Growing Like China: Firm Performance and Global Production Line Position*

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Abstract

Global value chains have fundamentally transformed international trade and development in recent decades. We use matched firm-level customs and census data and Input-Output tables for China to examine how firms position themselves in global production lines and how this position evolves with performance over the firm lifecycle. We document a sharp rise in import upstreamness, stable export downstreamness, and rapid expansion in production stages conducted in China over the 1992-2014 period, both in the aggregate and within firms over time. Firms span more production stages as they grow more productive, bigger and more experienced. This expansion is accompanied by a rise in input purchases, value added in production, and fixed cost levels and shares. It is ultimately associated with higher profits despite flat profit margins. We rationalize these patterns with a stylized model of the firm lifecycle with complementarity between economies of scope and scale. We conclude with suggestive cross-country panel evidence to inform promising avenues for future research.

JEL codes: F10, F14, F23, L23, L24, L25.
Keywords: Global value chains, production line position, upstreamness, firm heterogeneity, firm lifecycle, China.

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1 Introduction

Global value chains (GVCs) have fundamentally transformed international trade and development in recent decades (Baldwin 2016, Antràs 2019, World Development Report 2020). As production has fragmented across firm boundaries and country borders, new challenges and opportunities have arisen for individual firms and aggregate economies. And as countries at different phases of economic development have tended to specialize in different GVC segments, new policy questions have taken center stage: How do global supply chains affect firm performance in the short run and growth prospects in the long term? If global production lines enable firms in advanced economies to profitably offshore, do they also engender cross-border technology transfer and structural transformation in less developed countries, or do they instead entrench such countries in low-profitability, low-growth GVC activities? Despite great policy interest, only recently has academic research begun to overcome data and conceptual challenges to dispel common speculation and uncertainty around these issues.

In this paper, we examine how firms position themselves in global production lines and how this position evolves with firm productivity and performance over the firm lifecycle. Using matched firm-level customs and census data and Input-Output (IO) tables for China, we quantify Chinese firms' GVC participation and establish novel stylized facts about its path during 1992-2014. First, we document a sharp rise in import upstreamness, stable export downstreamness, and rapid expansion in production stages conducted in China over this period, both in the aggregate and within firms over time. Second, we show that firms span more production stages as they grow more productive, bigger and more experienced. This expansion is accompanied by a rise in input purchases, value added in production, and fixed cost levels and shares. It is also ultimately associated with higher profits despite flat profit margins. Finally, we rationalize these patterns with a stylized model of the firm lifecycle that features complementarity between economies of scope and scale.

China provides a fascinating context in which to study the implications of global production sharing for firm and aggregate growth. As the fastest growing economy over the last 30 years, China recently became the second largest country by GDP and the biggest exporter in the world. Key to this economic transformation has been its dramatic globalization, marked by its joining the WTO in 2001 and actively embracing processing trade since the mid-1980s (Feenstra and Wei 2010, Manova and Yu 2016).[1] Indeed, various trade and industrial policies have encouraged firms' participation in global value chains, such as the formalization of a processing trade regime under which foreign inputs can be imported duty-free for further processing, assembly and re-exporting, or the establishment of special economic zones that concentrate trade and FDI activity. Moreover,

[1] Brandt et al. (2008) quantify the contribution of two other sources of structural transformation to China's phenomenal growth over 1978-2004: large-scale reallocations from agriculture towards manufacturing and services and from state-owned enterprises towards private firms. At the same time, Hsieh and Klenow (2009) conclude there is extensive misallocation of productive resources across Chinese firms compared to the US.

while "factory China" originally emerged as a global hub for low-skill, low-cost production steps in the early 21st century, a steady increase in production wages and technological know-how have enabled the rise of innovative companies that are global leaders in their market.

Our first contribution is to characterize Chinese firms' position in global value chains and trace its evolution over the 1992-2014 period. We exploit the most detailed available IO table for China to build an industry-level measure of *upstreamness* for 135 industries. Introduced by Fally (2012) and Antràs et al. (2012), this measure captures an industry's distance to final demand in terms of the weighted average number of stages at which the industry is used as a production input before it reaches final consumers. Higher values signal more upstream sectors (e.g. rubber), and lower values indicate more downstream sectors (e.g. cars).

We quantify Chinese firms' global production line position by combining the industry indicator of upstreamness with the industry composition of firms' trade flows to construct the weighted average upstreamness of firm imports, U^M, the weighted average upstreamness of firm exports, U^X, and the difference between the two, $U^M - U^X$. In a strict sense, $U^M - U^X$ identifies the span of production stages that firms either execute themselves or outsource to other producers within China. As we show, $U^M - U^X$ is however orthogonal to firms' imported-input intensity and export-sales intensity, suggesting that it in fact reflects production stages performed in-house. Chinese customs data permit firm-level analysis for 2000-2014 and, drawing on province- or city-level data, aggregate analysis for 1992-2014.

We identify four *Macro Trends* in China's GVC participation in the aggregate. First, over 1992-2014, Chinese imports became significantly more upstream, while Chinese exports became slightly more downstream. Second, these developments were primarily driven by ordinary trade and not by processing trade. Third, import and export upstreamness evolved similarly for all firm ownership types, with persistent level differences among them. State-owned enterprises operated most upstream, private domestic firms operated in the middle, and joint ventures and foreign-owned affiliates operated most downstream. Finally, within firms over time, imports became significantly more upstream, exports became moderately more downstream, and the implied span of production stages performed within China increased quickly during 2000-2014.

Our second contribution is to establish new stylized facts about the relationship between Chinese firms' attributes, production line position, production operations, and performance over the firm lifecycle. We document five *Firm Facts* about the evolution in activity within firms over time. First, when firms become more productive, bigger and more experienced, they import significantly more upstream, export moderately more downstream, and span more production stages (in China). These results hold across different measures of firm productivity (real value added per worker, TFP estimates à la Levinsohn-Petrin or Olley-Pakes), firm size (sales, exports, employment), and firm experience (age, cumulative past trade activity).

