where \( b = \left[ 1 + \frac{a}{(\eta (1 + r(\varphi)) (1 - \rho) + \rho)^{\xi}} \left( \frac{p^D}{p^D} \right)^{\frac{\xi}{\xi + \tau}} \right]^{\frac{\tau + \xi}{\xi + \tau}} > 1. \)

Similarly to the domestic producers’ cost minimization problem, we can express exporters’ labor and intermediate inputs demand as the function of output:

\[ L_x(\varphi) = \lambda_x y_x(\varphi) (1 - \phi) \frac{1}{\tau w} \] (32)
\[ X_x(\varphi) = \lambda_x y_x(\varphi) \phi \frac{b}{\tau p^D} \] (33)

and by plugging this into the production function we can back out the multiplier \( \lambda_x : \)

\[ y_x(\varphi) = \varphi X_x(\varphi) \phi L_x(\varphi)^{1-\phi} \]
\[ y_x(\varphi) = \varphi \left( \lambda_x y_x(\varphi) \phi \frac{b}{\tau p^D} \right)^{\phi} \left( \lambda_x y_x(\varphi) (1 - \phi) \frac{1}{\tau w} \right)^{1-\phi} \]
From here it follows that \( \lambda_x \) is:

\[
\lambda_x = \frac{\tau \left( p^D \right)^{\phi} w^{1-\phi}}{\phi \Psi b^s}
\]

By using the normalization that \( w \equiv 1 \), and the assumptions on the technology and the market structure in the intermediate input sectors that imply \( p^D = p^F = 1 \), the multiplier \( \lambda_x \) becomes:

\[
\lambda_x = \frac{\tau}{\phi \Psi b^s}
\]  

(34)

Thus, the minimum total cost, \( TC_x(\phi) \), resulting from the exporters’ cost minimization problem is obtained by substituting (30)-(34) into the objective function (22):

\[
TC_x(\phi) = \tau w L_x(\phi) + \tau p^D X^D_x(\phi) + \tau (\eta (1 + r(\phi))(1 - \rho) + \rho) p^F X^F_x(\phi) + (\eta (1 + r(\phi))(1 - \rho) + \rho) f_M + f
\]

Depending on whether the exporter uses or not imported intermediate inputs, we can distinguish two case:

Case 1: If \( X^F_x(\phi) = 0 \):

\[
TC_x^1(\lambda_x; y_x(\phi)) = \tau w L_x(\phi) + \tau p^D X^D_x(\phi) + f_x
\]

\[
= \lambda_x y_x(\phi)(1 - \phi) + \lambda_x y_x(\phi)\phi + f_x
\]

\[
= \lambda_x y_x(\phi) + f
\]

By the perfect competition assumption in the intermediate input sector and the fact that wages are normalized to 1 we get:

\[
TC_x^1(y_x(\phi)) = \frac{\tau}{\phi \Psi} y_x(\phi) + f_x
\]  

(35)
Case 2: If $X^F_x(\varphi) > 0$:

$$
TC^2_x(\lambda_x; y_x(\varphi)) = \tau w L_x(\varphi) + \tau p^D X^D_x(\varphi) + \tau \left( (1 + r(\varphi)) (1 - \rho) + \rho \right) \left( p^F X^F_x(\varphi) \right) \\
+ \left( (1 + r(\varphi)) (1 - \rho) + \rho \right) f_M + f \\
= \lambda_x y_x(\varphi) (1 - \phi) + \lambda_x y_x(\varphi) \phi \frac{p^D x}{b^z} \\
+ \left( (1 + r(\varphi)) (1 - \rho) + \rho \right) \lambda_x y_x(\varphi) \frac{p^D x}{b^z \left[ (1 + r(\varphi)) (1 - \rho) + \rho \right]^{1+\xi} p^F x} \\
+ [\eta (1 + r(\varphi)) (1 - \rho) + \rho] f_M + f
$$

$$
TC^2_x(y_x(\varphi)) = \frac{\tau}{\varphi^\Psi b^x} y_x(\varphi) + \left( (1 + r(\varphi)) (1 - \rho) + \rho \right) f_M + f
$$

2. Price setting:

Producers set prices by maximizing profit subject to demand and the total cost derived from the cost minimization problem. Depending on whether the producers use domestic and/or imported intermediate inputs, one can distinguish two cases when solves the profit maximization problem both in the case of the domestic producers and exporters.

2.1. Domestic producer:

Case 1: $X^F_x(\varphi) = 0$:

$$
\max_{\{p^1(\varphi), y^1(\varphi)\}} \left\{ y^1(\varphi) p^1(\varphi) - TC^4(y^1(\varphi)) \right\} \\
\text{s.t.} \quad y^1(\varphi) = \frac{Y}{P} \left( \frac{p^1(\varphi)}{P} \right)^{-\sigma} \\
TC^4(y(\varphi)) = \frac{1}{\varphi^\Psi} y^1(\varphi) + f
$$
By plugging (38) and (39) into (37) we get:

$$\max_{p^1(\varphi)} \left\{ \frac{p^1(\varphi)}{P} \left( \frac{p^1(\varphi)}{P} \right)^{-\sigma} - \frac{1}{\varphi \Psi} \left( \frac{p^1(\varphi)}{P} \right)^{-\sigma} - f \right\}$$  \hspace{1cm} (40)$$

The FOC associated to the optimization problem in (40) is:

$$\frac{Y}{P^{1-\sigma}} (1-\sigma)p^1(\varphi)^{-\sigma} + \frac{\sigma Y}{\varphi \Psi P^{1-\sigma} p^1(\varphi)^{-\sigma-1}} = 0$$  \hspace{1cm} (41)$$

By plugging these back into (41), by using the demand function in (38) and the definition of revenue, we get the price \(p^1(\varphi)\), quantity supplied \(y^1(\varphi)\) and the revenue \(q^1(\varphi)\) generated by the variety produced by the firm with productivity \(\varphi\):

$$p^1(\varphi) = \frac{\sigma}{\sigma - 1} \frac{1}{\varphi \Psi}$$  \hspace{1cm} (42)$$

$$y^1(\varphi) = \frac{Y}{P^{1-\sigma}} \left[ \frac{\sigma}{\sigma - 1} \frac{1}{\varphi \Psi} \right]^{-\sigma}$$  \hspace{1cm} (43)$$

$$q^1(\varphi) = p^1(\varphi)y^1(\varphi) = \frac{Y}{P^{1-\sigma}} \left[ \frac{\sigma}{\sigma - 1} \frac{1}{\varphi \Psi} \right]^{1-\sigma}$$  \hspace{1cm} (44)$$

Case 2: If \(X_F(\varphi) > 0\):

$$\max_{\{p^2(\varphi), y^2(\varphi)\}} \left\{ \eta y^2(\varphi) p^2(\varphi) - TC^2(y(\varphi)) \right\}$$  \hspace{1cm} (45)$$

s.t.  \hspace{1cm} y^2(\varphi) = \frac{Y}{P} \left( \frac{p^2(\varphi)}{P} \right)^{-\sigma}$$  \hspace{1cm} (46)$$

$$TC^2(y^2(\varphi)) = \frac{1}{\varphi \Psi b^2} y^2(\varphi) + (\eta (1 + r(\varphi)) (1 - \rho) + \rho) f_M + f$$  \hspace{1cm} (47)$$

By plugging (46) and (47) into (45), we get the unconstrained optimization problem:
The FOC is:

$$\max_{\{p^2(p)\}} \left\{ \left( \eta p^2(p) - \frac{1}{\varphi \Psi b^\phi} \right) \frac{Y}{P} \left( \frac{p^2(p)}{P} \right)^{-\sigma} - \left( \eta (1 + r(p)) (1 - \rho) + \rho \right) f_M - f \right\}$$  \hspace{1cm} (48)

from which the following price $$p^2(p)$$, quantity supplied $$y^2(p)$$ and revenue results $$q^2(p)$$:

$$p^2(p) = \frac{\sigma}{\eta (\sigma - 1) \varphi \Psi b^\phi}$$  \hspace{1cm} (50)

$$y^2(p) = \frac{Y}{P^{1-\sigma}} \left[ \frac{\sigma}{\eta (\sigma - 1) \varphi \Psi b^\phi} \right]^{-\sigma}$$  \hspace{1cm} (51)

$$q^2(p) = p^2(p) y^2(p) = \frac{Y}{P^{1-\sigma}} \left( \frac{\sigma}{\eta (\sigma - 1) \varphi \Psi b^\phi} \right)^{1-\sigma}$$  \hspace{1cm} (52)

2.2. Exporter:

Case 1: If $$X^F_x(\varphi) = 0$$:

$$\max_{\{p^1_x(\varphi), y^1_x(\varphi)\}} \left\{ y^1_x(\varphi) p^1_x(\varphi) - TC^1_x(y^1_x(\varphi)) \right\}$$  \hspace{1cm} (53)

s.t.  \hspace{1cm} $$y^1_x(\varphi) = \frac{Y_x}{P_x} \left( \frac{p^1_x(\varphi)}{P_x} \right)^{-\sigma}$$  \hspace{1cm} (54)

$$TC^1_x(y^1_x(\varphi)) = \frac{\tau}{\varphi \Psi} y^1_x(\varphi) + f_x$$  \hspace{1cm} (55)

By plugging in the demand function:

$$\max_{\{p^1_x(\varphi)\}} \left\{ \frac{p^1_x(\varphi) Y_x}{P_x} \left( \frac{p^1_x(\varphi)}{P_x} \right)^{-\sigma} - \frac{\tau Y_x}{\varphi \Psi P_x} \left( \frac{p^1_x(\varphi)}{P_x} \right)^{-\sigma} - f_x \right\}$$  \hspace{1cm} (56)

The FOC:

$$\frac{Y_x}{P_x^{1-\sigma}}(1 - \sigma) p^1_x(\varphi)^{-\sigma} + \frac{\tau \sigma}{\varphi \Psi P_x^{1-\sigma}} p^1_x(\varphi)^{-1} = 0$$  \hspace{1cm} (57)
\[
\left(1 - \sigma + \frac{\tau \sigma}{\varphi \Psi p^1_x(\varphi)}\right) \frac{Y_x}{P^1_{x-\sigma}} p^1_x(\varphi)^{-\sigma} = 0
\]  
(58)

from which the following price \(p^1_x(\varphi)\), quantity \(y^1_x(\varphi)\) and revenue \(q^1_x(\varphi)\) result:

\[
p^1_x(\varphi) = \frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi \Psi}
\]  
(59)

\[
y^1_x(\varphi) = \frac{Y_x}{P^1_{x-\sigma}} \left[\frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi \Psi}\right]^{-\sigma}
\]  
(60)

\[
q^1_x(\varphi) = p^1_x(\varphi) y^1_x(\varphi) = \frac{Y_x}{P^1_{x-\sigma}} \left[\frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi \Psi}\right]^{1-\sigma}
\]  
(61)

Case 2: If \(X^F_x(\varphi) > 0\):

\[
\max_{\{p^2_x(\varphi), y^2_x(\varphi)\}} \left\{ \eta y^2_x(\varphi)p^2_x(\varphi) - TC_x(y^2_x(\varphi)) \right\}
\]  
(62)

\[
s.t. \quad y^2_x(\varphi) = \frac{Y_x}{P_x} \left(\frac{p^2_x(\varphi)}{P_x}\right)^{-\sigma}
\]  
(63)

\[
TC^2_x(y^2_x(\varphi)) = \frac{\tau}{\varphi \Psi b^\theta} y_x(\varphi) + (\eta (1 + r(\varphi)) (1 - \rho) + \rho) f_M + f_x
\]  
(64)

By plugging in the demand function:

\[
\max_{\{p^2(\varphi)\}} \left\{ \eta p^2_x(\varphi) \frac{Y_x}{P_x} \left(\frac{\varphi^2(\varphi)}{P_x}\right)^{-\sigma} \right. \\
\left. - \frac{\varphi \Psi b^\theta}{P_x} \frac{Y_x}{P_x} \left(\frac{\varphi^2(\varphi)}{P_x}\right)^{-\sigma} - (\eta (1 + r(\varphi)) (1 - \rho) + \rho) f_M - f_x \right\}
\]  
(65)

The FOC:

\[
\left(\eta (1 - \sigma) + \frac{\tau \sigma}{\varphi \Psi b^\theta p^2_x(\varphi)}\right) \frac{Y_x}{P^1_{x-\sigma}} p^2_x(\varphi)^{-\sigma} = 0
\]  
(66)

from which the following price \(p^2_x(\varphi)\), quantity \(y^2_x(\varphi)\) and revenue \(q^2_x(\varphi)\) result:

\[
p^2_x(\varphi) = \frac{\sigma}{\eta (\sigma - 1) \varphi \Psi b^\theta} \frac{\tau}{\varphi \Psi b^\theta}
\]  
(67)
\[
y^2_x(\varphi) = \frac{Y}{P^{1-\sigma}} \left[ \frac{\sigma}{\eta (\sigma - 1)} \frac{\tau}{\varphi \Psi b^\phi} \right]^{-\sigma} \tag{68}
\]

\[
q^2_x(\varphi) = p^2_x(\varphi)y^2_x(\varphi) = \frac{Y}{P^{1-\sigma}} \left( \frac{\sigma}{\eta (\sigma - 1)} \frac{\tau}{\varphi \Psi b^\phi} \right)^{1-\sigma} \tag{69}
\]

3. Material costs and profits by the four frm types:

3.1. Domestic producer:

Case 1: \(X^F(\varphi) = 0\)

Material costs: the total material cost of the domestic producer using domestic intermediate input only:

\[
p^D X^D(\varphi) = \phi \left( \frac{p^D}{\varphi \Psi b^\phi} \right)^{\sigma - 1} \frac{Y}{P^{1-\sigma}} \left[ \frac{\sigma}{\sigma - 1} \frac{1}{\Psi \varphi} \right]^{-\sigma} \tag{70}
\]

The profits by definition is:

\[
\pi^1(\varphi) = p^1(\varphi)y^1(\varphi) - p^D X^D(\varphi) - f \tag{71}
\]

and by plugging in the \(p^1(\varphi), y^1(\varphi)\) and \(p^D X^D(\varphi)\) from (42), (43) and (70), we get:

\[
\pi^1(\varphi) = \frac{Y}{\sigma P^{1-\sigma}} \left( \frac{\sigma}{\sigma - 1} \frac{1}{\varphi \Psi} \right)^{1-\sigma} - f \tag{72}
\]

This profit function written with respect to revenue is:

\[
\pi^1(\varphi) = \frac{1}{\sigma} q^1(\varphi) - f \tag{73}
\]

Case 2: \(X^F(\varphi) > 0\) :
Material costs: the total material cost of the firm using both domestic and imported intermediate input is given by:

\[ p^D X^D(\varphi) + p^F X^F(\varphi) \]  
\[ = p^D X(\varphi) \frac{X^D(\varphi)}{X(\varphi)} + p^D X(\varphi) \frac{X^D(\varphi)}{X(\varphi)} \frac{p^F X^F(\varphi)}{p^D X^D(\varphi)} \]  
\[ = p^D X(\varphi) \frac{X^D(\varphi)}{X(\varphi)} \left( 1 + \frac{p^F X^F(\varphi)}{p^D X^D(\varphi)} \right) \]  
\[ = \lambda \phi y^2(\varphi) \frac{1}{b^2} \left( 1 + \frac{p^F X^F(\varphi)}{p^D X^D(\varphi)} \right) \]  
\[ = \frac{\phi}{\varphi \Psi} \frac{1 + \frac{a}{(1 + r^*)(1 - \rho) + \rho}}{1 + \frac{a}{(1 + r^*)(1 - \rho) + \rho} \frac{\sigma}{\sigma - 1}} y^2(\varphi) \]

By using (51), the expression in (74) can be rewritten as:

\[ p^D X^D(\varphi) + p^F X^F(\varphi) \]  
\[ = \frac{\phi}{\varphi \Psi} \frac{1 + \frac{a}{(1 + r^*)(1 - \rho) + \rho}}{1 + \frac{a}{(1 + r^*)(1 - \rho) + \rho} \frac{\sigma}{\sigma - 1}} Y^{1-a} \left( \frac{\sigma}{\eta (\sigma - 1) \frac{\varphi \Psi b^2}} \right)^{\sigma - 1} \]

The profit by definition is:

\[ \pi^2(\varphi) = \eta p^2(\varphi) y^2(\varphi) - \frac{1}{\varphi \Psi b^2} y^2(\varphi) - ((1 + r^*) (1 - \rho) + \rho) f_M - f \]  
\[ = \eta \frac{Y}{\sigma} \left( \frac{\sigma}{\eta (\sigma - 1) \varphi \Psi b^2} \right)^{1-\sigma} - ((1 + r^*) (1 - \rho) + \rho) f_M - f \]  
\[ = \frac{\eta}{\sigma} y^2(\varphi) - ((1 + r^*) (1 - \rho) + \rho) f_M - f \]  
\[ = \frac{\eta}{\sigma} y^2(\varphi) - ((1 + r^*) (1 - \rho) + \rho) f_M - f \]
### 3.2. Exporters:

**Case 1:** \( X^F(\varphi) = 0 \)

*Material costs:* the production for the export markets (79.1) and the total production (79.2) in the case of exporters imply the following material costs:

\[
\tau p^D X^D_x(\varphi) = \phi \frac{\tau}{\varphi \Psi} \frac{Y_x}{P_x^{1-\sigma}} \left[ \frac{\sigma}{\sigma - 1} \right]^{-\sigma} = \phi \frac{Y}{P^{1-\sigma}} \left( \frac{\tau}{\varphi \Psi} \right)^{1-\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{-\sigma} \tag{79.1}
\]

\[
\tau p^D X^D_x(\varphi) + p^D X^D_x(\varphi) = \phi \frac{Y}{P^{1-\sigma}} \left( \frac{\tau}{\varphi \Psi} \right)^{1-\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{-\sigma} + \phi \frac{Y}{P^{1-\sigma}} \left( \frac{\sigma}{\sigma - 1} \right)^{-\sigma} \left( \frac{1}{\varphi \Psi} \right)^{1-\sigma} \tag{79.2}
\]

The profit by definition is:

\[
\pi^1_x(\varphi) = (N - 1) p^1_x(\varphi) y^1_x(\varphi) - p^D X^D_x(\varphi) - f_x \tag{80}
\]

By plugging (59), (60) into (80) and collecting terms, we get the profit function:

\[
\pi^1_x(\varphi) = \frac{(N - 1) Y}{\sigma P^{1-\sigma}} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} - f_x \tag{81}
\]

which can be re-written in terms of the revenue by using the expression from (61):

\[
\pi^1_x(\varphi) = \frac{(N - 1)}{\sigma} q^1_x(\varphi) - f_x \tag{82}
\]

**Case 2:** If \( X^F(\varphi) > 0 \):

*Material costs:* of the exporters using both domestic and imported intermediate inputs
By using the expressions in (67) and (68), the resulting profit function is:

\[
\tau \left( p^D X^D_x(\varphi) + p^F X^F_x(\varphi) \right) = \tau p^D X_x(\varphi) \frac{X^D_x(\varphi)}{X_x(\varphi)} + \tau p^D X_x(\varphi) \frac{X^P_x(\varphi) p^F X^F_x(\varphi)}{X_x(\varphi) p^D X^D_x(\varphi)}
\]

\[
= \tau p^D X_x(\varphi) \frac{X^D_x(\varphi)}{X_x(\varphi)} \left( 1 + \frac{p^F X^F_x(\varphi)}{p^D X^D_x(\varphi)} \right)
\]

\[
= \lambda_x \phi^2 y_x^2(\varphi) \frac{X^D_x(\varphi)}{X_x(\varphi)} \left( 1 + \frac{p^F X^F_x(\varphi)}{p^D X^D_x(\varphi)} \right)
\]

\[
= \lambda_x \phi^2 y_x^2(\varphi) \frac{1}{\varphi \Psi} \left( 1 + \frac{\alpha}{(\eta + r(\varphi))(1 - \rho) + 1 + \xi} \right)
\]

\[
= \frac{\phi \tau}{\varphi \Psi} \left( 1 + \frac{\alpha}{(1 + r^*) (1 - \rho) + 1 + \xi} \right) \frac{y_x^2(\varphi)}{} \left( 1 + \frac{\alpha}{(1 + r^*) (1 - \rho) + 1 + \xi} \right)
\]

\[
= \frac{1 + \frac{\alpha}{(1 + r^*) (1 - \rho) + 1 + \xi}}{\varphi \Psi} Y \left[ \frac{\sigma}{\eta (\sigma - 1) \varphi \Psi \phi^2} \right]^{1 - \sigma} \frac{1}{\varphi \Psi} \left( 1 + \tau^{1 - \sigma} \right)
\]

The profit by definition is:

\[
\pi_x^2(\varphi) = \eta (N - 1) p_x^2(\varphi) y_x^2(\varphi) - \frac{\tau}{\varphi \Psi \phi^2} y_x^2(\varphi) - (\eta + r(\varphi))(1 - \rho) + \rho) f_M - f_x
\]
\[ \pi^2_x(\varphi) = \frac{\eta (N - 1) \sigma}{\sigma P^{1-\sigma}} \left( \frac{\sigma}{\eta (\sigma - 1) \varphi \psi b^\sigma} \right)^{1-\sigma} - (1 + r^*) (1 - \rho) + \rho \) f_M - f_x \] (86)

can be rewritten in terms of the revenue in (69) as:

\[ \pi^2_x(\varphi) = \frac{\eta q^2_x(\varphi) - (1 + r^*) (1 - \rho) + \rho \) f_M - f_x}{\sigma} \] (87)

4. Material cost to sales (MS) and sales to value added (SVA) ratios:

4.1.1. Domestic producer using only domestic input:

\[ MS^1 = p^D x^D(\varphi) \frac{Y}{q^1(\varphi)} = \frac{\phi Y}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right) \left( \frac{1}{\varphi \psi} \right)^{1-\sigma} = \phi \frac{\sigma - 1}{\sigma} \] (88)

\[ VAS^1 = 1 - MS^1 = 1 - \phi \frac{\sigma - 1}{\sigma} \] (89)

4.1.2. Domestic producer using domestic and imported intermediate input:

\[ MS^2 = \frac{p^D x^D(\varphi) + p^F x^F(\varphi)}{p^2(\varphi) y^2(\varphi)} = \frac{\phi}{\varphi \psi} \left( \frac{1 + \frac{a}{\xi \xi}(1 + r^*)^{1+\xi}}{(1 + \frac{a}{\xi \xi}(1 - \rho) + \rho)^{1+\xi}} \right)^{\frac{\phi}{\sigma} + 1} \left( \frac{1 + \frac{a}{\xi \xi}(1 + r^*)^{1+\xi}}{(1 + \frac{a}{\xi \xi}(1 - \rho) + \rho)^{1+\xi}} \right)^{\frac{\phi}{\sigma}} \] (90)

\[ \frac{\phi}{\varphi \psi} \left( \frac{1 + \frac{a}{\xi \xi}(1 + r^*)^{1+\xi}}{(1 + \frac{a}{\xi \xi}(1 - \rho) + \rho)^{1+\xi}} \right)^{\frac{\phi}{\sigma} + 1} = \frac{\eta \phi}{\sigma} \frac{1 + \frac{a}{\xi \xi}(1 + r^*)^{1+\xi}}{(1 + \frac{a}{\xi \xi}(1 - \rho) + \rho)^{1+\xi}} \] (91)

4.1.3. Exporters using domestic intermediate input have material cost generated by the export to sales ratio as described in (92.1), while total material cost to sales ratio as described
These imply a value added to sales ratio:

\[ V A S^1_x = 1 - M S^1_x = 1 - \frac{\sigma - 1}{\sigma} = 1 - M S^1 \]  

(93)

4.1.4. Exporters using domestic and imported intermediate input:

The material cost implied by export sales to share ratio in the case of exporters is given by (94.1), while the total material cost to sales ratio is given by (94.2):

\[ M S^2_x = \frac{\tau (p^D X^D_x (\varphi) + p^F X^F_x (\varphi))}{q^2_x (\varphi)} = \frac{\phi \tau}{\varphi \Psi} \frac{1_{\eta} + \frac{a}{(1+\rho)(1-\rho)+\eta} r}{1_{\eta} + \frac{a}{(1+\rho)(1-\rho)+\eta} r + \frac{a}{(1+\rho)(1-\rho)+\eta} r} y^2_x (\varphi) \]

(94.1)

\[ = \frac{\phi \tau}{\varphi \Psi} \frac{1_{\eta} + \frac{a}{(1+\rho)(1-\rho)+\eta} r}{1_{\eta} + \frac{a}{(1+\rho)(1-\rho)+\eta} r + \frac{a}{(1+\rho)(1-\rho)+\eta} r} \]

\[ = \eta \phi \frac{\sigma - 1}{\sigma} \]

\[ \frac{1_{\eta} + \frac{a}{(1+\rho)(1-\rho)+\eta} r}{1_{\eta} + \frac{a}{(1+\rho)(1-\rho)+\eta} r + \frac{a}{(1+\rho)(1-\rho)+\eta} r} \]

(94.2)
\[ MS^2 = \frac{p^D x^D(\varphi) + p^F x^F(\varphi) + \tau \left( p^D X^D(\varphi) + p^F X^F(\varphi) \right)}{q^2(\varphi) + q_x^2(\varphi)} \]

\[ = \phi \left( \frac{1}{(1 + \tau)(1 - \rho + \rho \xi)^{1+1}} \right)^{\frac{1}{q+1}} + \left( \frac{1}{(1 + \tau)(1 - \rho + \rho \xi)^{1+1}} \right)^{\frac{1}{q+1}} T^{1-\sigma} \]

\[ = \phi \frac{\sigma - 1}{\sigma} \frac{1}{1 + \frac{a}{(1 + \tau)(1 - \rho + \rho \xi)^{1+1}}} \]

Thus, the value added to sales ratio is:

\[ VAS^2_x = 1 - MS^2_x = 1 - \eta \phi \frac{\sigma - 1}{\sigma} \frac{1}{1 + \frac{a}{(1 + \tau)(1 - \rho + \rho \xi)^{1+1}}} \]

\[ = 1 - MS^2 \]

5. Productivity cutoffs:

We define cutoff productivities \( \varphi^1, \varphi^2, \varphi^3, \varphi_x^1, \varphi_x^2, \varphi_x^3 \) such that in case (i) \( \forall \varphi \in (0, \varphi^1) \) productivity draw firms decide to exit the market, \( \forall \varphi \in (\varphi^1, \varphi_x^1) \) firms stay in the market, produce and sell on the domestic market by using domestic intermediate input only, \( \forall \varphi \in (\varphi_x^1, \varphi_x^2) \) firms start to export by using domestic intermediate input only, \( \forall \varphi \in (\varphi_x^2, 1) \) firms sell on the domestic market and export by using both domestic and imported intermediate inputs; in case (ii) \( \forall \varphi \in (0, \varphi^2) \) productivity draw firms decide to exit the market, \( \forall \varphi \in (\varphi^2, \varphi_x^2) \) firms stay in the market, produce and sell on the domestic market by using only domestic intermediate input, \( \forall \varphi \in (\varphi_x^2, \varphi_x^3) \) firms stay in the market, produce and sell on the domestic market by using both domestic and imported intermediate inputs, \( \forall \varphi \in (\varphi_x^3, 1) \) firms start to export by using both domestic and imported intermediate inputs.

In case (i) the three cutoff productivities \( \varphi^1, \varphi_x^1, \varphi_x^2 \) are pinned down by the following
system of equations:

\[
\begin{align*}
\pi^1(\varphi^1) &= 0 \quad (96) \\
\pi^1(\varphi_x^1) &= \pi^1(\varphi_x^1) + \pi^1_x(\varphi_x^1) \quad (97) \\
\pi^1(\varphi_x^2) + \pi^1_x(\varphi_x^2) &= \pi^2(\varphi_x^2) + \pi^2_x(\varphi_x^2) \quad (98)
\end{align*}
\]

\[
f_e = \left[ G(\varphi_x^2) - G(\varphi^1) \right] \sum_{t=0}^{\infty} (1 - \delta)^t \left\{ E \left[ \frac{1}{\sigma} q^1(\varphi) - f \right] \right\} + \\
+ \left[ G(\varphi_x^2) - G(\varphi_x^1) \right] \sum_{t=0}^{\infty} (1 - \delta)^t \left\{ E \left[ \frac{N - 1}{\sigma} q^1_x(\varphi) - f_x \right] \right\} + \\
+ \left[ 1 - G(\varphi_x^2) \right] \sum_{t=0}^{\infty} (1 - \delta)^t \left\{ E \left[ \frac{1}{\sigma} q^2(\varphi) + \frac{N - 1}{\sigma} q^2_x(\varphi) - f_x - f - ((1 + r^*)(1 - \rho) + \rho)f_M \right] \right\} 
\]

where equation (96) is the zero profit condition for producing for the domestic market such that firms with productivity draw $\varphi^1$ are indifferent between producing, selling on the domestic market and making profit $\pi^1(\varphi^1)$; equation (97) states that firms with productivity draw $\varphi_x^1$ are indifferent between producing by using only domestic intermediates, selling on the domestic market and making $\pi^1(\varphi_x^1)$ and producing by using only domestic intermediates, selling on both domestic and export markets with profit $\pi^1(\varphi_x^1) + \pi^1_x(\varphi_x^1)$; equation (98) states that firms with $\varphi_x^2$ are indifferent between producing for both the domestic and export market by using domestic intermediate input only and making $\pi^1(\varphi_x^2) + \pi^1_x(\varphi_x^2)$, and producing for both markets by using both domestic and imported intermediate inputs making $\pi^2(\varphi_x^2) + \pi^2_x(\varphi_x^2)$ profit; equation (99) is the free entry condition according to which firms that decide to enter the market must get in expectation at least as much profit that covers the sunk cost of entry, $f_e$, based on which they learn their productivity.

By using the definition of profits we derived in (72), (77), (81) and (87), the equations
(96) - (99) can be rewritten:

\[
\frac{Y}{\sigma P^{1-\sigma}} \left( \frac{\sigma}{\sigma - 1} \frac{1}{\varphi^1 \Psi} \right)^{1-\sigma} = f \tag{96'}
\]

\[
\frac{(N - 1)Y}{\sigma P^{1-\sigma}} \left( \frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi^1 \Psi} \right)^{1-\sigma} = f_x \tag{97'}
\]

\[
\frac{Y}{\sigma P^{1-\sigma}} \left[ \frac{\sigma}{(\sigma - 1) \varphi^1_x \Psi} \right]^{1-\sigma} (1 + (N - 1) \tau^{1-\sigma}) \left[ \eta^\sigma b^{\phi(\sigma-1)} - 1 \right] = ((1 + r^*) (1 - \rho) + \rho) f_M \tag{98'}
\]

From (96') and (97') it follows that:

\[
\varphi^1_x \varphi^1 = \tau \left( \frac{f_x}{(N - 1) f} \right) \frac{1}{\tau^{1-\sigma}} \tag{100}
\]

From (97') and (98') it follows after some algebraic manipulations that:

\[
\frac{\varphi^2_x}{\varphi^1_x} = \frac{1}{\tau} \left( \frac{(1 + r^*) (1 - \rho) + \rho) f_M}{f_x (\eta^\sigma b^{\phi(\sigma-1)} - 1) (1 + (N - 1) \tau^{1-\sigma})} \right)^{1-\sigma} \tag{101}
\]

From (96') and (98') it follows after some algebraic manipulation that:

\[
\frac{\varphi^2_x}{\varphi^1_x} = \left( \frac{(1 + r^*) (1 - \rho) + \rho) f_M}{(N - 1) f (1 + (N - 1) \tau^{1-\sigma}) (\eta^\sigma b^{\phi(\sigma-1)} - 1)} \right)^{1-\sigma} \tag{102}
\]

By using equations (100), (102) and (99), we compute \( \varphi^1 \) as the function of model parameters as follows:

(i) We compute the discounted sums by using that \( \sum_{t=0}^{\infty} (1 - \delta)^t = \frac{1}{\delta} \) and substituting it
to (99):

\[
[\frac{G(\varphi_2) - G(\varphi_1)}{\delta}] \left[ \frac{1}{\sigma} q^1(\varphi) - f \right] + [\frac{G(\varphi_2) - G(\varphi_1)}{\delta}] \left[ \frac{N - 1}{\sigma} q^1_x(\varphi) - f_x \right] +
\]

\[
+ [1 - G(\varphi_2)] \left[ \frac{1}{\sigma} q^2(\varphi) + \frac{N - 1}{\sigma} q^2_x(\varphi) - f_x - f - ((1 + r^*)(1 - \rho) + \rho f_M) \right] = f_e
\]

(ii) We compute the expected values as follows:

\[
E \left[ \frac{1}{\sigma} q^1(\varphi) - f \right] = \int_{\varphi_2}^{\varphi_1} \left[ \frac{1}{\sigma} q^1(\varphi) - f \right] \frac{g(\varphi)}{G(\varphi_2) - G(\varphi_1)} d\varphi
\]

\[
E \left[ \frac{N - 1}{\sigma} q^1_x(\varphi) - f_x \right] = \int_{\varphi_2}^{\varphi_1} \left[ \frac{N - 1}{\sigma} q^1_x(\varphi) - f_x \right] \frac{g(\varphi)}{G(\varphi_2) - G(\varphi_1)} d\varphi
\]

\[
E \left[ \frac{N - 1}{\sigma} q^2(\varphi) + \frac{N - 1}{\sigma} q^2_x(\varphi) - f_x - f - ((1 + r^*)(1 - \rho) + \rho f_M) \right] = \int_{\varphi_2}^{\varphi_1} \left[ \frac{1}{\sigma} q^2(\varphi) + \frac{N - 1}{\sigma} q^2_x(\varphi) - f_x - f - ((1 + r^*)(1 - \rho) + \rho f_M) \right] \frac{g(\varphi)}{[1 - G(\varphi_2)]} d\varphi
\]

and substitute them into the equation in (i) we get:

\[
f_{\varphi_2}^{\varphi_1} \left[ \frac{1}{\sigma} q^1(\varphi) - f \right] g(\varphi) d\varphi + f_{\varphi_2}^{\varphi_1} \left[ \frac{N - 1}{\sigma} q^1_x(\varphi) - f_x \right] g(\varphi) d\varphi +
\]

\[
+ f_{\varphi_2}^{\infty} \left[ \frac{1}{\sigma} q^2(\varphi) + \frac{N - 1}{\sigma} q^2_x(\varphi) - f_x - f - ((1 + r^*)(1 - \rho) + \rho f_M) \right] g(\varphi) d\varphi = \delta f_e
\]

(iii) By substituting the Pareto pdf \( g(\varphi) = \frac{k_\varphi}{\varphi^{k_\varphi + 1}} \) and the revenue functions \( q^1(\varphi), q^1_x(\varphi), q^2(\varphi) \) and \( q^2_x(\varphi) \) from (44), (52), (61) and (69), we compute the LHS of the expression in
(ii):

\[
\frac{1}{\sigma} \frac{Y}{P^{1-\sigma}} \frac{k \varphi_m^k}{k - (\sigma - 1)} \left( \frac{\sigma}{(\sigma - 1) \psi} \right)^{1-\sigma} \left[ (\varphi^1)^{(\sigma-1)-k} - (\varphi^1_{x})^{(\sigma-1)-k} \right] \\
+ \frac{1}{\sigma} \frac{Y}{P^{1-\sigma}} \frac{k \varphi_m^k}{k - (\sigma - 1)} \left( \frac{\sigma}{(\sigma - 1) \psi} \right)^{1-\sigma} \left( N - 1 \right)^{\tau - 1} \left[ (\varphi^1_x)^{(\sigma-1)-k} - (\varphi^1_{x})^{(\sigma-1)-k} \right] \\
+ \frac{1}{\sigma} \frac{Y}{P^{1-\sigma}} \frac{k \varphi_m^k}{k - (\sigma - 1)} \left( \frac{\sigma}{\eta (\sigma - 1) \psi b^\phi} \right)^{1-\sigma} \left[ (\varphi^2_{x})^{(\sigma-1)-k} + (N - 1)\tau - 1 \left( \varphi^2_{x})^{(\sigma-1)-k} \right) \right] \\
= \delta f_e + f [1 - G(\varphi^1)] + f_x [1 - G(\varphi^1_x)] + ((1 + r^*)(1 - \rho) + \rho) f_M [1 - G(\varphi^2_{x})]
\]

(iv) By using the expressions for \( \varphi^1_x / \varphi^1 \) and \( \varphi^2_x / \varphi^1 \), the expression for \( Y/P^{1-\sigma} = f \sigma / (\varphi^1)^{\sigma - 1} \left( \frac{\sigma}{(\sigma-1) \psi} \right) \) resulted from (96) and the Pareto cdf \( G(\varphi) = 1 - \left( \frac{\varphi}{\varphi_m} \right)^k \), we can write the equation in (iii) in terms of \( \varphi^1 \):

\[
\frac{fk}{k - (\sigma - 1)} \left[ 1 - \left( \frac{(1 + r^*) (1 - \rho) + \rho}{(N - 1) f (1 + (N - 1)\tau - 1) \left( \eta \sigma b^{\phi(\sigma - 1)} - 1 \right)} \right) \frac{(\sigma - 1)^k}{\sigma - 1} \right] (\varphi^1)^{-k} \\
+ \frac{\tau fk (N - 1)\tau - 1}{k - (\sigma - 1)} \left( \frac{f_x}{(N - 1) f} \right) \left( \frac{\sigma - 1}{\sigma - 1} \right) (\varphi^1)^{-k} \\
- \frac{fk (N - 1)\tau - 1}{k - (\sigma - 1)} \left( \frac{f_x}{(N - 1) f (1 + (N - 1)\tau - 1) \left( \eta \sigma b^{\phi(\sigma - 1)} - 1 \right)} \right) \frac{(\sigma - 1)^k}{\sigma - 1} (\varphi^1)^{-k} \\
+ \frac{\tau f_x (N - 1)\tau - 1}{k - (\sigma - 1)} \left( \eta b^\phi \right)^{\sigma - 1} \left[ \left( \frac{(1 + r^*) (1 - \rho) + \rho}{(N - 1) f (1 + (N - 1)\tau - 1) \left( \eta \sigma b^{\phi(\sigma - 1)} - 1 \right)} \right) \frac{(\sigma - 1)^k}{\sigma - 1} \right] (\varphi^1)^{-k} \\
= \delta f_e + f (\varphi^1)^{-k} + f_x \left( \tau \left( \frac{f_x}{(N - 1) f} \right) \right) (\varphi^1)^{-k} \\
+ ((1 + r^*)(1 - \rho) + \rho) f_M \left( \frac{(1 + r^*) (1 - \rho) + \rho}{(N - 1) f (1 + (N - 1)\tau - 1) \left( \eta \sigma b^{\phi(\sigma - 1)} - 1 \right)} \right) \frac{1}{(\varphi^1)^{-k}}
\]

We solve for \( \varphi^1 \) by denoting the terms independent of \( r^* \) by \( \Delta \) in order to simplify notation:

\[
(\varphi^1)^k = \Delta_1 + \Delta_2 \left( \frac{\eta \sigma b^{\phi(\sigma - 1)} - 1}{((1 + r^*) (1 - \rho) + \rho) f_M} \right)^{\frac{k - (\sigma - 1)}{\sigma - 1}} \{ \Delta_3 \eta \sigma b^{\phi(\sigma - 1)} + \Delta_4 \}
\]
where $\Delta_1 = \phi_k \left[ \frac{f(\sigma-1)}{\delta f_e k^{-\sigma}} + \frac{(N-1)f}{\delta f_e} \left( \frac{k}{(N-1)f(\sigma-1)} - \tau \right) \right]$, 
\[ \Delta_2 = \frac{\phi_k}{\delta f_e} \left( (N-1)f \right) \left( 1 + (N-1)\tau^{1-\sigma} \right) \left[ (N-1)f(1 + (N-1)\tau^{1-\sigma}) \right]^{\frac{k-(\sigma-1)}{\sigma-1}}, \]
\[ \Delta_3 = \frac{\phi_k}{\delta f_e} \left( \frac{k-\eta}{\eta(N-1)(k-(\sigma-1))} \right), \Delta_4 = \frac{\phi_k}{\delta f_e} \left( \frac{(N-1)(k-(\sigma-1))}{(N-1)(k-(\sigma-1))} \right). \]

(v) Once we solved for $\varphi^1$, we can easily solve for $\varphi^1_x$ and $\varphi^2_x$ by using equations (100) and (102).

In case (ii), the three cutoff productivities $\varphi^2, \varphi^3, \varphi^3_x$ are pinned down by the following system of equations:

\[ \pi^1(\varphi^2) = 0 \]  \hspace{1cm} (104)
\[ \pi^1(\varphi^3) = \pi^2(\varphi^3) \]  \hspace{1cm} (105)
\[ \pi^2(\varphi^3_x) = \pi^2(\varphi^3_x) + \pi^2(\varphi^3) \]  \hspace{1cm} (106)

\[ -f_e + [G(\varphi^3) - G(\varphi^2)] \sum_{t=0}^{\infty} (1 - \delta)^t \left\{ E \left[ \frac{1}{\sigma} q^1(\varphi) - f \right] \right\} + \]
\[ + [1 - G(\varphi^3)] \sum_{t=0}^{\infty} (1 - \delta)^t \left\{ E \left[ \frac{1}{\sigma} q^2(\varphi) - f - ((1 + r^*)(1 - \rho) + \rho)f_M \right] \right\} + \]
\[ + [1 - G(\varphi^3_x)] \sum_{t=0}^{\infty} (1 - \delta)^t \left\{ E \left[ \frac{N-1}{\sigma} q^2_x(\varphi) - f_x \right] \right\} \]

\[ = 0 \]  \hspace{1cm} (107)

where equation (104) is the zero profit condition for producing for the domestic market such that firms with productivity draw $\varphi^2$ are indifferent between selling on the domestic market and exiting; equation (105) states that firms with productivity draw $\varphi^3$ are indifferent between using only domestic intermediate inputs and selling on the domestic market, and using both inputs and selling on the domestic market; equation (106) states that firms with $\varphi^3_x$ are indifferent between producing for the domestic market by using both intermediate inputs, and producing for both markets by using both domestic and imported intermediate inputs. Equation (107) is the free entry condition.
By using the definition of profits we derived in (73), (77), (82) and (87), the equations (104) - (106) can be rewritten:

\[
\frac{Y}{\sigma P^{1-\sigma}} \left( \frac{1}{\sigma - 1} \frac{1}{\varphi^2 \Psi} \right)^{1-\sigma} = f
\]  

\[104'\]

\[
\frac{Y}{\sigma P^{1-\sigma}} \left( \frac{1}{\sigma - 1} \frac{1}{\varphi^3 \Psi} \right)^{1-\sigma} = \frac{\eta Y}{\sigma P^{1-\sigma}} \left[ \frac{1}{\eta (\sigma - 1)} \frac{1}{\varphi^3 \Psi b^\phi} \right]^{1-\sigma} - ((1 + r^*) (1 - \rho) + \rho) f_M
\]  

\[105'\]

\[
\frac{\eta (N - 1) Y}{\sigma P^{1-\sigma}} \left( \frac{\tau}{\eta (\sigma - 1)} \frac{1}{\varphi^3 \Psi b^\phi} \right)^{1-\sigma} = (1 + r^*) (1 - \rho) + \rho) f_M + f_x
\]  

\[106'\]

From (104’) and (105’) it follows that:

\[
\frac{\varphi^3}{\varphi^2} = \left( \frac{(1 + r^*) (1 - \rho) + \rho) f_M}{f \eta b^\phi}$$(\sigma - 1) - 1) \right)^{\frac{1}{\sigma - 1}}
\]  

\[108\]

From (104’) and (106’) it follows after some algebraic manipulations that:

\[
\frac{\varphi^3_x}{\varphi^2} = \left( \frac{(1 + r^*) (1 - \rho) + \rho) f_M + f_x}{f (N - 1) \eta \sigma \phi}$$(\sigma - 1) - 1) \right)^{\frac{1}{\sigma - 1}}
\]  

\[109\]

From (105’) and (106’) it follows after some algebraic manipulation that:

\[
\frac{\varphi^3_x}{\varphi^3} = \left( \frac{((1 + r^*) (1 - \rho) + \rho) f_M + f_x}{((1 + r^*) (1 - \rho) + \rho) f_M (N - 1) \eta \sigma \phi}$$(\sigma - 1) - 1) \right)^{\frac{1}{\sigma - 1}}
\]  

\[110\]

By using equations (107), (108) and (109), we compute $\overline{\varphi^2}$ as the function of model parameters as follows:

(i) We compute the discounted sums by using that $\sum_{t=0}^{\infty} (1 - \delta)^t = \frac{1}{\delta}$ and substituting it to (107):
\[
\left[G(\varphi^3) - G(\varphi^2)\right] \frac{1}{\delta} E \left[\frac{1}{\sigma} q^1(\varphi) - f\right] + \\
\left[1 - G(\varphi^3)\right] \frac{1}{\delta} E \left[\frac{1}{\sigma} q^2(\varphi) - f - ((1 + r^*)(1 - \rho) + \rho)f_M\right] + \\
\left[1 - G(\varphi^3)\right] \frac{1}{\delta} E \left[\frac{N - 1}{\sigma} q^2_x(\varphi) - f_x\right] = f_e
\]

(ii) We compute the expected values as follows:

\[
E \left[\frac{1}{\sigma} q^1(\varphi) - f\right] = \int_{\varphi^3}^{\varphi^2} \left[\frac{1}{\sigma} q^1(\varphi) - f\right] \frac{g(\varphi)}{G(\varphi^3) - G(\varphi^2)} d\varphi
\]

\[
E \left[\frac{1}{\sigma} q^2(\varphi) - f - ((1 + r^*)(1 - \rho) + \rho)f_M\right] = \int_{\varphi^3}^{\varphi^2} \left[\frac{1}{\sigma} q^2(\varphi) - f - ((1 + r^*)(1 - \rho) + \rho)f_M\right] \frac{g(\varphi)}{1 - G(\varphi^3)} d\varphi
\]

\[
E \left[\frac{N - 1}{\sigma} q^2_x(\varphi) - f_x\right] = \int_{\varphi^3}^{\varphi^2} \left[\frac{N - 1}{\sigma} q^2_x(\varphi) - f_x\right] \frac{g(\varphi)}{1 - G(\varphi^3)} d\varphi
\]

and substitute them into the expression in (i) we get:

\[
\frac{1}{\sigma} \int_{\varphi^3}^{\varphi^2} q^1(\varphi) g(\varphi) d\varphi + \frac{1}{\sigma} \int_{\varphi^3}^{\varphi^2} q^2(\varphi) g(\varphi) d\varphi + \frac{N - 1}{\sigma} \int_{\varphi^3}^{\varphi^2} q^2_x(\varphi) g(\varphi) d\varphi = \delta f_e + (1 - G(\varphi^2)) f + f_x \left(1 - G(\varphi^3)\right) + ((1 + r^*)(1 - \rho) + \rho)f_M(1 - G(\varphi^3))
\]