Second, when firms span more production stages (in China), they increase value added in production proportionately with output, but do not change the share of exports in total sales. Third, when firms expand along the production chain, they also scale up total input purchases proportionately with output, but do not change the share of imported inputs. Fourth, when firms perform more production steps, they raise the level of fixed costs and assets as proxied respectively by inventory holdings and net plant, property and equipment, as well as the share of these fixed costs and assets in total assets. Lastly, when firms internalize wider segments of the value chain, they earn higher profits without changing their profit margins in terms of profit-to-sales, profit-to-value added, or profit-to-assets ratios.

Extensive sensitivity analysis confirms the robustness of these five Firm Facts. The baseline specifications control not only for firm fixed effects, but also for year fixed effects that absorb common supply and demand shocks. They further condition on firms' skill (average wage) and capital intensity (net fixed assets per worker). The results are unaffected by omitting these firm controls or instead additionally controlling for the share of processing trade. Similar patterns also obtain when we experiment with alternative upstreamness measures based on less disaggregated Chinese IO tables available for an earlier period or more disaggregated IO tables for the United States. The findings likewise remain qualitatively stable across alternative firm samples.

Our third contribution is to develop a partial-equilibrium model of firms' decision over where to operate along the production chain and which production activities to perform in-house in order to maximize profits. Our goal is to provide a stylized theoretical framework that can rationalize the Firm Facts in the data and highlight key economic mechanisms at play, rather than to fully characterize firm interactions, price setting and market clearing in general equilibrium.

In the model, price-taking firms purchase inputs from upstream suppliers, add value in processing these inputs into more complete products along a sequential production line, and sell their output at downstream competitive markets. Firms simultaneously choose (i) the upstreamness of their purchased inputs, the downstreamness of their output, and hence their span of production stages, (ii) the quantity of the upstream intermediate input to purchase, and (iii) the quantity of inputs to use in completing in-house stages. Looking upstream, firms face a trade-off between sourcing a more fully processed but more expensive input and incurring the fixed and variables costs of conducting the inframarginal production steps in-house. Looking downstream, firms likewise weigh the benefit of selling a more finished output at a higher market price against the fixed and variable costs of conducting the inframarginal production steps. We show that under intuitive conditions on the price and cost profile along the production chain, there will be complementarity between production scope and scale. As a result, an exogenous positive shock to productivity would induce a firm to both span more production stages and operate on a bigger scale at each stage, ultimately earning higher profits.

Through the lens of this stylized model, we interpret Firm Fact 1 as consistent with a causal effect of changes to firm productivity on its optimal production line position. This causal interpretation extends to the findings for firm size and experience, to the extent that more productive firms have higher survivor probability and changes in firm size arise from changes in firm productivity or exogenous demand conditions. On the other hand, we view Firm Facts 2-5 as correlations among joint outcomes of the firm's profit maximization problem that reflect optimal operational decisions and resultant profits.

Our findings shed light on policy questions about the implications of global value chains for firm growth, and challenge concerns about GVC-induced stagnation traps. The new evidence we uncover suggests that the fragmentation of production across countries can enable firms to first specialize in narrower segments of the production line and gradually expand into more production stages, grow their production scale, add more value, and earn higher profits. This growth path may be especially important in emerging economies, where less productive and less experienced firms stand to gain more from knowledge transfer from foreign buyers and suppliers. Credit constrained firms may likewise be able to share in the gains from trade by operating fewer production stages to begin with, accumulating retained earnings, and using internal capital to fund expansion along the supply chain. Finally, our analysis highlights important distinctions between value added, profits and profit margins in the context of global production sharing.

Our results for the firm lifecycle with global value chains point to potentially important macro-level implications that future work can explore.[2] In the conclusion, we offer suggestive evidence that countries' aggregate position in global production lines indeed exhibits systematic, complex correlations with the level and growth rate of their trade activity and GDP per capita.

Our work contributes to several strands of research. We extend a growing literature in international trade on the rise of global value chains. Early empirical analyses have aimed to infer the country origins of value added embedded in country-level trade flows, and documented the increased fragmentation of production across borders (e.g. Hummels et al. 2001, Yi 2003, Johnson and Noguera 2012). Much subsequent work has emphasized the important role of international supply-chain linkages for firm operations. Successful exporters routinely use a large share of imported inputs in producing for foreign markets (e.g. Bernard et al. 2012). This is especially true in developing economies, where the range, cost and quality of domestic intermediates may be ill-suited to manufacturing products that meet the quality standards of foreign consumers and the technological needs of foreign downstream producers (e.g. Kugler and Verhoogen 2009, 2012, Bas and Strauss-Kahn 2015). Indeed, more than half of Chinese exports are conducted under processing

[2]Recent work suggests that heterogeneous dynamics and shock propagation across firms can indeed have sizeable effects on macro-economic outcomes. For example, Di Giovanni et al. (2018, Kramarz et al. (2020), and Gaubert and Itskhoki (2018) find important effects of micro-level granularity on exposure to foreign demand shocks, international business cycle comovement, and comparative advantage in the aggregate.

trade, and the large majority of Chinese exporters intensively use imported inputs (e.g. Manova and Zhang 2012, Wang and Yu 2012, Manova and Yu 2017).