(iii) By substituting the Pareto pdf \(g(\varphi) = \frac{ke^{-k\varphi}}{\varphi^{k+1}}\) and the revenue functions \(q^1(\varphi), q^1_x(\varphi), q^2(\varphi)\) and \(q^2_x(\varphi)\) from (44), (52), (61) and (69), we compute the LHS of the expression in
(ii):

\[
\frac{Y}{\sigma P^{1-\sigma}} \int_{\varphi_1}^{\varphi} \left[ \frac{\varphi}{\varphi - 1} \right]^{1-\sigma} g(\varphi) d\varphi + \frac{Y}{\sigma P^{1-\sigma}} \int_{\varphi}^{\infty} \left( \frac{1}{\eta(\sigma) - 1} \varphi^\psi \right)^{1-\sigma} g(\varphi) d\varphi
+ \frac{(N - 1) Y}{\sigma P^{1-\sigma}} \int_{\varphi}^{\infty} \left( \frac{\varphi}{\eta(\sigma) - 1} \varphi^\psi \right)^{1-\sigma} g(\varphi) d\varphi
= \delta f_x + \varphi_m^{\psi_1} f + \varphi_m^{\psi_2} f_x + \varphi_m^{\psi_3} ((1 + r)^*(1 - \rho) + \rho) f_M
\]

\[
\frac{Y}{\sigma P^{1-\sigma}} \frac{k \varphi_m^k}{k - (\sigma - 1)} \left( \frac{\varphi}{(\sigma - 1) \psi} \right)^{1-\sigma} \left\{ (\varphi^2)^{(\alpha - 1) - \kappa} - (\varphi^3)^{(\alpha - 1) - \kappa} \right\}
+ \frac{Y}{\sigma P^{1-\sigma}} \frac{k \varphi_m^k}{k - (\sigma - 1)} \left( \frac{\varphi}{\eta(\sigma) - 1} \varphi^\psi \right)^{1-\sigma} \left( \varphi^2 \right)^{(\alpha - 1) - \kappa}
+ \frac{(N - 1) Y}{\sigma P^{1-\sigma}} \frac{k \varphi_m^k}{k - (\sigma - 1)} \left( \frac{\varphi}{\eta(\sigma) - 1} \varphi^\psi \right)^{1-\sigma} \left( \varphi^3 \right)^{(\alpha - 1) - \kappa}
= \delta f_x + \varphi_m^{\psi_1} f + \varphi_m^{\psi_2} f_x + \varphi_m^{\psi_3} ((1 + r)^*(1 - \rho) + \rho) f_M
\]

(iv) By using the expressions for \( \varphi_1^{\sigma_1} / \varphi^1 \) and \( \varphi_2^{\sigma_2} / \varphi^1, \) and the expression for \( Y/P^{1-\sigma} = f \sigma / (\varphi^2)^{\sigma-1} (\sigma-1)^{1-\sigma} \) resulted from (104), we can write the equation in (iii) in terms of \( \varphi^2 : \)

\[
\frac{f k}{k - (\sigma - 1)} \left\{ 1 - \left( (1 + r^*) (1 - \rho) + \rho \right) \frac{f_M}{(\eta^\sigma b^\rho(\sigma - 1) - 1)} \right\}^{(\alpha - 1) - \kappa}
+ \frac{f k}{k - (\sigma - 1)} (\eta b^\rho)^{(\alpha - 1) - \kappa} \left( \frac{(1 + r^*) (1 - \rho) + \rho \right) \frac{f_M}{(\eta^\sigma b^\rho(\sigma - 1) - 1)}^{(\alpha - 1) - \kappa}
+ \frac{(N - 1) f k}{k - (\sigma - 1)} (\eta b^\rho)^{(\alpha - 1) - \kappa} \left( \frac{(1 + r^*) (1 - \rho) + \rho \right) \frac{f_M + f_x}{(\eta^\sigma b^\rho(\sigma - 1) - 1)}^{(\alpha - 1) - \kappa}
= \delta f_x + \varphi_m^{\psi_1} f + \varphi_m^{\psi_2} f_x + \varphi_m^{\psi_3} ((1 + r^*) (1 - \rho) + \rho) f_M
\]

We solve for \( \varphi^2 \) by denoting the terms independent of \( r^* \) in order to simplify notation\(^{26} \):

\[^{26} k((1 + r^*) (1 - \rho) + \rho) f_M > -k f_x (1 - \eta) - f_x \eta (\sigma - 1) \] always holds.
\begin{align*}
(\varphi^2)^k &= \Delta_5 + \Delta_6 \frac{((\eta^\sigma b^\phi - 1) \frac{k}{\sigma-1})}{[((1 + r^*) (1 - \rho) + \rho) f_M]^{\frac{k}{\sigma-1}}} \\
&\quad + \Delta_7 \frac{b^\phi}{k \frac{k}{\sigma-1}} \left\{ \frac{k (((1 + r^*) (1 - \rho) + \rho) f_M + f_x)}{f_x \eta (k - (\sigma - 1))} - 1 \right\}
\end{align*}

\Delta_5 = \frac{\varphi_m}{\delta f_e} f^{(\sigma-1)}(r^*, k, (\sigma-1)), \quad \Delta_6 = \frac{\varphi_m}{\delta f_e} f \frac{\sigma-1}{k \frac{\sigma-1}{k \cdot (\sigma-1)}}, \quad \Delta_7 = f_x [f (N - 1)]^{\frac{k}{\sigma-1}} \tau^{-k} \eta^{\sigma \phi_1}.

(v) Once we solved for \( \varphi^2 \), we can easily solve for \( \varphi^3 \) and \( \varphi^3_x \) by using equations (108) and (109).

6. Comparative statics:

Proof of Proposition 1:

From (90) we know that the material to sales ratio of the producers using both domestic and imported intermediate inputs is a function of \( r^* \) and it is given by

\[
MS^2 = \eta^\phi \frac{\sigma - 1 + az^{-1 - \xi}}{(1 + az^{-\xi})(1 + az^{-\xi} + \xi)}
\]

Change in the materials to sales ratio with respect to the change in \( r \) is given by (denote \( z = ((1 + r^*) (1 - \rho) + \rho) \)):

\[
dMS^2/dr^* = \frac{\partial}{\partial r^*} \left( \frac{\eta^\phi}{\sigma} \frac{\sigma - 1 + az^{-1 - \xi}}{1 + az^{-\xi}} \right)
= \eta^\phi \frac{\sigma - 1}{\sigma} \frac{(-1 - \xi) az^{-2 - \xi} (1 - \rho) (1 + az^{-\xi}) + \xi az^{-1 - \xi} (1 - \rho) (1 + az^{-1 - \xi})}{(1 + az^{-\xi})^2}
= \eta^\phi \frac{(\sigma - 1) (1 - \rho) az^{-1 - \xi}}{\sigma z (1 + az^{-\xi})^2} \left[ (-1 - \xi) (1 + az^{-\xi}) + \xi z (1 + az^{-1 - \xi}) \right]
= \eta^\phi \frac{(\sigma - 1) (1 - \rho) az^{-1 - \xi}}{\sigma z (1 + az^{-\xi})^2} \left[ -1 - \xi - \frac{a}{z^\xi} + \xi z \right]
\]

The sign of this expression depends on the sign of the \(-1 - \xi - \frac{a}{z^\xi} + \xi z\). If this latter expression is negative, then \( dMS^2/dr^* < 0 \). This happens if \( \xi z < 1 + \xi + \frac{a}{z^\xi} \). By using our notation, this is equivalent to \( b^\xi + \xi (1 - z) > 0 \). By plugging in \( z \), we get \( b^\xi + \xi (1 - z) = b^\xi - \xi (1 - \rho) r^* \). By using our assumption that \( 1 + \xi > 1, b^\xi > 1, 1 - \rho \in (0, 1) \) and \( r^* \in [0, 1] \),
it follows that if \( \xi \in (0, 1) \). This implies that \( \xi (1 - \rho) r^* \in (0, 1) \) and \( b^k > \xi (1 - \rho) r^* \). This implies \( \xi z < 1 + \frac{a}{z} \xi \) holds. Thus, we showed that \( dMS^2/dr^* < 0 \) \( \square \)

**Proof of Corollary 1**

Notice from Section 2.4 that \( VAS = 1 - MS \). Thus, the derivative of the sales to value added ratio with respect to \( r^* \) is:

\[
\frac{dVAS^2}{dr^*} = \frac{\partial VAS^2}{\partial MS^2} \frac{\partial MS^2}{\partial r^*} = -\frac{\partial MS^2}{\partial r^*}
\]

As it has been shown that \( dMS^2/dr^* < 0 \), it follows that \( dVAS^2/dr^* > 0 \) \( \square \)

**Proof of Proposition 2**

From equations (88) and (92.2) we know that the material to sales ratio of the producers using both domestic and imported intermediate inputs is a function of \( r^* \) and it is given by \( MS^2 = \eta \phi^\frac{\alpha - 1}{\sigma} \frac{1}{((1 + r^*)^{1/(1 - \rho)} + \rho)} \). From the proof of Proposition 1 we know that \( dMS^2/dr^* < 0 \). From equations (90) and (94.2) we know that the material to sales ratio of the producers using domestic intermediate inputs only is \( MS^1 = \phi^\frac{\alpha - 1}{\sigma} \). Thus, \( dMS^1/dr^* = 0 \), and it follows that \( |dMS^2/dr^*| < |dMS^1/dr^*| \).

By using the identity that \( VAS = 1 - MS \), it follows that \( |dVAS^2/dr^*| > |dVAS^1/dr^*| \) \( \square \)

**Proof of Proposition 3**

**case (i)**

Let \( A_1 = \left( \frac{\eta^\alpha b^{\phi(\sigma - 1)} - 1}{((1 + r^*)(1 - \rho) + \rho)} \right)^{\frac{k - (\sigma - 1)}{\sigma - 1}} \). As \( k > 0 \), \( \text{sign} \left( d \left( (\Xi^1)^k \right)/dr^* \right) = \text{sign} \left( d \left( (\Xi^1)^k \right)/dr^* \right) \).

\[
\frac{d((\Xi^1)^k)}{dr^*} = \Delta_2 \frac{dA_1}{dr^*} \left\{ \Delta_3 \eta^\alpha b^{\phi(\sigma - 1)} + \Delta_4 \right\} + \Delta_2 A_1 \Delta_3 \eta^\alpha b^{\phi(\sigma - 1)} - \frac{(1 - \rho)}{(1 + r^*)(1 - \rho)} \frac{d(b)}{dr^*}.
\]

\[
\frac{dA_1}{dr^*} = \frac{k - (\sigma - 1)}{\sigma - 1} A_1 \left[ \eta^\alpha \phi^\sigma - 1 \right] b^{\phi(\sigma - 1) - 1} \frac{d(b)}{dr^*} - \frac{(1 - \rho)}{(1 + r^*)(1 - \rho)} \frac{d(b)}{dr^*}
\]

which sign depends on \( \frac{d(b)}{dr^*} \) as \( k > (\sigma - 1) \), \( A_1 > 0 \) and \( \eta^\alpha \phi^\sigma - 1 > 0 \) given our assumptions on \( \sigma \) and \( \eta \). We know that \( b = \left[ 1 + \frac{a}{(1 + r^*)(1 - \rho) + \rho} \right] \left( \frac{p^0}{p^r} \right) \). Thus, \( \frac{d(b)}{dr^*} = -\frac{a(1 - \rho)b}{(a + (1 + r^*)(1 - \rho) + \rho)} \frac{(1 - \rho)}{(1 + r^*)(1 - \rho) + \rho} \leq 0 \) given our assumptions of \( \rho \in (0, 1) \). Thus, \( \frac{dA_1}{dr^*} < 0 \) and \( \frac{d(b)}{dr^*} < 0 \) imply that \( \frac{d((\Xi^1)^k)}{dr^*} < 0 \).
Now, we compute \((\varphi^2_x)^k\) by substituting \((\varphi^1)^k\) into:

\[
(\varphi^2_x)^k = (\varphi^1)^k \left( \frac{((1+r^*)(1-\rho)+\rho)f_M}{(N-1)(1+f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}} \right)^k_{\sigma-1}
\]

\[
= \frac{\Delta_1}{[(N-1)(1+f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}]^k} \left( \frac{((1+r^*)(1-\rho)+\rho)f_M}{(N-1)f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}} \right)^k_{\sigma-1}
\]

\[
+ \frac{\Delta_2}{[(N-1)(1+f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}]^k} \left( \frac{(1+r^*)(1-\rho)+\rho)f_M}{(N-1)f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}} \right) \{ \Delta_3 \eta^\sigma b^{(\sigma-1)} + \Delta_4 \}
\]

As \(k > 0\), \(\text{sign}(d(\varphi^2_x)/dr^*) = \text{sign} \left( d \left( \left( (\varphi^2_x)^k \right) /dr^* \right) \right)\). Let \(A_2 = \left( \frac{((1+r^*)(1-\rho)+\rho)f_M}{(N-1)f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}} \right)^k_{\sigma-1}
\)
and \(A_3 = \frac{((1+r^*)(1-\rho)+\rho)f_M}{(N-1)f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}}\). Thus,

\[
d(\varphi^2_x)^k_{dr^*} \quad \text{is given by: } d(\varphi^2_x)^k_{dr^*} = \frac{\Delta_1}{[(N-1)(1+f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}]^k} \frac{dA_2}{dr^*}
\]

\[
+ \frac{\Delta_2}{[(N-1)(1+f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}]^k} \frac{dA_3}{dr^*} \left\{ \Delta_3 \eta^\sigma b^{(\sigma-1)} + \Delta_4 \right\}
\]

\[
+ \Delta_2 A_3 \Delta_3 \eta^\sigma \phi(\sigma - 1) b^{(\sigma - 1)} \frac{d(b)}{dr^*} = \Delta_1 k A_2((1-\rho) f_M (\eta^\sigma b^{(\sigma-1)-1})^{-1})
\]

\[
= \frac{(\eta^\sigma b^{(\sigma-1)-1})\left( ((1+r^*)(1-\rho)+\rho) f_M(\sigma-1) \right) \left( (N-1)f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1} \right)^k}{\Delta_1 k A_2(\eta^\sigma b^{(\sigma-1)-1})^{-1} A_3} \frac{d(b)}{dr^*}
\]

\[
= \frac{\Delta_2 \left\{ \Delta_3 \eta^\sigma \phi(\sigma - 1) b^{(\sigma - 1)} + \Delta_4 \right\} (1-\rho) f_M}{\eta^\sigma b^{(\sigma-1)-1}}
\]

\[
+ \Delta_2 A_3 \Delta_3 \eta^\sigma \phi(\sigma - 1) b^{(\sigma - 1)} 1 \left( 1 - \frac{\{ \eta^\sigma b^{(\sigma-1)-1} + \frac{\Delta_4}{\Delta_3} \}}{\eta^\sigma b^{(\sigma-1)-1}} \right) \frac{d(b)}{dr^*}.
\]

We know that

\[
dA_2 = \frac{k^\sigma A_2 \left( \eta^\sigma b^{(\sigma-1)-1} \right) \left( (1-\rho) f_M \left( \eta^\sigma b^{(\sigma-1)-1} \right)^2 - ((1+r^*)(1-\rho)+\rho) f_M \eta^\sigma \phi(\sigma-1) b^{(\sigma-1)-1} \frac{d(b)}{dr^*} \right)_{\eta^\sigma b^{(\sigma-1)-1}}}{(N-1)f(1+(N-1)r^{1-\sigma})[\eta^\sigma b^{(\sigma-1)-1}]^{-1}} > 0
\]

since \(\frac{d(b)}{dr^*} < 0\).

\[
dA_3 = \frac{(1-\rho) f_M \left( \eta^\sigma b^{(\sigma-1)-1} \right) - ((1+r^*)(1-\rho)+\rho) f_M \eta^\sigma \phi(\sigma-1) b^{(\sigma-1)-1} \frac{d(b)}{dr^*}}{\eta^\sigma b^{(\sigma-1)-1}} > 0 \quad \text{since} \quad \frac{d(b)}{dr^*} < 0
\]

and \(\{ \eta^\sigma b^{(\sigma-1)-1} + \frac{\Delta_4}{\Delta_3} \} > (\eta^\sigma b^{(\sigma-1)-1} - 1) \left( (N-1)f(1+(N-1)r^{1-\sigma}) \right)^k_{\eta^\sigma b^{(\sigma-1)-1}} \) by our assumptions on the parameters. Thus,

\[
d\left( (\varphi^2_x)^k \right)_{dr^*} > 0.
\]

As \(k > 0\), \(\text{sign}(d(\varphi^2_x)/dr^*) = \text{sign} \left( d \left( \left( (\varphi^2_x)^k \right) /dr^* \right) \right)\). Denoting \(A_5 = \frac{k^\phi k}{((1+r^*)(1-\rho)+\rho)f_M+f_x}_{\sigma-1}\)
and \(A_6 = \frac{(\eta^\sigma b^{(\sigma-1)-1})^{\sigma-1}}{[((1+r^*)(1-\rho)+\rho)f_M]^{\sigma-1}}\),

\((\varphi^2)^k = \Delta_5 + \Delta_6 A_6 + \Delta_7 A_6 \left\{ \frac{k^\phi k ((1+r^*)(1-\rho)+\rho)f_M+f_x}{f_x\eta^\sigma b^{(\sigma-1)-1}} - 1 \right\}
\]

By taking the derivative with respect to \(r^*\):

\[
d\left( (\varphi^2_x)^k \right)_{dr^*} = \Delta_6 \frac{dA_6}{dr^*} + \Delta_7 \frac{dA_6}{dr^*} \left\{ \frac{k^\phi k ((1+r^*)(1-\rho)+\rho)f_M+f_x}{f_x\eta^\sigma b^{(\sigma-1)-1}} - 1 \right\} + \Delta_7 A_6 \frac{k^\phi k ((1-\rho)f_M)}{f_x\eta^\sigma b^{(\sigma-1)-1}} + \Delta_7 A_5 \frac{k^\phi k (1-\rho)f_M}{f_x\eta^\sigma b^{(\sigma-1)-1}}
\]

\[
= \Delta_6 \frac{dA_6}{dr^*} + \Delta_7 \frac{dA_6}{dr^*} \left\{ \frac{k^\phi k ((1+r^*)(1-\rho)+\rho)f_M+f_x}{f_x\eta^\sigma b^{(\sigma-1)-1}} - 1 \right\} + \Delta_7 A_5 \frac{k^\phi k (1-\rho)f_M}{f_x\eta^\sigma b^{(\sigma-1)-1}} + \Delta_7 A_5 \frac{k^\phi k (1-\rho)f_M}{f_x\eta^\sigma b^{(\sigma-1)-1}}
\]

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\[-\Delta_7 \frac{kk^b f_M (1-\rho)}{(\sigma-1)((1+r^*)(1-\rho)+\rho) f_M + f_x} \frac{k(1-\rho)}{f_x \eta (k-(\sigma-1))} \left\{ \frac{k((1+r^*)(1-\rho)+\rho) f_M + f_x}{f_x \eta (k-(\sigma-1))} - 1 \right\} \]

\[+ \Delta_7 \frac{b^k}{[(1+r^*)(1-\rho)+\rho) f_M + f_x]} \frac{k(1-\rho)}{f_x \eta (k-(\sigma-1))} \]

We already showed that \(\frac{dA_4}{dr^*} < 0, \frac{d(b)}{dr^*} < 0\). We compute and sign

\[
\frac{dA_5}{dr^*} = \frac{\phi k b^k}{[(1+r^*)(1-\rho)+\rho) f_M + f_x]} \frac{d(b)}{dr^*} - \frac{\phi k b^k}{[(1+r^*)(1-\rho)+\rho) f_M + f_x]} \frac{k(1-\rho)}{f_x \eta (k-(\sigma-1))} < 0
\]

since \(\frac{d(b)}{dr^*} < 0\).

Also, we compute and sign

\[
\frac{dA_6}{dr^*} = \frac{k}{\sigma-1} (\sigma^b b^b (\sigma-1)-1) \frac{d(b)}{dr^*} - \frac{k}{\sigma-1} (\sigma^b b^b (\sigma-1)-1) \frac{k(1-\rho)}{f_x \eta (k-(\sigma-1))} < 0
\]

since \(\frac{d(b)}{dr^*} < 0\). Based on this we can easily see that \(\frac{d((\sigma^2)^k)}{dr^*} < 0\) since \(f_x \eta (k-(\sigma-1)) < 0\) and \((1+r^*)(1-\rho)+\rho) f_M + f_x\) always hold as

\[
k ((1+r^*)(1-\rho)+\rho) f_M + f_x > f_x \eta (k-(\sigma-1))
\]

under case 1 productivity ranking.

We compute \((\sigma^3)^k\) as follows:

\[
(\sigma^3)^k = (\sigma^2)^k \left( \frac{((1+r^*)(1-\rho)+\rho) f_M}{f (\sigma^b b^b (\sigma-1)-1)} \right)^{k-1} f_x \eta (k-(\sigma-1)) \]

\[
= \Delta_5 A_2 + \Delta_6 \frac{f_M}{\sigma-1} ((1+r^*)(1-\rho)+\rho) + \Delta_7 A_7 \left[ \frac{k((1+r^*)(1-\rho)+\rho) f_M + f_x}{f_x \eta (k-(\sigma-1))} - 1 \right]
\]

where \(A_2 = \left( \frac{((1+r^*)(1-\rho)+\rho) f_M}{f (\sigma^b b^b (\sigma-1)-1)} \right)^{k-1}\), \(A_7 = \frac{b^k ((1+r^*)(1-\rho)+\rho) f_M}{f^2 (\sigma^b b^b (\sigma-1)-1) \sigma-1} \frac{k}{f_x \eta (k-(\sigma-1))}\).

We compute the derivative:

\[
\frac{d((\sigma^3)^k)}{dr^*} = \Delta_5 \frac{dA_2}{dr^*} + \Delta_6 \frac{dM}{\sigma-1} (1-\rho)
\]

\[
+ \Delta_7 \frac{dA_7}{dr^*} \left[ \frac{k((1+r^*)(1-\rho)+\rho) f_M + f_x}{f_x \eta (k-(\sigma-1))} - 1 \right] + \Delta_7 A_7 \frac{k(1-\rho) f_M}{f_x \eta (k-(\sigma-1))}
\]

We already showed that \(\frac{dA_2}{dr^*} > 0\) and based on our assumption on the model parameters we know that \(\Delta_6 \frac{dM}{\sigma-1} (1-\rho) > 0\) and \(\Delta_7 A_7 \frac{k(1-\rho) f_M}{f_x \eta (k-(\sigma-1))} > 0\).

\[
\frac{dA_7}{dr^*} = \frac{d(b)}{\sigma-1} \frac{b^k ((1+r^*)(1-\rho)+\rho) f_M}{f^2 (\sigma^b b^b (\sigma-1)-1) \sigma-1} \frac{k}{f_x \eta (k-(\sigma-1))} \frac{d(b)}{dr^*}
\]

\[
+ \frac{k}{\sigma-1} \frac{b^k ((1+r^*)(1-\rho)+\rho) f_M}{f^2 (\sigma^b b^b (\sigma-1)-1) \sigma-1} \frac{k}{f_x \eta (k-(\sigma-1))} \frac{d(b)}{dr^*}
\]

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ranking, it follows that \( \frac{d\Delta x}{dr^*} > 0 \). Thus, \( \frac{d\left( \frac{\pi^3}{r} \right)^k}{dr^*} > 0 \).

We compute \( \left( \frac{\pi^3}{r} \right)^k \) as follows:

\[
\left( \frac{\pi^3}{r} \right)^k = \Delta_5 \left( \frac{((1+r^*)(1-\rho)+\rho)f_{M}+f_{x}}{f(N-1)} \eta^{\sigma}(\pi^3)^{-1}(1-\sigma) \right) - \Delta_6 \frac{1}{f(N-1)^{1-\sigma}} \left( \frac{((1+r^*)(1-\rho)+\rho)f_{M}+f_{x}}{\eta^{\sigma}(\pi^3)^{-1}(1-\sigma)} \right)
\]

The derivative \( \frac{d\left( \frac{\pi^3}{r} \right)^k}{dr^*} \) is given by:

\[
\frac{d\left( \frac{\pi^3}{r} \right)^k}{dr^*} = \Delta_5 \frac{dA_8}{dr^*} + \Delta_6 \frac{1}{f(N-1)^{1-\sigma}} \left( \frac{((1+r^*)(1-\rho)+\rho)f_{M}+f_{x}}{\eta^{\sigma}(\pi^3)^{-1}(1-\sigma)} \right) - \Delta_7 \frac{1}{f(N-1)^{1-\sigma}} \left( \frac{((1+r^*)(1-\rho)+\rho)f_{M}+f_{x}}{\eta^{\sigma}(\pi^3)^{-1}(1-\sigma)} \right)
\]

where

\[
\frac{dA_8}{dr^*} = \frac{k}{\sigma-1} \left( \frac{((1+r^*)(1-\rho)+\rho)f_{M}+f_{x}}{f(N-1)} \right)^{-1} \frac{k}{\pi^3} \frac{f(N-1)}{\eta^{\sigma}(\pi^3)^{-1}(1-\sigma)} \frac{(1-\rho)f_{M}f(N-1)}{\eta^{\sigma}(\pi^3)^{-1}(1-\sigma)} \frac{d\left( \frac{\pi^3}{r} \right)^k}{dr^*}
\]

\[
\frac{dA_9}{dr^*} = \frac{1}{f(N-1)^{1-\sigma}} \left( \frac{((1+r^*)(1-\rho)+\rho)f_{M}+f_{x}}{\eta^{\sigma}(\pi^3)^{-1}(1-\sigma)} \right) - \frac{1}{f(N-1)^{1-\sigma}} \left( \frac{((1+r^*)(1-\rho)+\rho)f_{M}+f_{x}}{\eta^{\sigma}(\pi^3)^{-1}(1-\sigma)} \right)
\]

since \( b^{\phi(\sigma-1)} > \eta^{\sigma}b^{\phi(\sigma-1)} \) and \( \frac{((1+r^*)(1-\rho)+\rho)f_{M}}{k(1+(1+r^*)(1-\rho)+\rho)f_{M}+f_{x}} > 1 \) in case (ii) productivity ranking.

A.2 Data Appendix

1. Confidential micro data
1.1. *The balance sheet* data at the firm level are coming from the Hungarian Central Statistical Office. The data are collected by the Hungarian Fiscal Authority based on the annual Financial Reports that firms with double-entry bookkeeping must submit at the end of each fiscal year (end of December of the calendar year). The financial reports contain information on balance sheets and income statements of all operating firms in Hungary with double-entry bookkeeping. In this paper we use the following variables at firm-year unit of observation:

*Industry:* each firm reports a 4-digit NACE industry code based on its main economic activity; *Sales:* the total domestic and export sales reported in 1000 Hungarian forints, at current prices; *Materials:* total cost of material reported in 1000 Hungarian forints, at current prices; *Value added:* computed as the difference between total sales and material costs in 1000 Hungarian forints, at current prices; *Accounts payable:* total obligations to pay off as short-term debt to non-bank creditors reported in 1000 Hungarian forints, at current prices; *Short term credit:* total obligations to pay off as short-term debt to bank creditors reported in 1000 Hungarian forints, at current prices; *Accounts receivable:* payments expected to receive for the outstanding amounts reported in 1000 Hungarian forints, at current prices; *Number of employees:* number of workers employed by the firm in a given year.

1.2. Data on the *international trade transactions* of the Hungarian manufacturing firms are from the Hungarian Central Statistical Office. These data were collected by the Hungarian Custom Authority covering the whole universe of international trade transactions conducted by Hungarian firms. These data are reported at the firm level for each product classified at the 8-digit combined nomenclature (CN) in values and weights, for each country of origin/destination. The focus of this paper is on the following variables at firm-year-product-country of origin/destination unit of observation:

*Country of origin/destination:* country the imported product originates from in the case of imports or destination country of products shipped in the case of exports; *Product code:* combined nomenclature (CN) product code reported at the eight-digit level. CN
code is a European product classification with the first 6-digits corresponding to the World Harmonized System (HS-6); *Import*: total value of imports reported in 1000 Hungarian forints, at current prices; *Export sales*: total export sales reported in 1000 Hungarian forints, at current prices.

1.3. *Bank Account Numbers* Data on firms’ current account numbers are from a Hungarian private data provider, Wolters Kluwer Complex Kiado. The data is collected from the Hungarian Business Registry administered by the Hungarian Registry Court. The data are reported at the firm level and contain all the current account numbers of the firms, the date it was opened and closed in mm/dd/yy format. I use the first three numbers of the 24-digit current account number, in order to determine the bank at which the current account was opened. These numbers provide the GIRO code of the bank, the unique bank identifier set by the National Bank of Hungary.

2. *Publicly available data.*

1. *Input-Output Tables*

We use the Input-Output tables from year 2000 published by the Hungarian Central Statistical Office with 74 NACE 2-digit industry codes to identify firms in manufacturing sectors with 2 digit NACE codes ranging from 15 to 36.

2. *Product Concordances*

Imported intermediate inputs: are defined by using the correspondences\(^{27}\) between the Harmonized Commodity Description and Coding System, and Broad Economic Categories from the United Nations Intermediate Goods in Trade Statistics\(^{28}\). First, we create a concordance between the CN8 product codes reported in the Trade Data and the HS6 product codes used in the UN concordance tables which provides the BEC code for each HS6. I define intermediate imported input as the product with BEC codes: 111, 121, 21, 22, 31, 322, 42, 53.

\(^{27}\)For more details: http://unstats.un.org/unsd/cr/registry/regot.asp

3. Bank-level panel data

I use annual reports of the Hungarian Banking Association, the Hungarian Financial Supervisory Authority and the National Bank of Hungary on the development of the Hungarian financial sector to trace the ownership structure of the whole universe of commercial banks operating in Hungary between 1992-2006 by the unique GIRO identifier. I define a bank with domestic ownership if the previously listed reports provide the information that more than 50% of the banks’ shares were owned by Hungarian owner in a given year. Similarly, if more than 50% of the shares of the bank are owned by foreigners, I defined the bank as foreign owned.

By using the bank level panel data combined with the GIRO numbers recovered from the Bank Account Number data, we define two types of firms: firms banking with domestic banks and firms banking with foreign banks. Based on this, we define the following three dummy variables:

Banking with domestic bank only: variable takes value one if the firm had current account opened only at banks with domestic ownership and 0 otherwise; Banking with foreign bank only: variable takes value one if the firm had current account opened only at banks with foreign ownership and zero otherwise; Banking with both foreign and domestic bank: variable takes value one if the firm had current account opened at both types of banks and zero otherwise.

We obtain the dataset used in the paper by merging the dataset on firms’ balance sheets, international trade transactions and bank accounts based on the unique fiscal firm identifier, which then we merge to the bank-level panel data based on the unique bank identifier. We restrict the dataset to the sample of manufacturing firm and years 1998-2002. Manufacturing industries are defined according to NACE 2-digit industry codes ranging from 15 to 36 (i.e. excluding wholesalers, mining, services).

A.3 Results Appendix
Table 1.1  Average ratios by firms over the period 1998 - 2002

<table>
<thead>
<tr>
<th></th>
<th>Banking with domestic bank only</th>
<th>Banking with foreign bank only</th>
<th>Banking with both foreign and domestic bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value added to sales</td>
<td>0.395</td>
<td>0.349</td>
<td>0.192</td>
</tr>
<tr>
<td>Material cost to sales</td>
<td>0.605</td>
<td>0.651</td>
<td>0.818</td>
</tr>
<tr>
<td>Short term loan to sales</td>
<td>0.180</td>
<td>0.162</td>
<td>0.134</td>
</tr>
<tr>
<td>Payables to sales</td>
<td>0.130</td>
<td>0.141</td>
<td>0.175</td>
</tr>
<tr>
<td>Receivables to sales</td>
<td>0.163</td>
<td>0.176</td>
<td>0.147</td>
</tr>
<tr>
<td>Short term loan to material</td>
<td>0.299</td>
<td>0.249</td>
<td>0.248</td>
</tr>
<tr>
<td>Payables to material</td>
<td>0.216</td>
<td>0.217</td>
<td>0.214</td>
</tr>
<tr>
<td>Observations</td>
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<td>25,921</td>
<td>45,933</td>
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Table 1.2  Average ratios by firms over the period 1998 - 2002

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Importer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value added to sales</td>
<td>0.314</td>
<td>0.341</td>
</tr>
<tr>
<td>Material cost to sales</td>
<td>0.690</td>
<td>0.695</td>
</tr>
<tr>
<td>Short term loan to sales</td>
<td>0.157</td>
<td>0.173</td>
</tr>
<tr>
<td>Payables to sales</td>
<td>0.082</td>
<td>0.083</td>
</tr>
<tr>
<td>Receivables to sales</td>
<td>0.176</td>
<td>0.191</td>
</tr>
<tr>
<td>Short term loan to material</td>
<td>0.224</td>
<td>0.248</td>
</tr>
<tr>
<td>Payables to material</td>
<td>0.118</td>
<td>0.118</td>
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<td>0.244</td>
</tr>
<tr>
<td>Imported intermediate to sales</td>
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<td>25,636</td>
</tr>
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</table>
Table 2.1 The impact of liberalization on production and sales decisions - Baseline estimates

<table>
<thead>
<tr>
<th></th>
<th>Columns (1)</th>
<th>Columns (2)</th>
<th>Columns (3)</th>
<th>Columns (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>∆(Value added to sales)_{it}</td>
<td>∆(Value added to sales)_{it}</td>
<td>∆(Materials to sales)_{it}</td>
<td>∆(Materials to sales)_{it}</td>
</tr>
<tr>
<td>DB only_{i,2001}</td>
<td>-0.022**</td>
<td>-0.022**</td>
<td>0.027***</td>
<td>0.027***</td>
</tr>
<tr>
<td></td>
<td>[0.009]</td>
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<td>[0.008]</td>
<td>[0.008]</td>
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<tr>
<td>ln(empl)_{i,2001}</td>
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<td>0.003</td>
<td>0.025***</td>
<td>0.025***</td>
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<tr>
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<td>[0.002]</td>
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<td>[0.003]</td>
<td>[0.003]</td>
</tr>
<tr>
<td>Δln(empl)_{i,t}</td>
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<td>-0.002</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Industry FE</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
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<td>9,047</td>
<td>9,047</td>
<td>9,050</td>
<td>9,050</td>
</tr>
</tbody>
</table>

Note: The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. Banking with domestic bank only_{i,2001} is a dummy taking 1 if the firms did banking with domestic banks only in 2001. [] standard errors clustered at four-digit industry level; *** significant at 1%, ** significant at 5%. The estimation is based on a balanced panel of manufacturing firms.
Table 2.2 The impact of liberalization on financing decisions - Baseline estimates

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>∆(Short term loan to sales)_{it}</th>
<th>∆(Short term loan to sales)_{it}</th>
<th>∆(Payables to sales)_{it}</th>
<th>∆(Payables to sales)_{it}</th>
<th>∆(Receivables to sales)_{it}</th>
<th>∆(Receivables to sales)_{it}</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB only_{i,2001}</td>
<td>0.039***</td>
<td>0.039***</td>
<td>-0.001</td>
<td>-0.001</td>
<td>-0.004</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>[0.014]</td>
<td>[0.014]</td>
<td>[0.002]</td>
<td>[0.002]</td>
<td>[0.007]</td>
<td>[0.007]</td>
</tr>
<tr>
<td>ln(empl)_{i,2001}</td>
<td>-0.006**</td>
<td>-0.005**</td>
<td>0.0004</td>
<td>0.0004</td>
<td>-0.003***</td>
<td>-0.003***</td>
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<td>[0.003]</td>
<td>[0.001]</td>
<td>[0.001]</td>
<td>[0.001]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>Δln(empl)_{i,t}</td>
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<td>0.001</td>
<td></td>
<td>-0.018***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0.011]</td>
<td></td>
<td>[0.002]</td>
<td></td>
<td>[0.004]</td>
<td></td>
</tr>
<tr>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<td>9,052</td>
<td>9,052</td>
<td>9,050</td>
<td>9,050</td>
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</table>

Note: The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. Banking with domestic bank only_{i,2001} is a dummy taking 1 if the firms did banking with domestic banks only in 2001. [] robust standard errors clustered at four-digit industry level; *** significant at 1%, ** significant at 5%. The estimation is based on a balanced panel of manufacturing firms.
Table 2.3 The impact of liberalization on financing decisions - Baseline estimates

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Δ(Short term loan to material cost)_{it}</th>
<th>Δ(Short term loan to material cost)_{it}</th>
<th>Δ(Payables to material cost)_{it}</th>
<th>Δ(Payables to material cost)_{it}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>DB only_{i,2001}</td>
<td>0.084**</td>
<td>0.084**</td>
<td>-0.008**</td>
<td>-0.008**</td>
</tr>
<tr>
<td></td>
<td>[0.036]</td>
<td>[0.036]</td>
<td>[0.004]</td>
<td>[0.004]</td>
</tr>
<tr>
<td>ln(empl)_{i,2001}</td>
<td>-0.018</td>
<td>-0.017</td>
<td>-0.002**</td>
<td>-0.002**</td>
</tr>
<tr>
<td></td>
<td>[0.012]</td>
<td>[0.011]</td>
<td>[0.001]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>Δln(empl)_{i,t}</td>
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<td></td>
<td>0.003</td>
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<tr>
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<td>[0.034]</td>
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<td>[0.003]</td>
<td></td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
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<td>9,042</td>
<td>9,011</td>
<td>9,011</td>
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</table>

Note: The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. Banking with domestic bank only_{i,2001} is a dummy taking 1 if the firms did banking with domestic banks only in 2001. [ ] robust standard errors clustered at four-digit industry level; *** significant at 1%, ** significant at 5%. The estimation is based on a balanced panel of manufacturing firms.
Table 3.1 The impact of liberalization on production and sales decisions - Importers

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>$\Delta$(Import to sales)$_{it}$</th>
<th>$\Delta$(Import to sales)$_{it}$</th>
<th>$\Delta$(Imported input to sales)$_{it}$</th>
<th>$\Delta$(Imported input to sales)$_{it}$</th>
<th>$\Delta$(Domestic input to sales)$_{it}$</th>
<th>$\Delta$(Domestic input to sales)$_{it}$</th>
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</thead>
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<tr>
<td>(1)</td>
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<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td></td>
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<tr>
<td>DB only$_{i,2001}$</td>
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<td>0.016**</td>
<td>0.017***</td>
<td>0.017***</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>[0.008]</td>
<td>[0.008]</td>
<td>[0.006]</td>
<td>[0.006]</td>
<td>[0.011]</td>
<td>[0.011]</td>
</tr>
<tr>
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<td>0.001</td>
<td>-0.001</td>
<td>-0.001</td>
<td>0.004</td>
<td>0.004</td>
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<tr>
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<td>[0.002]</td>
<td>[0.002]</td>
<td>[0.002]</td>
<td>[0.002]</td>
<td>[0.003]</td>
<td>[0.003]</td>
</tr>
<tr>
<td>$\Delta$ln(empl)$_{i,t}$</td>
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<td>0.018***</td>
<td>-0.031</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0.007]</td>
<td>[0.005]</td>
<td>[0.019]</td>
<td></td>
<td></td>
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<td>Industry FE</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
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<td>2,614</td>
<td>2,614</td>
<td>2,614</td>
<td>2,614</td>
</tr>
</tbody>
</table>

Note: The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. Banking with domestic bank only$_{i,2001}$ is a dummy taking 1 if the firms did banking with domestic banks only in 2001. [] robust standard errors clustered at four-digit industry level; *** significant at 1%, ** significant at 5%. The estimation is based on a balanced panel of manufacturing firms.
Table 3.2 The impact of financial liberalization on financing decisions - Importers

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>∆(Short term loan to sales)_{it}</th>
<th>∆(Payables to sales)_{it}</th>
<th>∆(Receivables to sales)_{it}</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB only_{i,2001}</td>
<td>0.027**</td>
<td>0.004</td>
<td>-0.011</td>
<td>0.028**</td>
<td>0.004</td>
<td>-0.009</td>
<td>0.005</td>
<td>-0.010**</td>
<td>-0.010**</td>
</tr>
<tr>
<td>ln(empl)_{i,2001}</td>
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<td>-0.0002</td>
<td>-0.010**</td>
<td>0.004</td>
<td>0.0002</td>
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<td>0.005</td>
<td>0.004</td>
<td></td>
</tr>
<tr>
<td>∆ln(empl)_{i,t}</td>
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<td>-0.003</td>
<td>-0.065***</td>
<td>[0.015]</td>
<td>[0.005]</td>
<td>[0.015]</td>
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</table>

Note: The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. Banking with domestic bank only_{i,2001} is a dummy taking 1 if the firms did banking with domestic banks only in 2001. [] robust standard errors clustered at four-digit industry level; *** significant at 1%, ** significant at 5%. The estimation is based on a balanced panel of manufacturing firms.
Table 3.3 The impact of financial liberalization on financing decisions - Importers

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>$\Delta$(Short term loan to material cost)$_{it}$</th>
<th>$\Delta$(Short term loan to material cost)$_{it}$</th>
<th>$\Delta$(Payables to material cost)$_{it}$</th>
<th>$\Delta$(Payables to material cost)$_{it}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>DB only$_{i,2001}$</td>
<td>0.042**</td>
<td>0.043**</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>[0.019]</td>
<td>[0.019]</td>
<td>[0.008]</td>
<td>[0.010]</td>
</tr>
<tr>
<td>ln(empl)$_{i,2001}$</td>
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<td>0.003</td>
<td>-0.002</td>
<td>-0.002</td>
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<td>[0.006]</td>
<td>[0.002]</td>
<td>[0.002]</td>
</tr>
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<td>2,532</td>
<td>2,532</td>
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</table>

Note: The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. Banking with domestic bank only$_{i,2001}$ is a dummy taking 1 if the firms did banking with domestic banks only in 2001. [] robust standard errors clustered at four-digit industry level; *** significant at 1%; ** significant at 5%. The estimation is based on a balanced panel of manufacturing firms.
Table 4 The impact of financial liberalization on firms’ input imports market entry decisions

| Dependent variable | $P(I_t > 0 | I_{t-1} = 0)$ | $P(I_t > 0 | I_{t-1} = 0)$ | $P(I_t > 0 | I_{t-1} = 0)$ | $P(I_t > 0 | I_{t-1} = 0)$ |
|--------------------|---------------------------|---------------------------|---------------------------|---------------------------|
|                    | OLS                       | OLS                       | Probit                    | Probit                    |
|                    | (1)                       | (2)                       | (3)                       | (4)                       |
| DB only$_{i,2001}$ | 0.014***                  | 0.013**                  | 0.149***                  | 0.151***                  |
|                   | [0.005]                   | [0.006]                   | [0.051]                   | [0.051]                   |
| ln(empl)$_{i,2001}$| 0.006                     | 0.006                     | 0.061***                  | 0.062***                  |
|                   | [0.002]                   | [0.002]                   | [0.017]                   | [0.017]                   |
| $\Delta$ln(empl)$_{i,t}$| 0.0227***               |                           | 0.253***                  |
|                   | [0.0045]                  |                           | [0.046]                   |
| Industry FE       | yes                       | yes                       | yes                       | yes                       |
| Obs               | 10,403                    | 10,403                    | 10,403                    | 10,403                    |

Note: The dependent variable takes value one if the firm became an importer in 2002 relative to 2000, and zero otherwise. Banking with domestic bank only$_{i,2001}$ is a dummy taking 1 if the firms did banking with domestic banks only in 2001. *** significant at 1%, ** significant at 5%. 
Table 5.1  Alternative definition of the treatment group - whole sample

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>$\Delta$(Value added to sales)$_{it}$</th>
<th>$\Delta$(Materials to sales)$_{it}$</th>
<th>$\Delta$(Short term loan to sales)$_{it}$</th>
<th>$\Delta$(Payables to sales)$_{it}$</th>
<th>$\Delta$(Receivables to sales)$_{it}$</th>
<th>$\Delta$(Short term loan to material cost)$_{it}$</th>
<th>$\Delta$(Payables to material cost)$_{it}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB$_{i;2001}$</td>
<td>-0.020***</td>
<td>0.016***</td>
<td>0.035***</td>
<td>-0.001</td>
<td>0.001</td>
<td>0.066*</td>
<td>-0.007**</td>
</tr>
<tr>
<td></td>
<td>[0.006]</td>
<td>[0.005]</td>
<td>[0.010]</td>
<td>[0.002]</td>
<td>[0.004]</td>
<td>[0.037]</td>
<td>[0.003]</td>
</tr>
<tr>
<td>ln(empl)$_{i;2001}$</td>
<td>0.003***</td>
<td>0.023***</td>
<td>-0.004***</td>
<td>-0.0003</td>
<td>-0.002***</td>
<td>-0.006</td>
<td>-0.002***</td>
</tr>
<tr>
<td></td>
<td>[0.001]</td>
<td>[0.002]</td>
<td>[0.002]</td>
<td>[0.0004]</td>
<td>[0.0007]</td>
<td>[0.006]</td>
<td>[0.0007]</td>
</tr>
<tr>
<td>$\Delta$ln(empl)$_{i;t}$</td>
<td>0.028***</td>
<td>-0.001</td>
<td>-0.048***</td>
<td>0.0008</td>
<td>-0.015***</td>
<td>-0.099***</td>
<td>0.003***</td>
</tr>
<tr>
<td></td>
<td>[0.004]</td>
<td>[0.004]</td>
<td>[0.006]</td>
<td>[0.001]</td>
<td>[0.003]</td>
<td>[0.025]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>Obs</td>
<td>16,026</td>
<td>16,071</td>
<td>16,074</td>
<td>16,059</td>
<td>16,046</td>
<td>16,061</td>
<td>16,056</td>
</tr>
</tbody>
</table>

Table 5.2  Alternative definition of the treatment group - imports

| Dependent variable | $\Delta$(Import to sales)$_{it}$ | $\Delta$(Imported input to sales)$_{it}$ | $\Delta$(Domestic input to sales)$_{it}$ | $\Delta$(Short term loan to sales)$_{it}$ | $\Delta$(Payables to sales)$_{it}$ | $\Delta$(Receivables to sales)$_{it}$ | $\Delta$(Short term loan to material cost)$_{it}$ | $\Delta$(Payables to material cost)$_{it}$ |
|--------------------|----------------------------------|---------------------------------------|------------------------------------------|---------------------------------------|----------------------------------|--------------------------------|--------------------------------|--------------------------------|-------|
| DB$_{i;2001}$      | 0.005                            | 0.008**                               | 0.005                                    | 0.029**                               | -0.001                           | -0.003                           | 0.030**                          | -0.003                          |
|                    | [0.005]                           | [0.004]                                | [0.007]                                | [0.014]                               | [0.004]                           | [0.006]                           | [0.013]                           | [0.005]                          |
| ln(empl)$_{i;2001}$| -0.0007                           | -0.0006                               | 0.004**                                 | -0.007**                              | 0.0005                           | -0.003***                        | -0.002                           | -0.0005                         |
|                    | [0.001]                           | [0.001]                                | [0.002]                                | [0.003]                               | [0.008]                           | [0.001]                           | [0.003]                           | [0.001]                          |
| $\Delta$ln(empl)$_{i;t}$ | 0.018***                           | 0.011***                              | -0.039**                               | -0.064***                             | -0.003                           | -0.030***                        | -0.037***                        | 0.0004                          |
|                    | [0.006]                           | [0.003]                                | [0.015]                                | [0.017]                               | [0.004]                           | [0.008]                           | [0.018]                           | [0.005]                          |
| Obs                | 4,057                             | 4,057                                 | 3,310                                   | 3,942                                 | 3,839                            | 3,839                             | 3,921                             | 3,921                           |