We specifically advance recent work on global production lines, in which the production process is viewed as a technologically-sequenced series of stages. We provide one of the first firm-level analyses and document novel stylized facts that shed light on the few existing theoretical models in this literature. At the aggregate level, Costinot et al. (2013) examine how cross-country productivity differences affect the span of stages that countries specialize in. Fally (2012) and Antràs et al. (2012) conceptualize and empirically implement measures of the upstreamness vs. downstreamness of different industries along production chains. At the micro level, Antràs and Chor (2013) and Alfaro et al. (2019) study how firms' production line position influences their pricing and sourcing strategy in-house vs. at arm's length in a Grossman-Hart-Moore property-rights model of the firm. Fally and Hillberry (2018) consider instead Coasian organizational frictions related to market transaction costs in a sequential production setting. Antràs and de Gortari (2020) build and quantify a model with a discrete number of sequenced production stages, and explore how the geography of trade costs affects the equilibrium formation of global production chains. While our findings indirectly speak to these models, we also uncover new patterns in the data that can only be rationalized with richer models of the determinants of firms' production line position.

To the best of our knowledge, we present the first analysis of the relationship between firms' inherent attributes, chosen production line position and internal production operations, and performance over the firm lifecycle. We thus provide an intellectual bridge between trade research on GVC activity, development research on growth and structural transformation, and IO research on the organization of production across firms. Prior studies have linked access to imported inputs and learning from foreign partners to firm productivity growth (e.g. Amiti and Konings 2007, Goldberg et al. 2010, Halpern et al. 2015), examined trade-related growth in productivity and domestic value added within Chinese firms (e.g. Brandt et al. 2012, Kee and Tang 2014, Tang et al. 2020), and shown that processing trade can be a stepping stone to higher value-added, more profitable and more liquidity-intensive ordinary trade in the presence of financial frictions (e.g. Manova and Yu 2016). A separate line of research has identified systematic patterns at both the country and firm levels in the expansion of product scope and in the transition across products, based on similarity in input use, upstream-downstream production links, or progression towards greater technological sophistication (e.g. Hausmann et al. 2009, Bernard et al. 2011, Boehm et al. 2019). A third agenda analyzes price setting and rent sharing along sequential supply chains, often in the context of developing countries and production lines characterized by small upstream producers of homogeneous goods and large downstream processors and distributors (e.g. Miquel-Florensa and Macchiavello 2018, Macchiavello and Morjaria 2019, Cajal-Grossi et al. 2020).

The remainder of the paper is organized as follows. The next section introduces the data and the measure of upstreamness. Section 3 uncovers Macro Trends in China's position in global value chains during 1992-2014. Section 4 establishes Firm Facts about the joint evolution of firm attributes, production line position, production activities, and performance over the firm lifecycle. Section 5 presents a stylized model of firm behavior with production fragmentation that rationalizes the empirical patterns. The last section offers concluding remarks and suggestive cross-country panel evidence that inform promising avenues for future research.

2 Data

2.1 Trade statistics

We examine the evolution of China's international trade activity over the 1992-2014 period using three comprehensive datasets provided by the General Administration of the Chinese Customs. The first dataset covers the 1992-1996 period. It reports the value of total exports and imports in US dollars for each Chinese province by destination/origin country, HS 6-digit product (about 5,000 categories), firm ownership type, and trade regime. The second dataset provides slightly more disaggregated data for the years 1997-1999. It records the value of total exports and imports in US dollars for each Chinese city by country, HS 8-digit product (about 7,500 categories), firm ownership type, and trade regime. The third dataset comprises the universe of China's international trade transactions in 2000-2014 (known as the Chinese Customs Trade Statistics, CCTS). For this time interval, we observe the value of firm-level exports and imports in US dollars by country (except years 2012-2014), HS 8-digit product, ownership type, and trade regime.[3] To abstract from the seasonality and lumpiness inherent in high-frequency trade flows, we aggregate the raw data to the annual level.

The Chinese customs records allow us to distinguish between several firm organizational structures and operational modes. In the 2000-2014 transaction-level data, we can identify private domestic firms (PVT), state-owned enterprises (SOE), joint ventures (JV), and fully foreign-owned multinational affiliates (MNC). We also observe whether each transaction is conducted under the institutionally sanctioned regimes of processing or ordinary trade. Processing trade permits firms to import inputs intended for further processing, assembly and re-exporting on behalf of a foreign buyer without incurreing import duties. Firms are allowed to simultaneously conduct both processing and ordinary trade activities, and in practice about 25% of all exporters do (Manova and Yu 2016).

Figure 1A illustrates the dramatic rise in China's overall export and import activity over 1992-

[3] Product classification is consistent across countries at the 6-digit HS level. The number of distinct product codes in the Chinese 8-digit HS classification is comparable to that in the 10-digit HS trade data for the U.S. Since the three trade datasets use different revisions of the HS system, we use concordance tables provided by the United Nations to standardize the data to the 2007 version of the HS coding system.

2014 horizon. During this period, exports rose from about $84.9 billion in 1992 to close to $2.34 trillion in 2014 (in current U.S. dollars), with a pronounced uptake in the rate of expansion after China joined the WTO in 2001. This aggregate expansion was accompanied by substantial variation in trade participation across firms. The number of firms engaged in exporting more than quadrupled from 81,995 in 2000 to 364,116 in 2014. Average exports per firm doubled from $3.97 million in 2000 to $7.85 million in 2014, with large standard deviations around these means ($41.5 million in 2000 vs. $102.4 million in 2014).

We are interested in the operations of manufacturers over their lifecycle, and therefore want to remove wholesalers and retailers from the analysis. We identify trade intermediaries following a standard algorithm in the literature that locates keywords in firm names.[4] During 2000-2014, intermediaries account for 8% of all firms that pursue international trade and about 18-20% of aggregate trade by value.