Note: The sample contains a balanced panel of manufacturing firms over 1998-2002. The dependent variables are expressed as changes in the ratios from 2000 to 2002. DB$_{i;2001}$ is a dummy taking value one if the firm banks with domestic banks in 2001. [ ] standard errors clustered at four digit industry level. Industry fixed effects specified at four-digits industry level are included. **, * significant at 5%, and 10%.
<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>$\Delta$ (Value added to sales)$_{it-1}$</th>
<th>$\Delta$ (Materials to sales)$_{it-1}$</th>
<th>$\Delta$ (Short term loan to material cost)$_{it-1}$</th>
<th>$\Delta$ (Import to sales)$_{it-1}$</th>
<th>$\Delta$ (Imported input to sales)$_{it-1}$</th>
<th>$\Delta$ (Domestic input to sales)$_{it-1}$</th>
<th>$\Delta$ (Short term loan to material cost)$_{it-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td>DB only$_{i,2001}$</td>
<td>-0.007</td>
<td>0.004</td>
<td>-0.035</td>
<td>-0.003</td>
<td>-0.004</td>
<td>0.018**</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>[0.009]</td>
<td>[0.009]</td>
<td>[0.075]</td>
<td>[0.004]</td>
<td>[0.003]</td>
<td>[0.009]</td>
<td>[0.040]</td>
</tr>
<tr>
<td>ln(empl)$_{i,2001}$</td>
<td>-0.004***</td>
<td>0.004***</td>
<td>0.0007</td>
<td>0.029***</td>
<td>0.027***</td>
<td>-0.022***</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>[0.001]</td>
<td>[0.001]</td>
<td>[0.012]</td>
<td>[0.002]</td>
<td>[0.002]</td>
<td>[0.002]</td>
<td>[0.019]</td>
</tr>
<tr>
<td>Industry FE</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Obs</td>
<td>9,047</td>
<td>9,050</td>
<td>9,050</td>
<td>2,546</td>
<td>2,546</td>
<td>2,546</td>
<td>2,546</td>
</tr>
</tbody>
</table>

Note: The sample contains a balanced panel of manufacturing firms over 1998-2002. The dependent variables are expressed in level changes of ratios in 2000 relative to 1998. DB only$_{i,2001}$ is a dummy taking value one if the firms did banking with domestic banks only in 2001. [] clustered standard errors at four-digits industry level; *** significant at 1%** significant at 5%
<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>( \Delta (\text{Value added to sales})_{it} )</th>
<th>( \Delta (\text{Materials to sales})_{it} )</th>
<th>( \Delta (\text{Short term loan to sales})_{it} )</th>
<th>( \Delta (\text{Payables to sales})_{it} )</th>
<th>( \Delta (\text{Receivables to sales})_{it} )</th>
<th>( \Delta (\text{Short term loan to material cost})_{it} )</th>
<th>( \Delta (\text{Payables to material cost})_{it} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB only_Exporter_i,2001</td>
<td>0.046***</td>
<td>-0.054***</td>
<td>-0.015</td>
<td>0.012**</td>
<td>-0.0004</td>
<td>0.023</td>
<td>0.022**</td>
</tr>
<tr>
<td></td>
<td>[0.015]</td>
<td>[0.015]</td>
<td>[0.029]</td>
<td>[0.005]</td>
<td>[0.010]</td>
<td>[0.027]</td>
<td>[0.008]</td>
</tr>
<tr>
<td>DB only_i,2001</td>
<td>-0.036***</td>
<td>0.047***</td>
<td>0.043**</td>
<td>-0.004**</td>
<td>-0.003</td>
<td>-0.002</td>
<td>-0.015***</td>
</tr>
<tr>
<td></td>
<td>[0.012]</td>
<td>[0.010]</td>
<td>[0.019]</td>
<td>[0.002]</td>
<td>[0.007]</td>
<td>[0.017]</td>
<td>[0.004]</td>
</tr>
<tr>
<td>Exporter_i,2001</td>
<td>-0.021***</td>
<td>0.034***</td>
<td>-0.014</td>
<td>-0.003</td>
<td>0.004</td>
<td>-0.025**</td>
<td>-0.013***</td>
</tr>
<tr>
<td></td>
<td>[0.007]</td>
<td>[0.007]</td>
<td>[0.014]</td>
<td>[0.002]</td>
<td>[0.005]</td>
<td>[0.013]</td>
<td>[0.003]</td>
</tr>
<tr>
<td>ln(empl)_i,2001</td>
<td>0.005**</td>
<td>0.020***</td>
<td>-0.002</td>
<td>0.0004</td>
<td>-0.004***</td>
<td>-0.002</td>
<td>-0.0004</td>
</tr>
<tr>
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<td>[0.002]</td>
<td>[0.003]</td>
<td>[0.0006]</td>
<td>[0.001]</td>
<td>[0.003]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>( \Delta \text{ln(empl)}_{i,t} )</td>
<td>0.030***</td>
<td>-0.002</td>
<td>-0.046***</td>
<td>0.0005</td>
<td>-0.017***</td>
<td>-0.012</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>[0.005]</td>
<td>[0.006]</td>
<td>[0.010]</td>
<td>[0.001]</td>
<td>[0.004]</td>
<td>[0.009]</td>
<td>[0.002]</td>
</tr>
<tr>
<td>F-test</td>
<td>5.09</td>
<td>9.67</td>
<td>3.95</td>
<td>3.42</td>
<td>0.18</td>
<td>0.50</td>
<td>6.09</td>
</tr>
<tr>
<td>Industry FE</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Obs</td>
<td>9,047</td>
<td>9,050</td>
<td>9,009</td>
<td>9,009</td>
<td>9,050</td>
<td>9,030</td>
<td>9,011</td>
</tr>
</tbody>
</table>

Note: The sample contains a balanced panel of manufacturing firms over 1998-2002. The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. DB only\_i,2001 is a dummy taking 1 if the firms did banking with domestic banks only in 2001. Exporter is a dummy variable that takes value one if the firm registered positive export in 2001. DB only\_Exporter\_i,2001 is a the interaction term between DB only\_i,2001 and Exporter\_i,2001 dummy variables. [] clustered standard errors at four-digit industry level. *** significant at 1%, ** significant at 5%, * significant at 10%. F-test is on the joint significance of Exporter\_i,2001 and DB only\_Exporter\_i,2001 variables.
Table 7.2 Heterogeneity in the impact of financial liberalization across exporters vs. non-exporter importers

<table>
<thead>
<tr>
<th></th>
<th>( \Delta (\text{Import to sales})_{it} )</th>
<th>( \Delta (\text{Imported input to sales})_{it} )</th>
<th>( \Delta (\text{Domestic input to sales})_{it} )</th>
<th>( \Delta (\text{Short term loan to sales})_{it} )</th>
<th>( \Delta (\text{Payables to sales})_{it} )</th>
<th>( \Delta (\text{Receivables to sales})_{it} )</th>
<th>( \Delta (\text{Short term loan to material cost})_{it} )</th>
<th>( \Delta (\text{Payables to material cost})_{it} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td>DB only_Exporter(i,2001)</td>
<td>0.015</td>
<td>0.016</td>
<td>-0.034</td>
<td>-0.021</td>
<td>0.012</td>
<td>-0.010</td>
<td>-0.075</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>[0.017]</td>
<td>[0.017]</td>
<td>[0.030]</td>
<td>[0.028]</td>
<td>[0.012]</td>
<td>[0.019]</td>
<td>[0.057]</td>
<td>[0.021]</td>
</tr>
<tr>
<td>DB only(i,2001)</td>
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<td>0.002</td>
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<td>[0.021]</td>
<td>[0.011]</td>
<td>[0.018]</td>
<td>[0.049]</td>
<td>[0.018]</td>
</tr>
<tr>
<td>Exporter(i,2001)</td>
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<td>-0.011</td>
<td>0.038**</td>
<td>0.009</td>
<td>-0.006</td>
<td>0.0007</td>
<td>0.008</td>
<td>-0.018**</td>
</tr>
<tr>
<td></td>
<td>[0.011]</td>
<td>[0.009]</td>
<td>[0.017]</td>
<td>[0.011]</td>
<td>[0.004]</td>
<td>[0.008]</td>
<td>[0.021]</td>
<td>[0.006]</td>
</tr>
<tr>
<td>ln(empl)(i,2001)</td>
<td>0.001</td>
<td>-0.0005</td>
<td>0.002</td>
<td>-0.0002</td>
<td>0.0001</td>
<td>-0.003</td>
<td>-0.003</td>
<td>0.0008</td>
</tr>
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<td></td>
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<td>[0.002]</td>
<td>[0.005]</td>
<td>[0.003]</td>
<td>[0.001]</td>
<td>[0.002]</td>
<td>[0.006]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>(\Delta \text{ln(empl)}_{i,t})</td>
<td>0.03***</td>
<td>0.025***</td>
<td>-0.079</td>
<td>-0.047***</td>
<td>-0.002</td>
<td>-0.028**</td>
<td>-0.035</td>
<td>0.0065</td>
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<td>[0.006]</td>
<td>[0.031]</td>
<td>[0.013]</td>
<td>[0.005]</td>
<td>[0.010]</td>
<td>[0.024]</td>
<td>[0.006]</td>
</tr>
<tr>
<td>F-test</td>
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<td>1.56</td>
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<td>0.66</td>
<td>0.37</td>
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<td>0.83</td>
</tr>
<tr>
<td>Industry FE</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Obs</td>
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<td>2,733</td>
<td>2,733</td>
<td>2,733</td>
<td>2,849</td>
<td>2,799</td>
<td>2,855</td>
<td>2,798</td>
</tr>
</tbody>
</table>

Note: The sample contains manufacturing firms that were importers in 2001. The dependent variables are expressed in level changes of ratios in 2002 relative to the pre-liberalization period, 2000. DB only\(i,2001\) is a dummy taking 1 if the firms did banking with domestic banks only in 2001. Exporter is a dummy variable that takes value one if the firm registered positive export in 2001. DB only_Exporter\(i,2001\) is a interaction term between DB only\(i,2001\) and Exporter\(i,2001\) dummy variables. [] clustered standard errors at four-digit industry level. *** significant at 1%, ** significant at 5%, * significant at 10%. F-test is on the joint significance of Exporter\(i,2001\) and DB only_Exporter\(i,2001\) variables.
Chapter 3

International Financial Adjustment in a Canonical Open Economy Growth Model

3.1 Introduction

In influential work, Gourinchas and Rey (2007) have shown that international financial adjustment (IFA) in the expected returns on a country’s international investment portfolio as well as the expected path of the real exchange rate can complement or even substitute for the traditional adjustment channel via a narrowing of country’s ‘unsustainable’ current account imbalance. In their paper, GR derive this result using a log linearization of a net foreign asset accumulation identity without reference to any specific theoretical model of international financial adjustment in expected foreign asset returns or the real exchange rate. In this paper we calibrate the importance of IFA in a standard open economy growth model (Schmitt-Grohe and Uribe, 2003) with a well-defined steady level of foreign liabilities. In this model there is a country specific credit spread which varies as a function of the ratio
of foreign liabilities to GDP.\footnote{Devereux and Sutherland (2010) examined this question in a two country model in which the excess return arises from a risk premium in an asset-choice problem. They concluded the valuation channel could not be important in such a model, at least in the neighborhood of a non-stochastic steady state.}

We study a perfect foresight version of the model so that we can characterize the global dynamic adjustment in net foreign assets, the endogenous cost of debt service, and the path of the real exchange rate. This is important, because in this model, in a neighborhood of the steady state, IFA is not very important. However, away from the steady state – we look at simulations in which the initial stock of foreign debt is 10 percent above its steady state ratio to GDP and the initial capital stock is 10 percent below its steady state ratio to GDP – IFA is very important. In fact in our baseline simulation in which we calibrate the elasticity of the country credit spread to the debt to GDP ratio based on plausible empirical estimates from the literature as well as our own estimates, we find that allowing for an IFA channel results in a very rapid converge of the current account to its steady state (relative to the no IFA case) so that most of the time that the country is adjusting, all the adjustment is via forecastable changes in the costs of servicing debt and in the appreciation real exchange rate and none of the adjustment is in the current account. By contrast, in the no IFA case, current account adjustment by construction does all the work and current account adjustment is much slower. Finally we show that IFA adjustment via the real exchange rate can be important even if forecastable changes in the cost of debt service are not.

This paper is related to three strands of the recent international finance literature. First, it relates to the growing literature that studies the channels of international financial adjustment (Gourinchas and Rey, 2007, 2013). We contribute to this literature by measuring the relative importance of the trade and financial channels in a standard open economy growth model (Schmitt-Grohe and Uribe, 2003) with a well-defined steady level of foreign liabilities. This approach also sheds light on the mechanism through which the financial channel operates that is the financial externality faced by the representative household while making intertemporal borrowing decisions. Second, we contribute to the small open economy real
business cycle literature that studies the importance of country spread in the business cycle fluctuations of emerging economies (Mendoza, 1991; Schmitt-Grohe and Uribe, 2003, 2016; Neumeyer and Perri, 2005; Garcia-Cicco et al., 2010). We provide structural estimates of the elasticity of country spread with respect to the external debt position in the case of Central and Eastern European countries that are quantitatively larger than the calibration used by prior papers. However, our estimates are similar to the reduced form estimates found in the finance literature (Cantor and Packer, 1996; Eichengreen and Mody, 1998; Rowland and Torres, 2004; Hilscher and Nosbusch, 2010). Finally, we contribute to the quantitative real business cycle literature that focuses on developing approximation methods to small-scale DSGE models. We show that by solving for the global dynamics of the model under perfect foresight, without log-linearizing it, interesting non-linearities can be captured in the external adjustment of the small open economy in the long-run.

The rest of this chapter is organized as follows. Section 3.2 discusses the channels of international adjustment. Section 3.3 presents the theoretical framework, and Section 3.4 discusses the calibration. Section 3.5 presents the simulation results, while Section 3.6 concludes.

### 3.2 Channels of the Small Open Economy’s International Financial Adjustment

Countries can stabilize their net international investment position through two channels: the trade channel and the financial channel. As net foreign liabilities today must be compensated by trade surpluses in the future, the *trade channel* contributes to the external adjustment of the country by the adjustment in the value of the goods and services that the country imports or exports. However, the forecastable increase in the real returns on the net foreign assets or forecastable decrease in the real cost of servicing net international liabilities (i.e. the *financial channel*) can substitute for adjustment in trade flows. Thus, the *financial*
channel contributes to the external adjustment of the country through the adjustment in real interest rates and real exchange rates.

To illustrate this formally, we first derive a log-linearized version of the balance of payment accounting identity with gross international liability position, \( l_t \), and zero gross international asset position\(^2\):

\[
l_t = \rho (l_{t+1} - r_{t+1}) + (1 - \rho) nx_t
\]

where \( r_{t+1} \) is the interest payed on gross international liabilities, \( \rho \) is the discount rate and \( nx_t \) are net exports. Iterating forward on expression (1), the gross liability position of the country becomes:

\[
l_t = -\sum_{j=1}^{\infty} \rho^j r_{t+j} + nx_t + \sum_{j=1}^{\infty} \rho^j \Delta nx_{t+j}
\]

where the first term is the discounted sum of future returns, which captures all the international adjustments through the financial channel, the second and third terms are the discounted sum of future changes in the net exports, which captures the adjustment through the trade channel.

There is little empirical evidence on how important these channels are in countries’ international adjustment. Gourinchas and Rey (2007) find that about 27% of the cyclical international adjustment of the United States has been realized through the financial channel, primarily through a forecastable adjustment in the real exchange rate. But we do not have empirical evidence in the case of other countries such as Japan, UK or the Euro Zone. Moreover, we do not have any evidence on how important role these channels play in the case of emerging economies. Intuitively, we can expect that the financial channel may play an even more important role in the case of developing and emerging economies than it does in the case of developed ones, especially in the case of the emerging economies with larger external debt position.

The reduced form balance of payment identity allows for quantifying the size of the two

\(^2\)Section 1 of the Theory Appendix outlines the derivation of this log-linearized identity.
channels. However, it does not give any insight about how the real interest rate and real exchange rate channel interact with the trade channel. Moreover, as it is an identity and there is no micro-foundation behind it, it is not suitable for studying the mechanisms through which the trade and financial channels operate. Thus, the challenge is to find a theoretical machinery that rationalizes this resource constraint.

The small open economy real business cycle model rationalizes the intertemporal resource constraint in (1). This class of models augmented with endogenous interest and exchange rates provides a simple and elegant laboratory to understand how the financial and trade channels operate in an intertemporal framework that pins down the equilibrium path of the real cost of servicing international debt and the real cost of borrowing from the international markets. This framework also allows for studying the interaction between the trade and financial channel, and sheds light on the mechanism through which these channels operate.

In this chapter, we focus on emerging economies. We write down two versions of the small open economy real business cycle model that rationalizes the balance of payment accounting identity, thus quantifying the relative importance of the two channels becomes possible. Moreover, these models provide a micro-foundation for studying the way these channels operate, the way they interact with each other and the mechanism through which they operate. We present these models in the next section.

### 3.3 Theoretical Framework

In this section, we consider two versions of the small open economy real business cycle model that rationalizes the intertemporal resource constraint. This model augmented with endogenous interest rate, respectively with real exchange rate provides a simple and elegant laboratory to study the relative importance of the trade and financial channels in the external adjustment process of the small open economy, while also allowing for an interaction between these two channels. It also allows for shedding light on the potential mechanism through
which these channels operate.

First, we consider the non-stochastic version of the small open economy real business cycle model augmented with the debt dependent interest rate. While writing down this model, we closely follow the functional form assumptions made by Schmitt-Grohe and Uribe (2003). In this framework we can study the relative importance of the trade and real interest rate channels in the external adjustment of the small open economy.

As a next step, we zoom into the financial channel. We consider a version of the small open economy real business cycle model that allows us to disentangle the real interest rate and real exchange rate channels. In particular, we write down a non-stochastic version of the small open economy real business cycle model with debt dependent interest rate that is augmented with tradables and non-tradables sectors. In this model, the price of tradable relative to non-tradable pins down the real exchange rate. This framework allows us to study the relative importance of the trade, real exchange rate and real interest rate channels in the external adjustment of the small open economy. Thus, the main advantage of this framework relative to the previous one is that it allows for the decomposition of the financial channel into two components: the real exchange rate and the real interest rate channels.

3.3.1 The Small Open Economy RBC Model with External Interest Rate

3.3.1.1 The setup

We start by assuming that the country is a small open economy populated by a large number of identical households. We assume that the representative household’s per-period utility, $U(\cdot)$, is derived from consumption, $c_t$, and hours worked, $h_t$. Following the RBC literature on small open economies, we assume that the representative household’s preference is modeled
as GHH (Greenwood et al., 1988). This implies the following functional form for $U(\cdot)$:

$$U(C_t, h_t) = \frac{(C_t - h_t^\omega / \omega)^{1-\sigma}}{1 - \sigma}$$

(3)

where $\omega$ and $\sigma$ are utility parameters capturing the elasticity of substitution between consumption and hours worked, respectively the elasticity of substitution of the consumption today with consumption tomorrow. Thus, the discounted sum of per-period utility is given by:

$$\max \sum_{t=0}^{\infty} \beta^t U(c_t, h_t)$$

(4)

where $\beta \in (0, 1)$ is the discount factor.

The representative household’s per-period budget constraint is:

$$d_{t+1} = (1 + r_t(d_{t+1}))d_t + c_t + i_t - y_t + \phi (k_{t+1} - k_t)$$

(5)

where $d_t$ is the stock of debt that the small open economy accumulates up until period $t-1$ by borrowing in the international financial markets, $d_{t+1}$ is the stock of external debt that consists of the stock of debt at the end of period $t-1$ plus the new loans contracted by the small open economy on the international markets in the $t^{th}$ period; $i_t$ denotes investment in period $t$; $y_t$ is the domestic output in period $t$; and $k_t$ is the stock of physical capital at the end of period $t-1$.

The interest rate at which the small open economy borrows on the international markets in period $t$ is $r_t$. Following Schmitt-Grohe and Uribe (2003)$^3$, we assume that the domestic interest rate is the sum of the world interest rate on the international financial markets, $r^*$, and the spread that the small open economy pays upon borrowing on these markets. We assume that the country spread is endogenous. Its size depends on the deviation of the small open economy’s debt to output ratio, $\frac{d_{t+1}}{y_t}$, from its steady state value, $\tilde{d}$, and the debt

---

$^3$Technically, this functional form assumption ensures that the non-stochastic steady state of the model is independent of the initial conditions, and thus it is stationary.
elasticity of the domestic interest, captured by parameter $\psi$:

$$r(d_{t+1}) = r^* + \psi \left( \exp \left( \frac{d_{t+1}}{y_t} - \tilde{d} \right) \right)$$ (6)

These assumptions on the functional form of the domestic real interest rate imply that the cost of borrowing that the small open economy faces on the international markets is increasing in the world interest rate, the debt elasticity of the country spread (i.e. the more sensitive is the country spread to fluctuations in the external debt position of the country relative to its steady state), and the deviation of the debt to output ratio relative to its steady state.