Columns 1-3 in Table 1 provides summary statistics for the sample of non-intermediaries in the 2000-2014 panel. During this period, 532,704 exporters and 422,818 importers pursued trade at least once, and 259,439 firms were two-way traders in at least one year. The latter generated 13.77 log export revenues on average (standard deviation 2.39), and their mean log imported input purchases stood at 12.19 (standard deviation 3.03). The panel of two-way traders includes 31% private domestic entitites, 5% state-owned enterprises, 20% joint ventures, and 44% MNC affiliates. Of note, the share of private firms increased sizeably over time at the expense of SOEs and JVs. The average share of processing trade in firm exports and imports was 39% and 55%, respectively.

2.2 Production statistics

We employ detailed balance-sheet data on Chinese firms from the Annual Surveys of Industrial Firms (ASIF) conducted by China's National Bureau of Statistics (NBS). ASIF covers all state-owned enterprises and all private companies with sales above 5 million Chinese Yuan during 1999-2007.[5] ASIF provides information on firm size (total sales), production inputs (value added, employment, average wage, intermediate input and material purchases, total assets, asset structure, inventories), investment activities (R&D spending, advertising expenditure), and performance (profits). The data also report firms' age, ownership type and main industry of activity in the GBT 2-digit classification (about 450 categories). We use these data to construct various metrics for firms' production technology and several standard indicators of firm productivity, namely log real value

[4] Using the same data, Ahn et al. (2011) identify intermediaries in the same way in order to study wholesale activity.

[5] This is equivalent to 0.6 million USD based on the USD-CNY exchange rate in 2005. Following Wang and Yu (2012), the ASIF data are cleaned by excluding observations according to the following criteria: (a) firms in non-manufacturing industries (2-digit GB/T industry code >43 or <13); (b) observations with negative values for output, sales, exports, capital, total assets, total fixed assets, wages, or intermediate inputs, and observations with zero employees; (c) observations with total assets less than total fixed assets or total liquid assets, or with total sales less than exports.

added per worker and TFPR measures based on production function estimates by industry following Levinsohn-Petrin, Olley-Pakes and ACF.[6]

Our empirical analysis critically relies on combining firm-level trade and balance-sheet data from CCTS and ASIF. While each is organized around company registration numbers, they do not share unique firm identifiers. Following standard practice in the literature, we merge the census files to the customs records based on an algorithm that matches firms' names and contact information, including addresses and phone numbers.[7] This procedure delivers a large and representative sample. Due to well-known concerns with poor coverage of both firms and key variables in ASIF for 2007, our baseline matched CCTS-ASIF sample spans the 2000-2006 period. For the average year, we are able to obtain ASIF balance-sheet data for about one third of all CCTS exporters and CCTS trade transactions for 56% of ASIF firms with positive exports and about 75% of the total export value reported in ASIF.

Columns 4-6 in Table 1 summarize the variation in firm size, production inputs, investment activities and performance in the full ASIF panel for 1999-2007. Columns 7-9 report trade and production statitistics for the matched CCTS-ASIF panel of two-way traders in 2000-2006. Overall, matched traders exhibit similar trade patterns as the full CCTS sample, and their balance sheets are comparable to those of all exporters in ASIF (not shown). Appendix Table 1 reports unconditional two-way correlations among key firm indicators of productivity, size and experience.

2.3 Industry upstreamness

We use Chinese Input-Output (IO) Tables and the methodology developed in Fally (2012) and Antràs et al. (2012) to construct a measure of the relative production line position of different industries in the Chinese economic environment. Conceptually, the upstreamness of industry i, U_i, is a weighted average of the number of stages from final demand at which i enters as an input in production processes in the economy. More specifically, in an economy with $N \geq 1$ industries, we calculate U_i as follows:

$$U_i = 1 \cdot \frac{F_i}{Y_i} + 2 \cdot \frac{\sum_{j=1}^{N} d_{ij} F_j}{Y_i} + 3 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} d_{ik} d_{kj} F_j}{Y_i} + 4 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} \sum_{l=1}^{N} d_{il} d_{lk} d_{kj} F_j}{Y_i} + \ldots \quad (1)$$

where Y_i is gross output in industry i, and F_i the part of that output that goes to final use (i.e., consumption or investment). d_{ij} is the value of i needed to produce one dollar worth of j's output, and corresponds to the direct requirement coefficient in aggregate IO tables.[8]

[6] We construct real value added as the difference between output and total intermediate purchases, after deflating each by sector-year specific output and input deflators. The results for all TFPR estimates are robust to alternatively constructing them by both industry and firm ownership type.

[7] See Wang and Yu (2012) for a detailed description of the matching procedure.

[8] Following Antràs et al. (2012), we scale d_{ij} by the factor $\frac{Y_i}{Y_i - X_i + M_i - NI_i}$, where X_i and M_i denote respectively total exports and imports of i, and NI_i is the net change in inventories of i reported in the economy. This correction

Note that formula (1) assigns a weight of 1 to the share of industry-i output that goes directly to final use, a weight of 2 to the corresponding share that is channeled to final use through exactly one other industry, and so on. As Antràs et al. (2012) show, the infinite sum in (1) can be evaluated with a few matrix algebra steps. In particular, let D denote the matrix of direct requirement coefficients, this being a square matrix whose i-th row and j-th column has d_{ij} as its entry. Likewise, define F to be a column vector whose i-th entry is F_i. The numerator of (1) is then given exactly by the i-th entry of $[I-D]^{-2}F$, where I is the N-by-N identity matrix. The denominator of (1), Y_i, is in turn given by the i-th entry of $[I-D]^{-1}F$, where $[I-D]^{-1}$ is the Leontief inverse matrix.[9,10]

By construction, one can see from (1) that $U_i \geq 1$, with equality if and only if all of industry i's output goes directly to final use. The bigger U_i is, the further upstream the industry is in terms of its contribution to production chains. For example, rubber can be used directly as a final product (one step to final consumers) or in the manufacturing of tyres that are in turn assembled into cars that are then sold as a final product (three steps to final consumers). By contrast, apparel comprises mostly final goods (one step to final consumers), and rarely serves as an intermediate input to other sectors. Rubber would thus receive a higher upstreamness value than apparel.

Table 2A provides summary statistics for measured industry upstreamness in the cross-section of 135 industries in the Chinese IO tables for year 2007. U_i varies from 1.000 to 5.861, with a mean of 3.161 and standard deviation of 1.118.[11] Table 2B lists the 10 most upstream and the 10 most downstream industries in the data.

2.4 Firm production line position

We use the industry measures of upstreamness to characterize each firm's production line position. In particular, we compute the weighted average upstreamness of firm f's imports (U_{ft}^M) and exports (U_{ft}^X), as well as the difference between the two ($U_{ft}^M - U_{ft}^X$) as:

$$U_{ft}^M = \sum_{i=1}^{N} \frac{M_{fit}}{M_{ft}} U_i, \qquad U_{ft}^X = \sum_{i=1}^{N} \frac{X_{fit}}{X_{ft}} U_i, \qquad U_{ft}^M - U_{ft}^X = \sum_{i=1}^{N} \left(\frac{M_{fit}}{M_{ft}} - \frac{X_{fit}}{X_{ft}} \right) U_i, \quad (2)$$

accounts for industry-i flows across borders for use as an input, as well as flows into and out of inventories.

[9] Fally (2012) and Antràs et al. (2012) show that the upstreamness measure defined in (1) is the unique solution to the following recurrence relation:

$$U_i = 1 + \sum_{j=1}^{N} a_{ij} U_j,$$

where a_{ij} is the share of industry-i's output that is sold to industry j. Intuitively, industry i is viewed as being one stage more upstream than a weighted sum of the industries j that purchase i as an input.

[10] See also Miller and Termushoev (2017) and Antràs and Chor (2018) for a detailed exposition of the definition and construction of this upstreamness measure, extended to the context of multi-country Input-Output tables, such as the World Input-Output Database (WIOD).

[11] The average industry upstreamness value in the Chinese 2007 Input-Output Tables is higher than that reported for the US 2002 Input-Output Tables in Antràs et al. (2012). There is a general agreement in the rank ordering of industries, with agriculture and mining being the most upstream and services being the most downstream.

where $X_{ft} = \sum_{i=1}^{135} X_{fit}$ and $M_{ft} = \sum_{i=1}^{135} M_{fit}$ are f's total exports and imports. Since CCTS reports trade flows by HS product, we use concordance tables between HS product codes and Chinese IO industry categories to obtain the value of each firm's exports (X_{fit}) and imports (M_{fit}) in IO industry i in year t.

Columns 1-3 of Table 1 report summary statistics for the variation in U_{ft}^M, U_{ft}^X, and $U_{ft}^M - U_{ft}^X$ across firm-years with positive exports and imports in the CCTS 2000-2014 panel. The average upstreamness of firm imports is 3.68, while the average upstreamness of firm exports is 3.25, for an average difference of 0.42. There is significant dispersion around these means - the corresponding standard deviations are 0.76, 0.77 and 0.89. These metrics are qualitatively similar in the matched sample of two-way traders with both CCTS customs and ASIF production data in Columns 7-9.

In a broad sense, we will interpret changes in the average upstreamness of a firm's imports and exports as indicating changes in the span of production stages performed by the firm and thus in its production line position. There are two caveats to this interpretation. First, while we observe the product composition of a firm's exports and can infer the value of its domestic sales as the difference between total sales and total exports, we cannot know domestic sales by product. Thus U_{ft}^X would accurately reflect the downstreamness of firms' output only if they sell identical or similar products at home and abroad. While we cannot formally test this, we later show that the share of exports in total sales is not systematically correlated with U_{ft}^X (or with U_{ft}^M and $U_{ft}^M - U_{ft}^X$ for that matter, see Section 4.3). This suggests that even if firms tailor their product mix across markets, these adjustments occur within the same production line position along dimensions other than output downstreamness.

A second caveat is that we observe the product characteristics of firms' imported inputs and can infer the value of their domestic inputs as the difference between total input purchases and total imports, but we cannot know the product composition of their domestic inputs. Hence U_{ft}^M would correctly identify the upstreamness of firms' inputs only if they source domestic and foreign intermediates of similar average upstreamness. We once again cannot confirm or reject this directly, but we later establish that the share of imported inputs in total input purchases is not systematically correlated with U_{ft}^M (or with U_{ft}^X and $U_{ft}^M - U_{ft}^X$ for that matter, see Section 4.3). This is consistent with the idea that firms may buy different inputs from local and foreign suppliers, for example due to cross-country differences in marginal costs or quality, but these decisions are driven by factors orthogonal to input upstreamness.

Our analysis will thus most directly inform Chinese firms' position in global production lines, since $U_{ft}^M - U_{ft}^X$ characterizes the span of production stages that a Chinese firm oversees within China (whether in-house or by outsouricng to and managing domestic suppliers) in the process of manufacturing for downstream buyers worldwide. For convenience, below we do not distinguish between the broad and narrow interpretations of production line position and global production line position, unless we explicitly address this issue.

It is important to highlight that while a firm spanning an additional production stage does add more value in production, the relationship between the number of production stages and overall value added need not be linear. It may for instance depend on whether these production stages are performed further upstream or downstream along the production chain.

3 Aggregate Trends

We first examine broad trends in China's global production line position at the aggregate level over the 1992-2014 period. We characterize this position in each year by the weighted-average upstreamness of China's imports and exports, $U^M_{China,t}$ and $U^X_{China,t}$, constructed using the industry-level upstreamness measure with aggregate trade shares by industry as weights:

$$U^M_{China,t} = \sum_{i=1}^{N} \frac{M_{China,it}}{M_{China,t}} U_i, \quad \text{and} \qquad U^X_{China,t} = \sum_{i=1}^{N} \frac{X_{China,it}}{X_{China,t}} U_i. \tag{3}$$

Here, $\frac{M_{China,it}}{M_{China,t}}$ is the share of imports of industry i in China's total imports in year t, while $\frac{X_{China,it}}{X_{China,t}}$ is the corresponding industry-i export share.