Function $\phi(\cdot)$ is the capital adjustment cost that the representative consumer acquires for each unit of investment made in physical capital$^4$. Following Schmitt-Grohe and Uribe (2003), we assume that the capital adjustment cost is modeled as a quadratic function of the current and past capital stock levels, and it captures the fact that faster adjustments in the capital stock are more expensive:

$$\Phi (k_{t+1}, k_t) = \phi \left( \frac{1}{2} (k_{t+1} - k_t)^2 \right)$$ (7)

We assume that capital depreciates at rate $\delta \in (0, 1)$. Thus, the stock of physical capital owned by the representative household at time $t$ is the stock at the end of period $t-1$, net of depreciation, plus the value of the new investment, captured by the following capital accumulation equation:

$$k_{t+1} = (1 - \delta) k_t + i_t$$ (8)

Output is produced by hiring labor, $h_t$, and using physical capital, $k_t$, in order to produce

$^4$Technically, the role of this capital adjustment cost in the small open economy RBC model is to dampen the large volatility of investment in response to changes in the interest rate. The functional form is chosen such that in steady state the adjustment cost is zero, as we assume that $\phi(0) = \phi'(0) = 0$, and thus the marginal product of capital matches exactly the interest rate.
consumption goods, $y_t$, based on a neoclassical production technology:

$$y_t = F(k_t, h_t)$$ (9)

We assume that the production function is Cobb-Douglas with $\alpha$ being the share of capitals in total output:

$$F(k_t, h_t) = k_t^\alpha h_t^{1-\alpha}$$ (10)

### 3.3.1.2 Non-linear equilibrium conditions

The representative household maximizes lifetime utility (4) subject to the budget constraint in (5), and chooses the optimal path of $\{c_t, h_t, i_t, y_t, k_{t+1}, d_{t+1}, \lambda_t\}_{t=0}^\infty$. Thus, the following system of nonlinear equations describes the optimal dynamics of the model variables $\{c_t, h_t, i_t, y_t, k_{t+1}, d_{t+1}, \lambda_t, r_t\}_{t=0}^\infty$:

$$(c_t - h_t^\omega/\omega)^{-\sigma} = \lambda_t$$ (11)

$$(h_t^\omega - 1) (c_t - h_t^\omega/\omega)^{-\sigma} = \lambda_t (1 - \alpha) k_t^\alpha h_t^{-\alpha}$$ (12)

$$\lambda_t = \beta \lambda_{t+1} [1 + r(d_{t+1})]$$ (13)

$$\lambda_t [1 + \phi (k_{t+1} - k_t)] = \beta \lambda_{t+1} \left[1 - \delta + \phi (k_{t+2} - k_{t+1}) + \alpha \left(\frac{k_{t+1}}{h_{t+1}}\right)^{\alpha-1}\right]$$ (14)

$$d_{t+1} = (1 + r_t(d_{t+1}))d_t + c_t + k_{t+1} - (1 - \delta) k_t - k_t^\alpha h_t^{1-\alpha} + \frac{\phi}{2} (k_{t+1} - k_t)^2$$ (15)

$$y_t = k_t^\alpha h_t^{1-\alpha}$$ (16)

$$k_{t+1} = (1 - \delta) k_t + i_t$$ (17)
\[ r(d_{t+1}) = r^* + \psi \left( \exp \left( \frac{d_{t+1}}{y_t} - \tilde{d} \right) \right) \]  \tag{18}

### 3.3.2 The Small Open Economy RBC Model with External Interest Rate and Real Exchange Rate

#### 3.3.2.1 The setup

In this version of the model, we assume that the representative household’s utility, \( U(\cdot) \), is derived from consumption of tradable goods, \( c_t \), consumption of non-tradable goods \( c_{nt} \), and hours worked, \( h_t \). We assume that tradable and non-tradables consumption is aggregated into total consumption in the household’s utility in a Cobb-Douglas way, with \( b \) being the share of non-tradable in total consumption, while consumption and hours worked are aggregated by a CES function as in the previous version of the model:

\[
U(c_{nt}, c_t, h_t) = \left( \frac{c_{nt}^b c_t^{1-b} - h_t^\omega / \omega}{1 - \sigma} \right)^{1-\sigma} \tag{19}
\]

Thus, the discounted sum of per-period utility is given by:

\[
\max \sum_{t=0}^{\infty} \beta^t U(c_{nt}, c_t, h_t) \tag{20}
\]

where \( \beta \in (0, 1) \) is the discount factor.

The representative household’s per-period budget constraint evaluated at the price of tradables relative to the non-tradables is as follows:

\[
p_t d_{t+1} = p_t (1 + r_t(d_{t+1})) d_t + p_t c_t + c_{nt} + p_t i_t - y_t + p_t \frac{\phi}{2} (k_{t+1} - k_t)^2 \tag{21}
\]

By comparing equation (20) with equation (5), one can easily notice that the only difference between the two versions of the model is given by the assumption on the two sectors of the economy, tradables and non-tradables. We need these assumptions in order to pin down
the equilibrium path of the real exchange rate defined as the price of tradables relative to non-tradables\(^5\).

The total output in this economy is given by the sum of the output produced by the two sectors of the economy:

\[ y_t = N_t + p_t T_t \]  
(22)

We assume that the nature of the technology in the tradable sector is Cobb-Douglas, and this sector uses capital and labor to produce output \( T_t \):

\[ T_t = k_t^\alpha h_t^{1-\alpha} \]  
(23)

Moreover, we assume that the production in the non-tradable sector is based on an endowment which is fixed\(^6\) over time to \( N \):

\[ N_t = N \]  
(24)

### 3.3.2.2 Non-linear equilibrium conditions

The representative household maximizes lifetime utility (20) subject to the budget constraint in (21), and chooses the optimal path of \( \{ c_{nt}, c_t, h_t, i_t, y_t, k_{t+1}, d_{t+1}, \lambda_t \}_{t=0}^\infty \). Thus, the following system of nonlinear equations describe the optimal dynamics of the model variables \( \{ c_{nt}, c_t, h_t, i_t, y_t, k_{t+1}, d_{t+1}, \lambda_t, p_t, r_t \}_{t=0}^\infty \):

\[
\left( c_{nt}^b c_t^{1-b} - h_t^\omega / \omega \right)^{-\sigma} b c_{nt}^{b-1} c_t^{1-b} = \lambda_t
\]  
(25)

\[
\left( c_{nt}^b c_t^{1-b} - h_t^\omega / \omega \right)^{-\sigma} (1-b) c_{nt}^b c_t^{1-b} = \lambda_t p_t
\]  
(26)

\(^5\)Based on this definition of the relative price, the real exchange rate is defined as the price of one unit of foreign currency in terms of domestic currency. Thus, an increase in the relative price (i.e. real exchange rate) captures a real depreciation of the domestic currency relative to the foreign currency.

\(^6\)One can generalize this assumption by making assumptions about the nature of the technology, the type of the inputs used etc. This generalization would not affect the conclusions that we draw in this paper.
\[
(c_{nt}^{1-b} - h_t^\omega / \omega)^{-\sigma} h_t^{\omega-1} = \lambda_t p_t (1 - \alpha) k_t^\alpha h_t^{-\alpha}
\] (27)

\[
\lambda_t p_t = \beta \lambda_{t+1} p_{t+1} [1 + r(d_{t+1})]
\] (28)

\[
\lambda_t p_t [1 + \phi (k_{t+1} - k_t)] = \beta \lambda_{t+1} p_{t+1} \left[ 1 - \delta + \phi (k_{t+2} - k_{t+1}) + \alpha \left( \frac{k_{t+1}}{h_{t+1}} \right)^{\alpha-1} \right]
\] (29)

\[
p_t d_{t+1} = p_t (1 + r_t(d_{t+1})) d_t + p_t c_t + c_{nt} + p_t i_t - y_t + p_t \frac{\phi}{2} (k_{t+1} - k_t)^2
\] (30)

\[
y_t = N + p_t k_t^\alpha h_t^{1-\alpha}
\] (31)

\[
k_{t+1} = (1 - \delta) k_t + i_t
\] (32)

\[
r(d_{t+1}) = r^* + \psi \left( \exp \left( \frac{d_{t+1}}{y_t} - \tilde{d} \right) \right)
\] (33)

\[
c_{nt} = N
\] (34)

### 3.4 Calibration

In order to solve the system of difference equations that characterize the optimal decision of the small open economy in the two versions of the RBC model considered in the previous section, we have to assign values to the model parameters. In this section we describe the way we calibrate these parameters which we group in two categories: financial parameters such as the elasticity of country spread and other model parameters.
3.4.1 The Elasticity of Country Spread with Respect to the Debt to GDP Ratio

The elasticity of country spread with respect to the debt to GDP ratio of the small open economy, \( \psi \), plays an important role in understanding the channels through which the small open economy adjusts externally. As the size of this parameter determines the size of the country spread for a given gap between the actual and steady state debt to GDP ratio, it has implications for the importance of the financial channel relative to the trade channel.

The small open economy real business cycle literature focusing on emerging economies has been traditionally calibrating this parameter to the value 0.001. This calibration was first introduced by Mendoza (1991) that studied real business cycle fluctuations in the case of the Canadian economy. This calibration quantitatively implies a country spread which is close to zero. As we show in Table 1, a 0.1 increase in the debt to GDP ratio relative to the steady state induces only one basis point increase in the country spread. The cost of borrowing of the small open economy is about the same as the world interest rate, exogenous to the small open economy, under this calibration. Thus, we expect that none or only a tiny fraction of the overall external adjustment is through the financial channel. We label this case as the "No financial adjustment" case as outlined in the third column of Table 1.

<table>
<thead>
<tr>
<th>Value of ( \psi )</th>
<th>Source</th>
<th>Type of adjustment in the model</th>
<th>Implied adjustment in spread (bp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>Mendoza (1991)</td>
<td>No financial adjustment</td>
<td>1</td>
</tr>
<tr>
<td>0.07</td>
<td>Rowland and Torres (2004)</td>
<td>Financial adjustment</td>
<td>70</td>
</tr>
<tr>
<td>1.3</td>
<td>Schmitt-Grohe and Uribe (2016)</td>
<td>Financial adjustment</td>
<td>1300</td>
</tr>
</tbody>
</table>

The empirical literature which investigates the determinants of country spread (Cantor and Packer, 1996; Eichengreen and Mody, 1998; Hilscher; Rowland and Torres, 2004;
Nosbusch et al, 2010) has concluded that it is misleading to assume that country spread is exogenous, by pointing out that there is not only a certain feedback relationship between the country spread and the world interest rate, but the country spread also reacts to movements in economic fundamentals such as the degree of the external indebtedness of the country. A series of reduced form papers have shown recently that in the case of emerging economies the elasticity of country spread with respect to fluctuations in the external debt position of these countries is much larger. For instance, Rowland and Torres (2004) estimate, by using panel data econometrics techniques, that an average increase of 0.1 in the debt to GDP ratio implies a 70 basis point increase on average in the JP Morgan EMBI Global spread in the case of a panel of sixteen emerging economies. Considering a larger set of emerging economies, a panel of thirty-one countries, Hilscher et al. (2010) also document a similar size of the elasticity of country spread: they estimate in a panel regression framework that a 0.1 increase in the debt to GDP ratio implies an increase of the country spread by about 50 basis points.

In addition to these reduced form findings, we also document in this paper that the elasticity of country spread with respect to the debt to GDP ratio is much higher than 0.001. By using Bayesian estimation techniques, we estimate a small open economy real business cycle model with endogenous country spread in the case of five Central and Eastern
European countries\textsuperscript{7}. Table 2 contains the point estimates of the $\psi$ parameter.

Table 2. Bayesian estimates of $\psi$ based on a prior distribution gamma

<table>
<thead>
<tr>
<th>Country</th>
<th>Posterior mean</th>
<th>Confidence interval</th>
<th>Implied adjustment in spread (bp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulgaria</td>
<td>0.044</td>
<td>[0.013, 0.073]</td>
<td>44</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>0.061</td>
<td>[0.023, 0.094]</td>
<td>61</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.072</td>
<td>[0.029, 0.112]</td>
<td>72</td>
</tr>
<tr>
<td>Poland</td>
<td>0.077</td>
<td>[0.031, 0.124]</td>
<td>77</td>
</tr>
<tr>
<td>Romania</td>
<td>0.081</td>
<td>[0.032, 0.131]</td>
<td>81</td>
</tr>
</tbody>
</table>

Note: Confidence interval concerning the 90\% probability region.

The posterior mean ranges between 0.04 and 0.08, suggesting that the size of elasticity of country spread with respect to the debt to GDP ratio implied by the structure of the small open economy RBC model and observables on output, consumption, investment and net exports, is consistent with the reduced form findings. An increase in the debt to GDP ratio by 0.1 induces about 70 basis point increase in the spread on average across the five countries in the case for which we performed the estimation.

Thus, in line with the reduced form findings of the previous literature and the structural estimates documented in this paper, we consider a case in which we calibrate the $\psi$ parameter to 0.07. As outlined in Table 1, we consider a third case in which we calibrate $\psi$ to 1.3, a value that is documented by Schmitt-Grohe and Uribe (2016) in the case of Argentina. However, this large elasticity implies a 1300 basis point increase in the country spread for a 0.1 increase in the debt to GDP ratio.

\textsuperscript{7}The model is similar in structure to the model outlined in this paper. Details on the model and the estimation are included in Section A.3 of the Appendix.
3.4.2 Other Parameters of the Model

We calibrate the other parameters of the models by closely following the calibration used in the real business cycle literature on emerging economies as summarized in Table 3. We calibrate the capital share of income ($\alpha$) to the long-run average of the compensation of labor input to value added ratio in emerging economies. The rate of depreciation of capital ($\delta$) is calibrated to 0.1.

The preference parameters are set as follows: the coefficient of relative risk aversion ($\sigma$) defining the curvature of the utility function is set to 2, while the exponent of labor in the utility function, $\omega$, is set to 1.455. These are in line with Schmitt-Grohe and Uribe (2003), Neumeyer and Perri (2005) and Garcia-Cicco et al. (2010).

Table 3. Calibration of the other model parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Comments</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>Capital share of income</td>
<td>0.32</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Capital depreciation</td>
<td>0.1</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Relative risk aversion</td>
<td>2</td>
</tr>
<tr>
<td>$\omega$</td>
<td>Labor in the utility function</td>
<td>1.455</td>
</tr>
<tr>
<td>$r^*$</td>
<td>Steady state level of gross foreign real interest rate</td>
<td>0.01</td>
</tr>
<tr>
<td>$\tilde{d}$</td>
<td>Countries' long run external debt to GDP ratio</td>
<td>0.744</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Capital adjustment cost parameter</td>
<td>8</td>
</tr>
<tr>
<td>$b$</td>
<td>Share of non-tradable sector</td>
<td>0.7</td>
</tr>
<tr>
<td>$N$</td>
<td>Endowment in the non-tradable sector</td>
<td>70</td>
</tr>
</tbody>
</table>

The steady state level of gross foreign real interest rate or risk free real interest rate ($r^*$) is calibrated to 0.01 which implies a discount factor ($\beta$) equal to 0.99. $\tilde{d}$, the long run external debt to GDP ratio, is set to 0.744 in line with Schmitt-Grohe and Uribe (2003) who argue that this is consistent with the average of the net foreign asset to GDP ratio across emerging economies.
economies. Following the same paper, we calibrate the capital adjustment cost parameter ($\phi$) to 8. The rationale behind this large value is twofold. On the one hand, adjusting capital stock in emerging economies is costly given a series of capital market frictions that are not present in developed economies. On the other hand, setting this parameter to a lower value would imply that investment is too volatile relative to the data.

Finally, we assume that the non-tradable sector accounts for about 70% of the total output of the small open economy setting in this way parameter $b$ to 0.7. Moreover, we assume that the endowment in the non-tradable sector is constant over time and we set it to 70. This is a simplifying assumption which does not have implications for the conclusions at which we arrive based on the simulation exercise in the next section.

3.5 The External Financial Adjustment of the Small Open Economy

In this section we use the two small open economy real business cycle models outlined in Section 3.3 to study how the financial and trade channels operate in an explicit intertemporal model that pins down the equilibrium paths of real exchange rate and forecastable returns on the net international investment position of the small open economy. Moreover, by using the calibrations presented in the previous section, we simulate the non-linear model under the assumption of perfect foresight to study how the two financial channels interact with the trade channel and shed light on the mechanism through which these channels operate.

The findings of the simulation exercise are striking. First, we show that the financial channel plays a more important role relative to the trade channel in the external adjustment of the emerging countries when the country’s external spread is more sensitive to fluctuations in the debt to GDP ratio relative to the steady state. This is mainly due to the positive financial externality present in the model implied mechanism, the importance of which increases with the debt elasticity of the spread. Second, we document that initial conditions
matter for the type of the channel through the country undergoes the external adjustment. The results of the simulation exercise show that the larger the initial external debt position of the country relative to steady state is, the more important the financial channel is. Third, we show that the financial channel plays a more important role than the trade channel in the long run. Finally, we show that the global results are different from the local ones: the financial channel plays a smaller role in the log-linearized model. The following two sections present the details and demonstrate these findings. First, we take the small open economy RBC model augmented with endogenous country spread and simulate it to study the importance of the real interest rate channel, as the only financial channel in this version of the model, relative to the trade channel. Then, we simulate the second version of the model that encompasses both the real interest rate and real exchange rate as financial channels.

3.5.1 The Role of the Real Interest Rate Channel

In order to study the relative importance of the trade and real interest rate channels in the small open economy’s external adjustment process, we first perform simulations of the small open economy real business cycle model augmented by endogenous country spread. Thus, in this version of the model the real interest rate is the only channel of financial adjustment. We calibrate the system of non-linear equations in (11) - (18). As we assume perfect foresight, this exercise is nothing else than a deterministic simulation of the non-linear equilibrium conditions by using numerical methods. Thus, we can study the global dynamics of the simulated adjustment instead of the local one which was the case if we log-linearized the system. We simulate the adjustment of the model economy back to the steady state from an initial state in which all the model variables, except the capital stock and the external debt position, are at their steady state value. We assume that initially the capital stock is by 10% below its steady state, while the external debt position is by 10% above its steady state. We perform the simulation in two cases. First we assume that the elasticity of country spread, \( \psi \), is low by calibrating it to 0.001. Then, we keep all the parameter values the same but we
increase the value of $\psi$ to 0.07. The results of the simulation under the two calibrations of $\psi$ are summarized in Figure 1. These simulation results suggest a series of interesting findings.

First, the financial channel seems to play a much more important role than the trade channel when the country spread is more sensitive to fluctuations in the debt to GDP ratio relative to the steady state. By comparing the adjustment path of the external debt, the country spread, the current account and the trade balance, we can easily notice that the external adjustment takes place through a combination of the trade and real interest rate channels. However, starting from period thirty the type of the adjustment becomes very different across the two economies. In particular, the external adjustment of the economy that has low elasticity of the spread (i.e. $\psi$ calibrated to 0.001) is only through adjustment in current account starting from period thirty. As the cost of borrowing is not sensitive to the increase in external debt, the country over-borrows in order to build up capital stock and all the external adjustment is through the trade channel. On the other hand, in the economy with the larger elasticity of the spread most of the adjustment in the initial periods and all of the adjustment on the long run is through the financial channel, i.e. the real interest rate channel. As the country spread is sensitive to fluctuations in the external debt in this economy, the country will pay down debt and build up capital stock by saving and running trade surplus in the initial periods of the adjustment. But in period thirty, the economy reaches the level of external debt and capital stock that is consistent with the steady state level of trade balance and current account. Thus, starting from this period all the adjustment is through the real interest rate channel. This difference in the importance of the financial channel across economies with different values of $\psi$ becomes even more striking when we calibrate this parameter to 1.3. Appendix A.4.1. summarizes the simulation results which suggest that essentially all the external adjustment is through the financial channel when the country spread is extremely sensitive to fluctuations in the external debt position relative to steady state.

Second, by examining the adjustment path of consumption per capita and utility, one
Figure 1. Results of the simulation of the small open economy RBC model with endogenous country spread.

Note: Initial external debt above and capital below the steady state by 10%.
The rest of the model variables are initially at steady state.
can notice that there seems to be a gain from the financial adjustment. This is because
the financial adjustment rewards countries for paying down debt. This is rationalized in the
model by the positive financial externality created by the endogenous country spread. Since
the spread depends on the deviation of the external debt to GDP ratio from its steady state,
building up capital stock and financing domestic consumption by building up new external
debt increases the cost of borrowing tomorrow and creates debt spiral over time. Moreover,
this increase in the cost of borrowing tomorrow is larger the larger the debt elasticity of
the spread. The small open economy internalizes the consequences of building up more
debt today as it makes per-period decisions by an optimal consumption-saving decision over
time. Thus, it will start the external adjustment by saving and paying down debt in the
initial periods that generates a positive financial externality over time, as the cost of external
borrowing falls over time. The more external debt is paid down, the larger the fall in the
cost of borrowing over time such that the spread adjusts back to a level at which the small
open economy can restart borrowing from the international markets.

The presence of the positive financial externality in the model rationalizes the finding
that the importance of the financial channel increases with the size of the debt elasticity of
the spread. Moreover, by the presence of this financial externality, the financial channel has
also non-trivial implications for welfare. Table 4 contains the sum of discounted simulated
utilities under different calibrations of the debt elasticity of country spread\(^8\), and under the
assumption that the initial debt is above its steady state debt by 10%, while the initial
capital stock is below its steady state by 10%.

Table 4. The sum of discounted utilities and the elasticity of country spread

<table>
<thead>
<tr>
<th>ψ</th>
<th>0.001</th>
<th>0.7</th>
<th>1.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life-time utility (U_0)</td>
<td>103.02</td>
<td>104.05</td>
<td>123.4</td>
</tr>
</tbody>
</table>

\(^8\)To compute this, we simulate the consumption and hours worked under different parametrizations of ψ
and compute the life-time utility as \(\sum_{t=0}^{\infty} \beta U(c_t, h_t)\) with \(\beta\) equal to 0.99, the discount factor value implied
by the \(r^*\) calibrated to 0.01.
It shows that the larger $\psi$ is the larger the discounted sum of lifetime utility implied by the model. This suggests that there is always a gain from financial adjustment because it rewards countries over time for paying down debt.

However, the financial externality and, thus, the financial channel plays an important role in the external adjustment of the small open economy if the country starts the adjustment from an initial external debt position that is above the steady state. In order to illustrate this, we do additional simulation exercises in which we fix the initial external debt position at a level below the steady state by 0.1. Table 5 contains the sum of discounted simulated utilities under different calibration of the debt elasticity of country spread and different assumptions on the initial value of the external debt position and capital stock$^9$. Essentially, the difference in the level of lifetime utilities across the economies with different $\psi$ is given by the positive financial externality that is quantitatively important when the initial external debt is above its steady state. As Table 5 illustrates, the financial channel matters for the utility ranking only when the country is a net debtor on the international financial markets. When the initial debt is below the steady state (i.e. the initial external debt of the country is less than the steady state value), then the discounted lifetime utility is at the same level across the economies with and without IFA.

Table 5. The sum of discounted utilities and the elasticity of country spread

<table>
<thead>
<tr>
<th>$\psi$</th>
<th>0.001</th>
<th>0.07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial capital and debt below steady state by 0.1</td>
<td>37.6</td>
<td>37.4</td>
</tr>
<tr>
<td>Initial capital and debt above steady state by 0.1</td>
<td>37.7</td>
<td>38.1</td>
</tr>
<tr>
<td>Initial capital above and debt below steady state by 0.1</td>
<td>36.5</td>
<td>36.1</td>
</tr>
<tr>
<td>Initial capital below and debt above steady state by 0.1</td>
<td>38.9</td>
<td>39.4</td>
</tr>
</tbody>
</table>

Finally, Figure 1 suggests that the financial channel plays a more important role in

$^9$To compute this, we simulate the consumption and hours worked under different parametrizations of $\psi$ and compute the lifetime utility as $\sum_{t=0}^{\infty} \beta U(c_t, h_t)$ with $\beta$ equal to 0.99, the discount factor value implied by the $r^*$ calibrated to 0.01.
the external adjustment on the long run: as the country pays down external debt in the initial periods, it starts to enjoy the benefits of the financial externality on the long run and adjusts almost exclusively through the real interest rate channel. Figure 1 also suggests very different global results from the local ones which studies the patterns of financial adjustment in the neighborhood of the steady state. The first striking finding with respect to this is that the financial channel plays a small role in the log-linearized model. The second is that the interesting initial non-linearity in the adjustment is ignored in the log-linearized model. By looking at the adjustment path of the external debt position in the neighborhood of the steady state (i.e. around period four hundred) one would ignore not only the initial over- and under-shooting in the external debt position in the initial periods of the adjustment, but also the presence of real interest rate as adjustment channel. This is mainly because the country spread is close to zero for these values of the external debt.

3.5.2 The Relative Importance of the Real Exchange and Interest Rate Channels

In order to study the relative importance of the trade, real interest rate and real exchange rate channels in the external adjustment process of the emerging economies, we first perform simulations of the small open economy RBC model augmented with endogenous spread, tradable and non-tradable sectors. Thus, in this version of the model the real interest rate and the real exchange are the channels of financial adjustment. We calibrate the system of non-linear equations in (25) - (33). Similarly to the previous simulation, under the assumption of perfect foresight, we solve the non-linear equilibrium conditions by using numerical methods. Then, we simulate the model by assuming that the initial capital stock is by 10% below its steady state, while the external debt position is by 10% above its steady state and the elasticity of country spread, $\psi$, can take two values: 0.001 and 0.07.