Macro Trend 1: *Over 1992-2014, Chinese imports became significantly more upstream, while Chinese exports became slightly more downstream.*

Figure 1 traces the evolution of $U^M_{China,t}$ and $U^X_{China,t}$ over our entire sample period. Two striking features stand out: First, Chinese exports are persistently more downstream than Chinese imports. This reflects the tendency for Chinese firms to use imported inputs when producing goods that are then exported to foreign markets, and is consistent with – but not exclusively driven by – the important role that processing trade plays in the Chinese economy. As we report below, this relative position of China's export and import upstreamness is a strong pronounced pattern that emerges in many cuts of the data that we study. Note that there is nothing mechanical that preordains that a country's exports will necessarily be on average more downstream than its imports. For example, countries rich in natural resources would exhibit the opposite pattern, if their international trade is composed mainly of exports of these raw materials in exchange for imports of final goods.[12]

Second, the average production line position of aggregate Chinese exports has remained fairly stable over this 23-year interval, with a slight decline from 3.289 to 3.206. By contrast, aggregate Chinese imports have become dramatically more upstream, with average import upstreamness rising from an initial value of 3.566 to 4.024. This latter rise in the upstreamness of China's imports is not driven simply by purchases of natural resources and commodities: When we re-compute the

[12] See for example, Chor (2014), who reports that the weighted-average upstreamness of imports was lower than that of exports for such resource-rich countries as Australia, New Zealand, and Brunei, using trade data from 2002.

weighted-average measure in (3) using only manufacturing trade flows – with the weights being the corresponding share of manufacturing industry i in total manufacturing trade flows – we continue to find that China's import upstreamness rose, from 3.476 in 1992 to 3.740 in 2014. This suggests that over time, Chinese firms have either developed the capacity and/or found it more profitable to perform more and more upstream stages of production processes, thus spanning wider segments of global value chains. This "fanning out" pattern illustrated in Figure 1 in China's global production line position is broadly consistent with the observation that the domestic value added embedded in Chinese exports has been rising over time (see for example, Kee and Tang 2016).

We next look into the sources of this aggregate trend in China's import and export upstreamness, by distinguishing between different subsamples in the customs data.

Macro Trend 2: *Over 1992-2014, the evolution of Chinese import upstreamness and export downstreamness was driven by ordinary trade and not by processing trade.*

Figure 2 plots the weighted-average upstreamness of Chinese trade flows, separately for processing trade (dashed lines) and ordinary trade (solid lines). As expected, processing exports are consistently more downstream than the imports (of goods-in-process and other inputs) shipped into China under the processing trade regime. The global production line position of Chinese processing activities has been relatively stable during 1992-2014, with the main trend being a moderate increase in the upstreamness of processing imports. The "fanning out" pattern in China's production line position seen earlier in Figure 1 appears instead to be driven by ordinary trade flows. Ordinary trade exports moved modestly but steadily downstream, and continuously remained upstream from processing exports. Meanwhile, the upstreamness of ordinary imports exhibited a dramatic increase: While ordinary exports and imports had similar upstreamness values at the start of the sample period, ordinary imports had become almost a full production stage more upstream than ordinary exports by 2014.

Macro Trend 3: *Over 1992-2014, import and export upstreamness evolved similarly for all firm ownership types. State-owned enterprises operated most upstream, private domestic firms operated in the middle, and joint ventures and foreign-owned affiliates operated most downstream.*

Figure 3 reveals a clear and stable ranking of the production line positions across firms with different ownership structures, when we compute the weighted-average upstreamness measures in (3) separately for each firm ownership type. The imports and exports of state-owned enterprises (solid lines) are systematically more upstream than the corresponding trade flows of private domestic firms (dashed lines); the latter in turn import and export products that are on average more upstream than those of joint ventures and fully-owned multinational affiliates (dot-dashed lines). Note that over time, there has been an increase in the import upstreamness of all three firm types, with the climb being most distinct for state-owned enterprises.[13]

The above trends in the evolution of China's export and import upstreamness in the aggregate can arise from changes within surviving firms and/or changes in the composition of firms over time. To shed light on this, we turn our focus to the sample of years for which we have firm identifiers in the customs data (i.e., 2000-2014), to examine the production line position of firms as inferred from their trade flows.

Macro Trend 4: *Within firms over time, imports became significantly more upstream, exports became moderately more downstream, and the implied span of production stages performed within China increased during 2000-2014.*

We uncover this trend in the global production line position of China-based firms by estimating variants of the following regression specification:

$$\{U_{ft}^M, U_{ft}^X, U_{ft}^M - U_{ft}^X\} = \alpha_{2000} + \sum\nolimits_{t=2001}^{2014} \alpha_t YEAR_t + \varphi_f + \varepsilon_{ft}. \tag{4}$$

The outcome variable is in turn the average upstreamness of a firm's imports (U_{ft}^M), the average upstreamness of a firm's exports (U_{ft}^X), and the difference between these two ($U_{ft}^M - U_{ft}^X$), as defined earlier in (2). We conservatively cluster the standard errors by firm, to account for possible correlated shocks within firms over time in the ε_{ft} error terms.[14]

We quantify common time trends in firms' production line position by estimating coefficients α_t for a full set of year dummies $YEAR_t$, conditional on firm fixed effects, φ_f. The constant term α_{2000} thus reflects the baseline average production line position across firms present in the first year in the panel (2000), while the α_t coefficients for $2001 \leq t \leq 2014$ capture average cumulative changes (relative to 2000) based on all firms that are active in year t.

In Columns 1-2 of Table 3, we estimate (4) for U_{ft}^M and U_{ft}^X respectively using the full CCTS sample for 2000-2014. Columns 3-4 run these same regressions on the sub-sample of non-intermediary firms, given that the import and export activities of trade intermediaries are not driven directly by their own production decisions. In both the full CCTS sample and the non-intermediary sub-sample, we find that the export upstreamness of firms declined steadily but modestly between 2000-2014, while the upstreamness of their imports rose quickly. The point estimates for the α_t's are significant across these four columns for almost all years, and typically rise in absolute terms over time. Note that the size of the increase in import upstreamness over time is an order of

[13] We have also compared the production line position of trade intermediary versus non-intermediary firms in Appendix Figure 1. The average export and import upstreamness (respectively) of these two subsets of firms was similar, with the only mild difference being that the exports of non-intermediary firms were slightly more downstream than that of intermediary firms. In terms of changes over time though, both intermediaries and non-intermediaries shared a common time trend: The average upstreamness of exports was stable over time, while their import upstreamness rose distinctly.

[14] Results are unaffected if we were to instead use heteroskedasticity-robust (but unclustered) standard errors.

magnitude higher than the corresponding decrease in export upstreamness.

In the rest of Table 3, we further restrict the sample to non-intermediary firm-year observations that record a positive volume of both exports and imports. We find in Column 5 that the import upstreamness of these non-intermediary "two-way traders" also increased dramatically during 2000-2014. On the other hand, their exports became only moderately more downstream, with a good number of the α_t coefficients in Column 6 yielding statistically insignificant point estimates. For a representative firm, the implied cumulative changes in U^M_{ft} and U^X_{ft} over this period are 0.1992 and 0.0001 respectively, from average starting levels of $\alpha^M_{2000} = 3.5396$ and $\alpha^X_{2000} = 3.2558$. As a result, the gap between the upstreamness of firms' imports and exports widened, implying an expansion in the span of production stages performed within China of 0.1991 on average, or more than 70% up from the baseline average value of $U^M_{ft} - U^X_{ft}$ of 0.2838 (Column 7).[15]

Of interest is how firms' production line position relates to the range of inputs they buy from upstream suppliers and the variety of outputs they sell to downstream buyers. In Appendix Table 2, we expand specification (4) for U^M_{ft}, U^X_{ft} and $U^M_{ft} - U^X_{ft}$ to control respectively for the number of HS-6 digit products that firms import, N^M_{ft}, the number of products they export N^X_{ft}, and both N^M_{ft} and N^X_{ft}. We find that the point estimates for α_t are barely affected, with significant coefficients typically reduced by 2-2.5%. This suggests that expansions along the production chain within firms over time reflect primarily the internalization of production steps within firm boundaries, rather than changes in input and output product scope or potential effects of such changes on the measurement of U^M_{ft} and U^X_{ft}.[16]

Figure 4 illustrates these within-firm changes over time in the span of production stages performed in China. We graph several kernel density plots of the difference between import and export upstreamness, $U^M_{ft} - U^X_{ft}$, for non-intermediary two-way traders.[17] We focus first on all such firms that were two-way traders throughout the entire duration of our sample period, whom we refer to as "survivors". The figure demonstrates that these firms tend to span more production stages as they age, as can be seen from the rightward shift in the distribution of $U^M_{ft} - U^X_{ft}$ for "survivors" between 2000 and 2014. One can further compare these "survivors" in 2014 against "entrant" firms that were new two-way traders in 2014, these being non-intermediary firms that both export and import in 2014 but not in 2013. The kernel density plot of $U^M_{ft} - U^X_{ft}$ is concentrated more tightly around its peak value for these "entrants", confirming that new two-way traders tend to perform a much narrower span of production stages than "survivors" that have continuously been two-way

[15] We obtain very similar results if we were to restrict the regressions to the subsample of non-intermediary firms that were "two-way traders" in *every* year between 2000-2014, or in every year between 2000-2006. The latter corresponds to the years for which we can merge the CCTS with the ASIF manufacturing survey data.

[16] The data also indicates that importing further upstream is associated with sourcing fewer imported inputs, while exporting further downstream is correlated with exporting more products. However, the implied economic magnitudes of these associations are quite small.

[17] The kernel density plots are very similar if we were to include trade intermediaries (available on request).

traders for many prior years.[18]

Together, the patterns in Figure 4 and Table 3 suggest that firms that are new to importing or exporting may begin by conducting fewer production steps than incumbents, and then gradually expand into more production stages as they survive and grow. In the next section, we investigate further the firm-level correlates of production line position over the firm lifecycle.

4 Firm Lifecycle Facts

4.1 Estimation approach

We examine the evolution of firms' global production line position, operations and performance over the firm lifecycle in three steps. We first analyze how firm productivity, size and experience correlate with import and export upstreamness. We then document how firms' global production line position varies with their value added, input use, asset and cost structure. Lastly, we study the link between production staging, profits and profitability.

Our goal is twofold. On the one hand, we want to agnostically establish novel and robust stylized facts that paint a coherent picture of how key firm attributes and performance metrics co-evolve with their global production line position. At the same time, we also aim to inform the determinants and consequences of firms' participation in global production chains, and to offer a conceptual framework that can rationalize the empirical patterns through the lens of profit maximization. In Section 5, we will interpret the first set of results below in terms of drivers of firms' production line position and the second and third set of results in terms of its correlates and outcomes.