The results of the simulation under the two calibration of $\psi$ are summarized in Figure 2. These simulation results suggest that the findings documented in the previous section based
on the simulation of the model with only real interest rate as financial channel are robust to the introduction of real exchange rate as an additional source of international financial adjustment. Thus, the financial channel seems to be more important on the long run, and in particular when the country spread is more sensitive to fluctuations in the debt to GDP ratio. The real exchange rate, defined as the relative price of tradables adjusts over time back to steady state through a real appreciation. However, there is essentially no significant difference in the adjustment path across the two economies except for the first few periods. All these suggest that the main source of external adjustment is the real interest rate channel in the emerging economies that are characterized by debt elastic country spread.

The importance of the financial channel increases with the size of the debt elasticity of the spread also when real exchange rate as IFA channel is present in the model in addition to the country spread (i.e., the only channel of adjustment in the baseline version of the model considered in the previous section). Table 6 contains the sum of discounted simulated utilities under different calibrations of the debt elasticity of country spread\(^{10}\), and under the assumption that the initial debt is above its steady state debt by 10%, while the initial capital stock is below its steady state by 10%.

<table>
<thead>
<tr>
<th>(\psi)</th>
<th>0.001</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life-time utility ((U_0))</td>
<td>96.12</td>
<td>97.11</td>
</tr>
</tbody>
</table>

The two columns of Table 6 show that the larger \(\psi\) is the larger the discounted sum of lifetime utility implied by the model. This suggests that there is always a gain from financial adjustment because it rewards countries over time for paying down debt.

\(^{10}\)To compute this, we simulate the consumption and hours worked under different parametrizations of \(\psi\) and compute the life-time utility as \(\sum_{t=0}^{\infty} \beta U(c_t, h_t)\) with \(\beta\) equal to 0.99, the discount factor value implied by the \(r^*\) calibrated to 0.01.
Figure 2. Results of the simulation of the small open economy RBC model with endogenous country spread, tradable and non-tradable sectors.

Note: Initial external debt above and capital below the steady state by 10%.
The rest of the model variables are initially at steady state.
3.6 Conclusions

In this paper we have calibrated and demonstrated the importance of IFA in a standard open economy growth model (Schmitt-Grohe and Uribe (2003)) with a well-defined steady level of foreign liabilities. In this model there is a country specific credit spread which varies as a function of the ratio of foreign liabilities to GDP. We studied a perfect foreign version of the model so that we could characterize the global dynamic adjustment in net foreign assets, the endogenous cost of debt service, and the path of the real exchange rate. This is important, because in this model, in a neighborhood of the steady state, IFA is not very important.

In our baseline simulation in which we calibrate the elasticity of the country credit spread to the debt to GDP ratio based on plausible empirical estimates from the literature as well as our own estimates, we find that allowing for an IFA channel results in a very rapid converge of the current account to its steady state (relative to the no IFA case) so that most of the time that the country is adjusting, all the adjustment is via forecastable changes in the costs of servicing debt and in the appreciation real exchange rate and none of the adjustment is in the current account. By contrast, in the no IFA case, current account adjustment by construction does all the work and current account adjustment calibrated to be much slower.

Finally we show that IFA adjustment via the real exchange rate can be important even if forecastable changes in the cost of debt service are not. We discussed above, in this textbook model there is a negative externality to foreign borrowing in that no borrower internalizes that the credit spread faced by borrowers in the country are a function of aggregate debt. We were able quantify that not only is IFA important in this model, lifetime utility in the model with IFA is higher than in the model without even though – really because – the cost of debt service is higher period by period until convergence is achieved.
A.1 Derivation of the BoP Accounting Identity with Zero Gross International Asset Position

We aim to derive the log-linearized balance of payment accounting identity in the special case when the gross international asset position of the country is zero in any time period, i.e. \( A_{t+1} = A_t = 0 \).

The BoP accounting identity in levels is:

\[
\frac{A_{t+1} - L_{t+1}}{A_t - L_t} = R_{t+1} \left( 1 + \frac{X_t - M_t}{A_t - L_t} \right)
\] (A.1)

where \( A_t \) is the gross international asset position, \( L_t \) is the gross international liability position, \( R_t \) is the real interest rate, \( X_t \) is total exports and \( M_t \) is total imports.

The assumption \( A_{t+1} = A_t = 0 \) implies that A.1 can be written as:

\[
\frac{L_{t+1}}{L_t} = R_{t+1} \left( 1 - \frac{X_t - M_t}{L_t} \right)
\] (A.2)

While the steady state value of the gross asset position is zero, i.e. \( A = 0 \).

In the following, we want to show that the log-linearized version of the identity in A.2 is:

\[
l_t = nx_t - \rho nx_t + \rho l_{t+1} - \rho r_{t+1}
\] (A.3)

where \( l_t \) is the log-deviation of the gross liability position from its steady state, \( nx_t \) is the log-deviation of net exports, defined as \( X_t - M_t \) from its steady state, \( r_{t+1} \) is the log deviation of the real interest rate from its steady state, \( \rho \equiv 1 - \frac{X-M}{L} \) with \( X, M \) and \( L \) being the steady state values of exports, imports and gross liability position.

By iterating forward on A.3 we get the intertemporal balance of payment identity that pins down the current level of gross liability as the function of the discounted sum of future
real service of the external debt and the discounted sum of future changes in net exports:

\[ l_t = -\sum_{j=1}^{\infty} \rho^j r_{t+j} + nx_t + \sum_{j=1}^{\infty} \rho^j \Delta nx_{t+j} \]  
(A.4)

**Proof:**

First, we want to log-linearize (A.2) which we do in three steps.

**Step 1:** (A.2) in steady state, denoted with the same letters but with the time index omitted, becomes:

\[ 1 = R \left( 1 - \frac{X}{L} \right) \]  
(A.5)

After some algebraic manipulation we get:

\[ \frac{1}{R} = 1 - \frac{X}{L} \]  
(A.6)

Denote \( \frac{1}{R} \equiv \rho \). Then, we can rewrite (A.6) as:

\[ \rho \equiv 1 - \frac{X}{L} \]  
(A.7)

**Step 2:** Take the log of (A.2):

\[ \log (L_{t+1}) - \log (L_t) = \log (R_{t+1}) + \log \left( 1 - \frac{X_t - M_t}{L_t} \right) \]  
(A.8)

**Step 3:** Take first-order Taylor series expansion of the expression in (A.8) around the log steady-state.

First, let’s focus on the left-hand side of the expression and write its first-order Taylor
series expansion as:

\[
\log (L_{t+1}) - \log (L_t) = \log(e^{\log(L_{t+1})}) - \log(e^{\log(L_t)}) \simeq
\]

\[
\simeq \log (L) - \log (L) + \frac{1}{e^{\log(L)}}e^{\log(L)}(\log (L_{t+1}) - \log (L)) - \]

\[
- \frac{1}{e^{\log(L)}}e^{\log(L)}(\log (L_t) - \log (L))
\]

\[
= (\log (L_{t+1}) - \log (L)) - (\log (L_t) - \log (L))
\]

Denote the deviation of the variable from the log steady state as \( x_t = \log (X_t) - \log (X) \).

Then, (A.9) can be written as:

\[
\log (L_{t+1}) - \log (L_t) \simeq l_{t+1} - l_t
\]

Second, we take the first-order Taylor series expansion of the right-hand side of (A.8) around the steady state:
\[
\log (R_{t+1}) + \log \left(1 - \frac{X_t - M_t}{L_t}\right) = \log \left(e^{\log(R_{t+1})}\right) + \log \left(1 - \frac{e^{\log(NX_t)}}{e^{\log(L_t)}}\right) \simeq (A.10)
\]

\[
\simeq \frac{1}{e^{\log(R)}} e^{\log(R)} \left(\log(R_{t+1}) - \log(R)\right) +
\]

\[
+ \frac{1}{1 - \frac{e^{\log(NX)}}{e^{\log(L)}}} \left(- \frac{e^{\log(NX)}}{e^{\log(L)}}\right) \left(\log(NX_t) - \log(NX)\right) +
\]

\[
+ \frac{1}{1 - \frac{e^{\log(NX)}}{e^{\log(L)}}} \left(- \frac{e^{\log(NX)}}{e^{\log(L)}}\right) \left(\log(L_t) - \log(L)\right)
\]

\[
= (\log(R_{t+1}) - \log(R)) +
\]

\[
+ \frac{NX}{NX - L} \left(\log(NX_t) - \log(NX)\right) +
\]

\[
- \frac{NX}{NX - L} \left(\log(L_t) - \log(L)\right)
\]

\[
= (\log(R_{t+1}) - \log(R))
\]

\[
+ \frac{NX}{NX - L} \left[\log(NX_t) - \log(NX)\right] - \log(L_t) - \log(L)]
\]

\[(1)
\]

By using the notation in the case of log deviations, \((A.10)\) becomes:

\[
\log (R_{t+1}) + \log \left(1 - \frac{X_t - M_t}{L_t}\right) \simeq r_{t+1} + \frac{NX}{NX - L} \left[nX_t - l_t\right]
\]

By using expression \((A.7)\) derived in the steady state, we can rewrite \(\frac{NX}{NX - L}\) as:

\[
\frac{NX}{NX - L} = \frac{X - M}{X - M - L} = \frac{X - M - L + L}{X - M - L} = 1 + \frac{L}{X - M - L}
\]

\[(A.11)\]

\[
= 1 + \frac{1}{X - L - M} = 1 - \frac{1}{1 - \frac{X - M}{L}} =
\]

\[
= 1 - \frac{1}{\rho}
\]
Thus, the log-linearized version of equation (A.2) is:

\[ l_{t+1} - l_t = r_{t+1} + \left( 1 - \frac{1}{\rho} \right) [nx_t - l_t] \tag{A.12} \]

By rearranging A.12 we get:

\[ l_t = nx_t - \rho nx_t + \rho l_{t+1} - \rho r_{t+1} \tag{A.13} \]

One can easily notice that the expression in A.13 is exactly the expression in A.3 that we wanted to show.

Next, we want to show that A.4 holds in this framework. By iterating forward on (A.13) we get:

\[ l_{t+1} = nx_{t+1} - \rho nx_{t+1} + \rho l_{t+2} - \rho r_{t+2} \tag{A.14} \]

Use (A.14) and plug it into (A.13):

\[ l_t = nx_t - \rho nx_t + \rho (nx_{t+1} - \rho nx_{t+1} + \rho l_{t+2} - \rho r_{t+2} - \rho r_{t+2}) - \rho r_{t+2} \]

\[ = nx_t + \rho (nx_{t+1} - nx_t) - \rho^2 nx_{t+1} + \rho^2 l_{t+2} - \rho r_{t+1} - \rho^2 r_{t+2} \]

\[ = nx_t + \rho \Delta nx_{t+1} = \sum_{j=1}^{\rho^2} \rho^j r_{t+j} + \rho^2 l_{t+2} - \rho^2 nx_{t+1} \tag{A.15} \]

Similarly, by iterating n-steps ahead and plugging the iterated expression back into (A.15) we get:

\[ l_t - nx_t = \sum_{j=1}^{n} \rho^j \Delta nx_{t+j} - \sum_{j=1}^{n} \rho^j r_{t+j} + \rho^n l_{t+n+1} - \rho^n nx_{t+n} \tag{A.16} \]

By using the transversality condition on the gross liability position:

\[ \lim_{n \to \infty} E[\rho^n l_{t+n+1}] = 0 \tag{A.17} \]

and taking expression (A.16) in expectation conditional on information available at time t,
we get the expression:

\[ nx_t - l_t = \sum_{j=1}^{\infty} \rho^j (r_{t+j} - \Delta nx_{t+j}) \]  \hspace{1cm} (A.18)

By re-arranging terms, (A.18) can be written as:

\[ l_t = -\sum_{j=1}^{\infty} \rho^j r_{t+j} + nx_t + \sum_{j=1}^{\infty} \rho^j \Delta nx_{t+j} \]  \hspace{1cm} (A.19)

But this is exactly the identity that we have in (A.4). Thus, we just proved that the current gross liability position can be written as the expression in A.4.  \(\square\)

**A.2 Estimation Appendix**

The bayesian estimates of the model parameters included in Table 2 are obtained by structurally estimating a full scale small open economy RBC model by using Bayesian techniques. This model is consistent with the small open economy model with endogenous country spread considered in Section 3.3. Here we augment this model with a working capital constraint. This appendix is organized as follows. First, we outline the model. Then we present the estimation strategy we use to parameterize the model.

**A.2.1 Model Specification**

**A.2.1.1 Households' behavior**

The representative household chooses the sequence of values for \(\{C_t, h_t, I_t, K_{t+1}, D_{t+1}\}\) in order to maximize the expected discounted sum of lifetime utility derived from the consumption of goods and leisure:

\[ \max_{\{C_t, h_t, I_t, K_{t+1}, D_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, h_t, \Gamma_{t-1}) \]  \hspace{1cm} (B.1)

where \(C_t\) is time \(t\) consumption, \(h_t\) labor supplied by the household at time \(t\), \(\beta\) is the discount factor, \(\Gamma_{t-1}\) allows for balanced growth path in utility\(^{11}\), \(U()\) is twice differentiable concave

\(^{11}\text{More details about the way balanced growth path is defined you can find in the next subsection.}\)
utility function, increasing in its first argument and decreasing in its second argument.

The household acquires income by supplying labor, \( h_t \) to the firms and getting the wage, \( w_t \) in exchange, by renting capital, \( K_t \) to the firms at the rental rate of capital \( u_t \), and by borrowing from, \( D_{t+1} > 0 \) or by investing, \( D_{t+1} < 0 \) in one period noncontingent bonds on the international financial market. Thus, one unit of foreign asset or debt costs \( q_t \) in units of consumption goods. The household uses this income to purchase consumption goods, \( C_t \), to invest in investment goods, \( I_t \) and to pay back previous loans, \( D_t > 0 \), contracted from or to sell international bonds, \( D_t < 0 \), purchased from these markets. In this way she accumulates two types of capital stock which she owns entirely: physical capital, \( K_t \) and internationally traded noncontingent bond, \( D_t \). Thus, the household’s per period budget constraint is:

\[
w_t h_t + u_t K_t + q_t D_{t+1} = D_t + C_t + I_t \tag{B.2}
\]

where the left-hand side of the identity characterizes the structure of the per period income, while the right-hand side represent the per period expenditures.

Changing the capital stock is costly and in each period \( t \) it is realized according to a capital accumulation rule which states that the per period capital stock is nothing else than the sum of the existing capital stock net of depreciation, plus current investments minus the adjustment cost, \( \Phi(K_{t+1}, K_t) \), paid for each unit of capital accumulated:

\[
K_{t+1} = (1 - \delta) K_t + I_t - \Phi(K_{t+1}, K_t) K_t \tag{B.3}
\]

This modeling technique is frequently used in the RBC literature because it improves the performances of the model to generate moderate investment volatility and increases the persistence of investment. By assumption, \( \Phi() \) is a strictly increasing, concave function.

**A.2.1.2 Firms’ behavior**

The representative firm behaves in a perfectly competitive way, hires labor, \( h_t \) and rents capital, \( k_t \) in order to produce consumption goods, \( Y_t \) based on a neoclassical production
technology, $F()$: 

$$Y_t = a_t F(K_t, \Gamma_t h_t) \quad (B.4)$$

where $a_t$ models transitory technology improvement defined as an exogenous autoregressive stationary, $|\rho_a| < 1$, process of order one:

$$\log a_t = \rho_a \log a_{t-1} + \epsilon^a_t \quad (B.5)$$

which captures shocks to total factor productivity as one source of uncertainty through $\epsilon^a_t$, i.i.d. process with mean zero and standard deviation $\sigma_a$. $\Gamma_t$ models permanent technology improvements as a labor augmenting productivity growth. As Aguiar and Gopinath (2007a) showed, assuming stochastic trend improvement, the neoclassical growth model does better job in replicating emerging market business cycle stylized facts like the countercyclical nature of trade balance to output ratio or higher volatility of consumption than output. The main intuition is related to the fact that as a result of a positive permanent productivity shock, labor productivity increases permanently. This generates a larger increase in permanent income and consumption than in current income which is financed by issuing external debt. In line with Aguiar and Gopinath (2007a), we assume that permanent technology shocks act through an exogenous and mean reverting stationary process:

$$\Gamma_t = g_t \Gamma_{t-1} \quad (B.6)$$

$$\log \left( \frac{g_t}{\mu} \right) = \rho_g \log \left( \frac{g_{t-1}}{\mu} \right) + \epsilon^g_t$$

where $|\rho_g| < 1$, $\epsilon^g_t$ is an i.i.d. process with mean zero and standard deviation $\sigma_g$, and it models shocks to labor productivity which are incorporated into $\Gamma_t$ through $g_t$, resulting in trend growth improvements. $\mu$ represents long-run labor productivity growth.

The representative firm has the primary objective to maximize the total discounted sum
of all future profits, $\Pi_t$, subject to a working capital constraint:

$$\max_{\{a_t,h_t,k_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \Pi_t = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ a_t F(K_t, \Gamma_t h_t) - w_t h_t \left[ 1 + \theta (R_{t-1} - 1) \right] - u_t K_t \right\} \quad (B.7)$$

In other words, the working capital constraint induces an additional friction into the model since the representative firm must borrow at $R_{t-1}$ rate of interest from the representative household in each period in order to be able to finance $\theta$ fraction of the wage bill at the beginning of each period, in advance of the realization of the income. Neumeyer and Perri (2005) and Uribe and Yue (2006) argue that this financial friction creates a linkage between interest rate movements and real economic activity, which improves the ability of the baseline RBC model to generate strong countercyclical trade balance through the following mechanism: falling interest rate, on the one hand, reduces the cost of labor allowing firms to hire more labor and consequently to produce more output. On the other hand, the lower the cost of borrowing boosts aggregate demand which generates deterioration in trade balance. Thus output and trade balance move in the opposite direction when the cost of financing changes through borrowing.

**A.2.2 Closing the Model**

**A.2.2.1 The cost of borrowing**

In order to solve the model a few more assumptions are needed concerning the dynamics of domestic and world interest rates, country spread, the price of the foreign debt, and the functional forms of the utility, production and capital adjustment cost function.

We assume that the domestic interest rate at which households lend to firms is defined as the product of gross country spread, $S_t$, and gross foreign interest rate, $R^*_t$:

$$R_t = S_t R^*_t \quad (B.8)$$

The dynamics of world interest rate is described by a mean reverting stationary, $|\rho_{r^*}| < \ldots$
1, first order autoregressive process:

\[
\log \left( \frac{R_t^*}{\overline{R}} \right) = \rho_t \log \left( \frac{R_{t-1}^*}{\overline{R}} \right) + \epsilon_t^* \tag{B.9}
\]

where \( \epsilon_t^* \) is an i.i.d. process with zero mean and standard deviation \( \sigma_{\epsilon_t^*} \).

The country spread is not only the function of the permanent and transitory technology shocks, but also it depends on the household’s external debt position fed into the cost of borrowing through an interest rate premium, \( \Psi() \):

\[
\log \left( \frac{S_t}{\overline{S}} \right) = -\eta \left[ \log a_{t+1} + \log \left( a_{t+1}^\alpha / \mu_\alpha \right) \right] + \Psi \left( \frac{D_{t+1}}{\Gamma_t} \right) \tag{B.10}
\]

where \( \Psi() \), is defined as an increasing and convex function of the external debt position of domestic household:

\[
\Psi \left( \frac{D_{t+1}}{\Gamma_t} \right) = \psi \left[ \exp \left( \frac{D_{t+1}}{\Gamma_t} - d \right) - 1 \right] \tag{B.11}
\]

In this way, the price of the external debt is given by:

\[
q_t = \frac{1}{R_t} \tag{B.12}
\]

### A.2.2.2 Functional forms

Household’s preferences are modeled according to Greenwood et al. (1988) (GHH) preferences since many papers show that they improve the performances of international RBC models in replicating business cycle stylized facts:

\[
U \left( C_t, h_t, \Gamma_{t-1} \right) = \frac{(C_t - \tau \Gamma_{t-1} h_t^\omega)^{1-\sigma}}{1-\sigma}, \ \omega > 1, \ \tau > 0 \tag{B.13}
\]

Capital adjustment cost is modeled as a quadratic function of the current and past

\[\text{Cobb-Douglas preferences are also widely used but, as Neumeyer and Perri (2005) show, they have poorer modeling performances in replicating emerging market stylized fact than GHH preferences.}\]
capital stock level and it captures the fact that faster adjustments in the capital stock are more expensive:

\[ \Phi (K_{t+1}, K_t) = \frac{\phi}{2} \left( \frac{K_{t+1}}{K_t} - \mu \right)^2 \]  

(B.14)

The production function is assumed to be Cobb-Douglas, where \( \Gamma_t \) allows for labor augmenting productivity growth and \( \alpha \) represents the share of labor in total income:

\[ F (K_t, \Gamma_t h_t) = K_t^{1-\alpha} (\Gamma_t h_t)^\alpha \]  

(B.15)

Finally, the trade balance to output ratio is defined as:

\[ TBY_t = \frac{Y_t - C_t - I_t}{Y_t} \]  

(B.16)

In order to get the model to the data, a log-linear solution to the stationarized version of the model has to be derived. Therefore we proceed in the following way: (1) we stationarize the model by detrending all the variables which exhibit long run growth (2) then we derive the first order conditions, which characterize the optimal behavior of the two types of agents in the economy (3) finally, we log-linearize the optimality conditions around the steady state of the model. The resulting linear rational expectation system of difference equations which fully characterizes the optimal dynamics of the state and control variables was solved in Matlab.

**A.2.3 Calibration and Estimation**

In order to solve the linear rational expectation system of difference equations, which fully characterizes the optimal dynamics of the model economy, values to the model parameters must be assigned. We do this in two different ways: we estimate, by using Bayesian techniques, a set of parameters which are considered in the literature as being country specific or difficult to calibrate, and we calibrate the rest of the parameters.
Table A.2.1. Calibrated Model Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Bulgaria</th>
<th>The Czech Republic</th>
<th>Hungary</th>
<th>Poland</th>
<th>Romania</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.6742</td>
<td>0.6012</td>
<td>0.6097</td>
<td>0.6820</td>
<td>0.6428</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>$\tau$</td>
<td>s.t. $\bar{h}$</td>
<td>s.t. $\bar{h}$</td>
<td>s.t. $\bar{h}$</td>
<td>s.t. $\bar{h}$</td>
<td>s.t. $\bar{h}$</td>
</tr>
<tr>
<td>$\omega$</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>$\mu$</td>
<td>1.0130</td>
<td>1.0106</td>
<td>1.0071</td>
<td>1.0110</td>
<td>1.0151</td>
</tr>
<tr>
<td>$\tau^*$</td>
<td>1.0039</td>
<td>1.0039</td>
<td>1.0039</td>
<td>1.0039</td>
<td>1.0039</td>
</tr>
<tr>
<td>$\bar{d}$</td>
<td>0.4457</td>
<td>0.1703</td>
<td>0.7617</td>
<td>0.3545</td>
<td>0.3145</td>
</tr>
<tr>
<td>$\bar{h}$</td>
<td>0.3877</td>
<td>0.4665</td>
<td>0.3912</td>
<td>0.3828</td>
<td>0.4385</td>
</tr>
</tbody>
</table>

A.2.3.1 Calibrated parameters

We set the value of the calibrated parameters based on long averages provided by macroeconomic data in the case of each country, or we set them to values commonly used in emerging market business cycle literature. These are presented in Table A.2.1 for each country.

The labor share of income, $\alpha$, is set at the ten years average of the compensation of labor input to value added ratio in the case of each country. The rate of capital depreciation, $\delta$, is 0.025, which would imply a 10% annual depreciation rate and which is commonly used in emerging market business cycles papers. The preference parameters are set as follows: the coefficient of relative risk aversion, $\sigma$, defining the curvature of the utility function is 2; $\omega$, the exponent of labor in the utility function is 1.6 and the weight of labor in the per period utility, $\tau$, is set such that it implies that households allocate $\bar{h}$ share of their total time to working. These definitions and parameterizations are in line with those assumed by Schmidt-Grohe and Uribe (2003), Neumeyer and Perri (2005), Garcia-Cicco et al. (2010).

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13 The last section of this appendix presents the source of this data.
and others. \( \beta \) discount factor is set at 0.98 which would imply a 2.04\% quarterly risk free real interest rate.

The long run productivity growth, \( \mu \), is defined as average real GDP growth rate over the period 2000-2009\(^{14}\). The steady state level of gross foreign interest rate, \( r^* \), is computed as the quarterly average of the Euro Zone real interest rate over 2000-2009 period. \( \bar{d} \), the long run external debt to GDP ratio, is proxied as the 1997-2007 average of the net foreign asset to GDP ratio. The steady state share of labor, \( \bar{h} \), is defined as the ten years average employment to total population ratio.

**A.2.3.2 Estimated parameters**

We use Bayesian techniques as proposed by Smets and Wouters (2003), Lubik and Schorfheide (2005) and An and Schorfheide (2007) over the sample period 1995Q1:2009Q4 in order to estimate those parameters which are country specific (e.g. working capital parameter, capital adjustment cost coefficient) or difficult to calibrate (e.g. the persistence and standard deviation of different shocks, the elasticity of country spread with respect to the Solow residual). These authors argue that the main advantage of the Bayesian estimation of DSGE models in comparison with moment or impulse response matching is that the parameters are seen as random variables, and a prior density which incorporate initial beliefs and information about these parameters is specified together with a likelihood function for the DSGE model. Based on these, the posterior mode of each parameter can be computed and by using Bayes theorem to update initial beliefs, the conditional distribution of each parameter (i.e. posterior distribution) is calculated given the observable variables (i.e. data) and the model. An and Schorfheide (2007) point out that the main benefit of this posterior distribution consists of the fact that it permits to perform inference concerning the parameters and to conduct a likelihood based checking of the goodness of fit.

\(^{14}\)This type of association between parameter and statistical definition is used by Aguiar and Gopinath (2007a) in the case of Argentina and than it was taken over by other papers, e.g. Aguiar and Gopinath (2007b), Chang and Fernandez (2009).
Basically, this is a two step procedure: (1) in the first step the posterior mode is computed by using an optimization routine to find that value of the parameters which minimizes the negative log-likelihood given the model, the data based on which we perform the estimation and prior probability distribution of the parameters to be estimated.\textsuperscript{15} The inverse of the Hessian of the log-likelihood function is evaluated at the optimal posterior mode. (2) The second step consists of running a Markov Chain Metropolis-Hastings (MCMH) algorithm which constructs a Gaussian approximation around the posterior mode in the following way: it draws a number from a normal distribution characterized by mean equal to the posterior mode obtained in the previous step and variance-covariance matrix set at the inverse of the log-likelihood function evaluated at the same posterior mode and scaled up by a constant (i.e. jumping distribution). Then it decides whether to accept this newly drawn value as the mean of the jumping distribution used for the next draw with a certain probability (i.e. acceptance ratio computed as the ratio between the log-likelihood of the model evaluated at the newly drawn parameter and the same likelihood evaluated at the parameter value obtained from the previous draw) or to continue with the parameter value obtained from the previous draw, with probability one minus the acceptance ratio. The more these draws are repeated the more efficiently and effectively the algorithm can explore the posterior distribution in the neighborhood of the posterior mode.

Therefore three main ingredients are needed to implement the above described procedure: the model, the observable variables and the definition of the prior distribution of the estimated parameters. Firstly, the model has to be written in a linear rational expectation system form which is solved by using numerical methods.\textsuperscript{16} Then the model is written in state space form together with the measurement equations while its likelihood is computed by using the Kalman filter.

\textsuperscript{15}To find the optimal value of the posterior mode we use a Monte-Carlo based optimization routine, with 100000 simulations, implemented in Dynare. This turned out to be a more robust method than solving a simple constrained minimization problem.

\textsuperscript{16}For this we use perturbation methods implemented in Dynare toolbox which provide as a solution a linear dynamic version of the model which contains the dynamics of the state and control variables, i.e. policy functions.
Secondly, the observable variables must be defined and fed into the model. We use four observable variables because they are available in the case of all countries and the methodology based on which they are collected should not differ across countries. These are the HP filtered quarterly gross domestic product \((obsY)\), consumption \((obsC)\) and investment \((obsINVE)\) taken in logarithm and HP filtered trade balance to output ratio \((obsTBY)\) over the period 1995:1-2009:4. We assume that these observables are subject to measurement errors because of two reasons. One reason is technical in nature, and it aims to overcome the stochastic singularity problem, i.e. the number of structural shocks in the model must be equal to the number of observables considered for the estimation. Since in the present models there are three, respectively four shocks, at least one measurement error must be included while estimating the uniform interest rate and non-persistent country spread version of the model or at least two measurement errors have to be defined when estimating the uniform interest rate and persistent country spread extension. We assume that the measurement errors \(\{\epsilon_{obsY}, \epsilon_{obsC}, \epsilon_{obsI}, \epsilon_{obsTBY}\}\) follow i.i.d. processes with zero mean and \(\sigma_z^2 = \{\epsilon_{obsY}, \epsilon_{obsC}, \epsilon_{obsI}, \epsilon_{obsTBY}\}\) standard deviation. The other reason for defining measurement errors is related to the potential role they play in conducting robustness check of the results. Therefore, when estimating the model we distinguish two cases: estimation without measurement errors, when we augment the state space just by as many measurement errors as many are needed to overcome the stochastic singularity problem, versus estimation with measurement errors, when we consider that all the observables contain measurement error. By considering that macroeconomic data usually contain errors and omissions because of aggregation, changes in methodologies, definitions, rules and regulations applied during collecting them the inclusion of measurement errors should improve the estimation results if the errors are indeed influential.

Finally, the prior distribution is usually subjective because it describes uncertainty and prior knowledge about the model and its parameters. We select the shape of the distribution based on those applied in earlier papers on emerging market business cycles and based on the
restrictions regarding possible domain of definition of different parameters. The expected value and standard deviation of each distribution assumed are set at values provided by macroeconomic data. Overall, we estimate eleven structural parameters, as reported in Table 5 which can be divided into two groups.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior shape</th>
<th>Expected value</th>
<th>Std. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_{z1}$</td>
<td>Gamma</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Inverse Gamma</td>
<td>0.2</td>
<td>Inf</td>
</tr>
<tr>
<td>$\rho_a$</td>
<td>Beta</td>
<td>0.9</td>
<td>0.01</td>
</tr>
<tr>
<td>$\rho_g$</td>
<td>Beta</td>
<td>0.72</td>
<td>0.01</td>
</tr>
<tr>
<td>$\rho_{r^*}$</td>
<td>Beta</td>
<td>0.8</td>
<td>0.01</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Gamma</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Gamma</td>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Gamma</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Beta</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>$\sigma_{z2}$</td>
<td>Gamma</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Inverse Gamma</td>
<td>0.02</td>
<td>Inf</td>
</tr>
</tbody>
</table>

Table A.2.2 Prior Distribution of the Estimated Model Parameters

The first group contains the persistence and the standard deviation of the shock processes. In line with previous studies, we assume that the persistence of the $AR(1)$ shock processes follow $Beta$ distribution because this distribution is the most suitable for parameters taking values between zero and one. The standard deviation of this distribution is harmonized across different shocks and it is set at 0.01 while the mean of the distribution differs across shocks. Since the transitory technology shock is documented in the literature as persistent (e.g. Smets and Wouters, 2007; Chang and Fernandez, 2009; Garcia-Cicco et al., 2010), we set the mean of the distribution of $\rho_a$ to 0.9; the mean of the persistence of
permanent technology shock, $\rho_g$, is set at 0.72 since previous estimation results reported in the RBC literature suggests that it is less persistent than the transitory one; quantitative macroeconomic literature provides a series of evidences that US and Euro Zone real interest rates are both highly persistent or they follow an almost random walk process. Uribe and Yue (2006) estimate an AR(1) process on the 3-month real gross Treasury bill rate and they obtain a significant point estimate of the persistence parameter equal to 0.83. Similarly, Lubik and Schorfheide (2005) estimate the same parameter and get 0.84 in the case of the US and 0.83 in the Eurozone. Thus, we set the mean of the distribution of $\rho_{r^*}$ at 0.8 while the distribution of the persistence of country spread is assumed to have mean 0.65 in line with the autocorrelation coefficient of the EMBI spread reported in the first section of the paper.

The distribution of the standard deviation of the shock processes $(\sigma_z = \{\epsilon_a, \epsilon_g, \epsilon_{r^*}, \epsilon_s\})$ is considered being the same across different types of shocks. Generally, in the quantitative macro literature dealing with Bayesian estimation of DSGE models, standard errors of shocks are assumed to follow inverse gamma distribution mainly because this is a sensible distribution to relative shock sizes\(^{17}\). Moreover, gamma distribution could be another good candidate for the distribution followed by these standard deviations because it is used in the case of parameters which take positive values. Thus, we estimate each specification of the model by considering two cases: first, we assume that the standard deviation of the shocks follows gamma distribution with mean 0.2 and standard deviation 0.1, while, in the other case, we consider inverse gamma distribution with mean 0.1 and scale parameter infinity.

The second group of structural parameters consists of those parameters which characterize financial decisions in the model. These are the elasticities of country spread with respect to Euro Zone interest rate, $\eta_{r^*}$, and Solow residual, $\eta_{SR}$. Since with the exception of $\eta_{SR}$ in the case of Argentina there are no previous evidences concerning the Bayesian estimation of these parameter we assume that they follow Gamma distribution (i.e. they take positive values because it is intuitive to assume that country spread increases as Euro Zone interest

\(^{17}\)For a detailed description of the most frequently used distributions in DSGE Bayesian estimation, advantages and shortcomings of them consult Ermolaev et al. (2008): Estimating GPM with Dynare mimeo.
rate gets higher or when a negative productivity shock hits the economy) with mean 0.5 and standard deviation 0.1. The mean of the distribution was set based on the observed correlation coefficient between EMBI spread and Euro Zone interest rate, on the one hand, and EMBI spread and output, on the other hand.

Another financial parameter of the model is the debt-elastic interest rate parameter, \( \psi \), which measures the sensitivity of interest rate/country spread to fluctuations in external debt position. This parameter is usually not estimated and is calibrated at 0.001, value which was proposed by Mendoza (1991) in the case of the Canadian economy. Garcia-Cicco et al. (2010) are the only authors who estimate this parameter, assuming that it follows uniform distribution. Thus it is worth to pay particular attention to this parameter and estimate it because it could easily happen that in the case of emerging economies the data would attribute a higher value to it. Logically it can be expected that country spread is more sensitive to movements in debt position in emerging economies than in developed countries; hence calibrating it to 0.001 would be erroneous. We assume that this parameter follows a gamma distribution with mean 0.15 and standard deviation 0.05. This is a rather loose prior but since there is no previous evidence on estimating it, the prior should take into account this uncertainty (i.e. this is why the standard deviation of the distribution takes relatively high value).

Because the capital adjustment cost parameter, \( \phi \), is a positive parameter it is assumed to follow a gamma distribution with mean 6 and standard deviation 2.\(^\text{18}\) This is a somewhat tighter prior than those assumed by Chang and Fernandez (2009) who estimate \( \phi \) by considering that it follows a gamma (3,2) distribution in the case of Mexico or Smets and Wouters (2007) who assume normal (1.25, 0.24) in the case of Eurozone. However, this is in line with Garcia-Cicco et al. (2010) who consider gamma(8,4) distribution. The working

\[^{18}\text{We estimated the model by assuming a loose prior for the distribution of } \phi \text{ like gamma (3,2) for the first time and then we systematically tightened the prior by increasing the mean of the distribution. It turned out that indifferently of how tight or loose the prior is the data and the model had the tendency to push up the posterior mode of } \phi \text{ to values around 6 across all the countries. Hence we set the mean at 6 in order to obtain a better fit.}\]
capital constraint, $\theta$, parameter takes values between zero and one, thus we assume that it follows Beta distribution with mean 0.5 and standard deviation 0.1. The main motivation for setting the mean of this parameter to 0.5 is provided by the data which suggests that the cross country average of the short run private credit of non-financial corporations to value added ratio is around 0.45. This assumption is similar to those made by Chang and Fernandez (2009).

Finally there is a set of nonstructural parameters which consists of the standard deviation of measurement errors ($\sigma_{z2} = \{\epsilon_{\text{obs}Y}, \epsilon_{\text{obs}C}, \epsilon_{\text{obs}I}, \epsilon_{\text{obs}TBY}\}$). We estimate the model by assuming that these parameters follow: inverse gamma with mean 0.02 and scale parameter set to infinity or gamma distribution with mean 0.02 and standard deviation 0.01. This is a wide prior, but in this way uncertainty concerning the values of these standard deviations can be incorporated into the prior knowledge.

We set the algorithm to make one hundred thousand draws$^{19}$; the initial 50% of draws were dropped out to ensure that the results do not depend on the initial value, and the scaling parameter in the jumping distribution was fine tuned (around 0.4) such that to obtain approximately one third acceptance ratio. Moreover, in order to conduct convergence diagnostic (i.e. ensure that two different chains converge to the same stationary distribution) we run two parallel Markov Chains and check the presence of convergence by comparing recursively computed second order moments$^{20}$ of the distributions constructed under each and every draw per chain.

The estimation results can be summarized as follows: (1) The goodness of fit statistics indicate that the specification which fits the best the data assumes gamma distribution for the standard deviations of the shocks, all the observable variables contain measurement

$^{19}$Initially, we set the number of draws to half a million in the MCMH algorithm but due to the robustness of the optimization method used in the first step the two chains started to converge fast after 20000 draws. We checked if this convergence is present in the case of all the five countries by estimating the Chang and Fernandez (2009) version of the model with both 100000 and half a million draws. The estimation results and the convergence statistics confirmed that 100000 draws are enough to achieve convergence.

$^{20}$These second order moments are the variance of the distribution, skewness and confidence interval constructed around the parameter mean.
errors and the parameter $\psi$ is estimated in the case of all the five sampled countries, (2) The point estimates of $\psi$ suggest that it is erroneous to calibrate the debt elastic interest rate parameter to 0.001, as proposed by Mendoza (1991) and as it has been used so far in the literature. The data suggests that, given the considered model setup, $\psi$ varies in $[0.02, 0.23]$ interval across countries and across different model specifications, (3) The posterior means of the persistence and standard deviation parameters of the shocks are relatively stable across different model specifications, and (4) Financial parameters (like the elasticity of country spread, working capital constraint or capital adjustment cost parameter) vary slightly across different model versions. In addition, a certain degree of heterogeneity in the point estimates of these financial parameters can be observed across countries. The rest of this subsection discusses these results in more details.

When the debt elastic interest rate parameter, $\psi$, is not estimated, the estimates of financial parameters\textsuperscript{21}, especially that of the capital adjustment cost parameter changes significantly, as reported in Table A.2.3. Independently of the model version considered, by calibrating $\psi$ to 0.001, as proposed by Mendoza (1991), the estimate of the capital adjustment cost parameter becomes more than double in comparison with the case when $\psi$ is estimated. In addition, the elasticity of country spread and the working capital constraint parameter increase.

<table>
<thead>
<tr>
<th>$\psi$</th>
<th>Bulgaria</th>
<th>Czech Rep.</th>
<th>Hungary</th>
<th>Poland</th>
<th>Romania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibrated to 0.001</td>
<td>17.29</td>
<td>13.14</td>
<td>13.62</td>
<td>14.22</td>
<td>14.68</td>
</tr>
<tr>
<td>Estimated</td>
<td>7.93</td>
<td>7.79</td>
<td>6.48</td>
<td>4.99</td>
<td>7.61</td>
</tr>
</tbody>
</table>

Table A.2.3. Posterior mean of $\phi$ under different specification of $\psi$

This result is not counterintuitive at all and it actually underlines the role of capital adjustment cost in the model. When $\psi$ is calibrated to a low value relative to what the

\textsuperscript{21}For example, the elasticity of country spread with respect to the Solow residual and Euro Zone interest rate or the working capital constraint parameter.
data would imply the interest rate is less sensible to large movements in external debt, i.e. external financing is relatively cheap. Consequently, agents would like to adjust even more their capital stock by using besides their own funds more external financing, generating in this way higher investment volatility. In order to limit this investment volatility, the cost of an additional unit of capital accumulated must be higher, i.e. the capital adjustment cost parameter must increase.

For example, Chang and Fernandez (2009) calibrate $\psi$ instead of estimating it and they obtain a point estimate of $\phi$ equal to 14.72 in the case of Argentina. This result is similar to those we report in Table A.2.3 suggesting two digit numbers for $\phi$ across all the countries when $\psi$ is calibrated. However, when $\psi$ is estimated its point estimates vary in $[0.02, 0.23]$ interval depending on country, model and prior specification. These are somewhat lower estimates than the $\psi$ equal to 2.8 reported by Garcia-Cicco et al. (2010). This indicates that the data shifts the posterior mode of the conditional distribution upper, to the right in the distribution of the parameter, suggesting that the external debt elasticity of country spread or interest rate in the case of CEECs might be higher than 0.001, i.e. country spread or interest rate is more sensitive to changes in the external debt position in CEECs than in developed ones, like Canada.

Regarding the estimates of $\phi$ reported in Table A.2.3, one can observe that $\phi$ takes values between 3.4 and 8.2 when $\psi$ is estimated. These results are not at odds neither with the previous evidences in RBC literature nor with the existing empirical evidences obtained from research on investment behavior. For example Cummins et al. (2006) estimate $\phi$ by using cross section data of firms from the US and conclude that the estimated $\phi$ is about 7.2 in the US. Thus, the estimates of $\phi$ obtained both in the case of the uniform interest rate model and the persistent spread model are quite plausible. To motivate lower estimates of $\phi$, one can use the figures reported by Aguiar and Gopinath (2007a) who obtain estimates for $\phi$ between 2.82 and 3.79 by using moment matching, or those recently documented by Garcia-Cicco et al. (2010) (i.e. they estimate $\phi$ at 4.6 in the case of Argentina by using
Bayesian techniques).

**A.3 Data Appendix**

1. National account components from Eurostat (quarterly frequency): the following components measured in millions of national currency chain-linked volumes (reference year 2000) are used in the paper (with the corresponding identification code in the brackets):

   1.1. Output: gross domestic product at market prices (B1GM) series
   1.2. Consumption: household and NPISH final consumption expenditure (P31_S14_S15):
   1.3. Investment: gross fixed capital formation (P51)
   1.4. Exports: exports of goods and services (P6)
   1.5. Imports: imports of goods and services (P7)
   1.6. Trade balance to output ratio: is the ratio between net exports, computed as the difference between exports of goods and services (P6) and imports of goods and services (P7), and gross domestic product at market prices (B1GM)

   weseasonally adjusted of all the above presented series by using Tramo-Seats method implemented in Demetra 2.1. software package.

   Cyclical components (logarithmic deviation from the long run trend) of the seasonally adjusted output, consumption investment and trade balance to GDP ratio: are computed in three steps (i) firstly, the above described level series are taken in logarithm (ii) the time series, obtained in this way, are filtered by using Hodrick-Prescott filter with \( \lambda = 1600 \) scale parameter (iii) the cyclical component of each series is computed as a difference between the logged level series and its trend component.

2. Real Euro Zone interest rate (quarterly frequency): is computed as the difference between the overnight German money market rate and annualized quarterly German inflation rate. The source of the interest rate is the Online Historical Financial Statistics published by The Deutsche Bundesbank and it is defined as Frankfurt banks / Overnight money / Monthly average: SU0101, from which the quarterly series is constructed by taking the
corresponding monthly rate at the end of each quarter. The annualized quarter-to-quarter inflation rate is computed based on the quarterly consumer price index (13464ZF)(2000=100) from International Financial Statistics of IMF according to the following formula:

$$\inf = 400 \times \ln \left( \frac{CPI_{t,2000=100}}{CPI_{t-1,2000=100}} \right)$$  \hspace{1cm} (20)

3. Country spread (quarterly frequency): is quantified by using JP Morgan EMBI Global Divers-Stripped spread in Poland (JPMGPOC (SSPRD)) covering the period 1995Q1:2009Q4, in Hungary (JPMGHNC (SSPRD)) over the period 1999Q1:2009Q4 and in Bulgaria (JPMP-BUL (BSPRD)), 1994Q3:2009Q4; In order to compute EMBI spread US-dollar denominated Brady bonds, Eurobonds, and traded loans issued or guaranteed by sovereign entities are considered. Only issues with a current face amount outstanding of $500 million or more and a remaining life of greater than 2 1/2 years are eligible for inclusion in the index. Moreover the yield spread used in the case of Hungary is computed as the absolute difference between yield on long term Eurobonds issued by the Hungarian government (568915(RYAN)) and yield on long term US Treasury bonds. (993766(RYAN)).

4. Compensation of labor input (annual frequency): (i) total compensation of labor (lab_tot) is obtained from the EU KLEMS database for The Czech Republic, Poland and Romania. This is computed as the sum of compensation for employees and that part of the operating surplus/ mixed income which represents the compensation for self-employed Data concerning mixed income is not available in the case of Bulgaria and Romania (ii) compensation of employees at industry level published by Eurostat in the National Accounts by 6 branches at current prices (nama_nace06_c) and defined as the total remuneration, in cash or in kind, payable by an employer to an employee in return for work done by the latter. Social contributions paid by the employer are also included in this indicator.

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22 Source: http://www.jpmorgan.com/pages/jpmorgan/investbk/solutions/research/EMBI
23 Source: Datastream
24 For more details see EU KLEMS Growth and Productivity Accounts Version 1.0 Methodology, March 2007 http://www.euklems.net/
5. Value added (annual frequency): (i) total value added in the economy (all industries) at current prices, in millions of euro, is obtained from the EU KLEMS database \(\text{va}_\text{tot}\) for Hungary, the Czech Republic and Poland; in the case of Bulgaria and Romania the source of value added is Eurostat \(\text{B1G}\) (ii) industry level value added series, at current prices, in millions of national currency, are from the National Accounts aggregates and employment by branch tables \(\text{NACE}\) \(\text{nama}_\text{nace}\) published by Eurostat.

6. Private credit of non-financial corporations (annual frequency): since there are no publicly available figures concerning the type of loans besides their maturity for the Czech Republic, Hungary and Romania, short term financial liabilities (stocks) of non-financial corporations in millions of national currency, from the Czech National Bank’s, the National Bank’s of Hungary and the Romanian National Bank’s Monetary and financial statistics, are taken as proxy for working capital loans; working capital loans to non-financial private corporations (stocks) in millions of national currency is considered in the case of Poland published by the National Bank of Poland in the Monetary and financial statistics: Assets and liabilities of monetary financial institutions; Bulgaria: there is no publicly available data.

7. Real GDP growth rate (quarterly frequency): measured as the percentage change of the gross domestic product at constant prices relative to the previous period from the GDP and main components-volumes \(\text{namq}_\text{gdp}_k\) table published by Eurostat


10. Employment: (annual frequency): measured as annual average total employment (15-64 years, resident population concept - LFS) in thousand of persons from the Employment

\(^{25}\)More details about the source of the data at http://www.philiplane.org/EWN.html
(main characteristics and rates) (lfsi_emp_a ) table published by Eurostat.

11. Population: is in thousand of persons and it is obtained from Population, activity and inactivity - Annual averages (lfsi_act_a) table, Eurostat.
A.4 Graphs

A.4.1. Results of the simulation of the small open economy RBC model with endogenous country spread (initial external debt above and capital below their steady state by 10%)
Bibliography


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