We explore the variation within firms over time with the following specifications:

$$\left\{U^M_{ft}, U^X_{ft}, U^M_{ft} - U^X_{ft}\right\} = \alpha + \beta Z_{ft} + \Gamma\Omega_{ft} + \varphi_f + \varphi_t + \varepsilon_{ft}, \quad (5)$$

$$\{Y_{ft}, \Pi_{ft}\} = \alpha + \beta \left\{U^M_{ft}, U^X_{ft}, U^M_{ft} - U^X_{ft}\right\} + \Gamma\Omega_{ft} + \varphi_f + \varphi_t + \varepsilon_{ft}. \quad (6)$$

In regression (5), the outcome variable is each of the three indicators of firms' participation in global value chains: the average upstreamness of firms' imports, U^M_{ft}, the average upstreamness of firms' exports, U^X_{ft}, and the difference between these two, $U^M_{ft} - U^X_{ft}$. The main variables of interest on the right-hand side, Z_{ft}, will be measures of firm size, productivity, and experience. In regression (6), we examine how firms' production line position correlates with various aspects of firm

[18] We performed a Kolgomorov-Smirnov test to compare the distributions of $U^M_{ft} - U^X_{ft}$ for: (i) "survivors" in 2000 against "survivors" in 2014; and (ii) "survivors" in 2014 against "entrants" in 2014. All tests comfortably rejected the null hypothesis of identical distributions, with p-values smaller than 0.0001. We obtain virtually identical findings if we were to alternatively define "entrants" to be firms that were not two-way traders in 2011-2013, but were two-way traders in 2014. Likewise, the density plots are very similar if we were to define "entrants" to be firms that were not two-way traders in 2000, but were two-way traders in 2014.

operations related to value added, input purchases, asset composition, marketing and investment, as well as with performance metrics of profitability.

In both specifications (5) and (6), we absorb permanent observed and unobserved firm characteristics with firm fixed effects, φ_f, and macroeconomic supply and demand shocks with year dummies, φ_t. We further control for time-varying firm characteristics, Ω_{ft}, including physical and human capital intensity proxied respectively by log net fixed assers per worker and log average wage. All results are robust to omitting these controls, and their addition has minimal effects on the coefficient estimates of interest.

Note that φ_f account for intransient variation in institutional and market conditions across production locations (i.e. Chinese cities, provinces, or special economic zones), such as labor costs, capital availability, infrastructure, and contract enforcement. In addition, φ_f subsume systematic technological and operational differences across firm ownership types. Since φ_f capture firms' primary industry of activity, they also embed systematic variation across sectors in available production techniques, factor intensities, and technological scope for fragmenting manufacturing stages across establishments.

Coefficient of interest β is identified purely from the variation within firms over their lifecycle, and reflects how changes in their supply chain position are associated with changes in their attributes and outcomes. In the background, the year fixed effects, φ_t, isolate broad trends in China's position in global production lines that are common to all firms. We conservatively cluster errors, ε_{ft}, by firm to account for correlated shocks within firms over time. Results generally become statistically even more significant when we instead use Huber-White robust standard errors.

The 2000-2014 panel of CCTS trade statistics for manufacturing firms (i.e. excluding trade intermediaries) comprises 2,385,331 exporter-year and 1,628,806 importer-year observations. Since not all producers pursue both expors and imports every year, the sample drops to 1,060,154 firm-year observations with data on U^M_{ft}, U^X_{ft} and $U^X_{ft} - U^M_{ft}$. This constitutes the baseline regression sample for specifications that exploit CCTS data only. When we additionally require information from firms' balance sheets, the sample declines further to about 175,000 observations: Recall that ASIF data spans a shorter time period and the firm match between CCTS and ASIF is comprehensive but incomplete. Importantly, this variation in sample size across specifications does not appear to generate estimation bias. For example, restricting the sample to CCTS-ASIF matched firms in 2000-2006 does not affect the qualitative conclusions drawn from regressions that otherwise use the full 2000-2014 CCTS panel. We have also confirmed that all results for U^M_{ft} and U^X_{ft} hold when we broaden the sample respectively to all importers regardless of export status or all exporters regardless of import status.

4.2 Firm productivity, size and experience

We first provide evidence that firms' global production line position evolves systematically with their productivity, size and experience over time. We estimate specification (5) using various proxies for these three firm attributes as the variable of interest Z_{ft}.

Firm Fact 1: *When firms become more productive, bigger and more experienced, they import significantly more upstream, export moderately more downstream, and span more production stages (in China).*

For now, note that these empirical findings do not directly reveal whether firms' expansion along global production lines occurs through the performance of more manufacturing stages in-house or the outsourcing of previously imported inputs (i.e. previously offshored stages) to domestic suppliers. In other words, the observed behavior describes what production stages are carried out in China rather than within the boundaries of the firm, since we do not yet distinguish between value added within a firm and its use of domestic inputs. Nevertheless, these results do imply that firms take responsibility for the supervision and completion of a wider segment of the supply chain within China, one way or another.

4.2.1 OLS correlation

We begin with the role of firm productivity in Table 4. We find consistent patterns using several standard productivity measures in the literature. In Panel A, we consider log real value added per worker, constructed as the difference between output value and intermediate inputs, after deflating respectively by output and input deflators specific to the firm's primary industry. Of note, the results are robust to using alternative value added measures such as nominal value added (where the year and firm fixed effects subsume the variation in value-added deflators across time and primary industry) or value added as reported directly on firms' balance sheets. In Panels B and C, we apply the Levinsohn-Petrin and Olley-Pakes methodologies to obtain TFPR residuals from a production function estimated separately for each GBT-2 industry. Qualitatively similar results obtain if we further allow for differences across organizational types (domestic vs. foreign-owned) or adopt the ACF estimation method instead.

We document in Columns 1-3 of Table 4 that within firms over time, higher productivity is associated with significanty more upstream imports ($\uparrow U^M_{ft}$) and stable export downstreamness ($\sim U^X_{ft}$). As a result, productivity improvements are accompanied by firms managing a wider span of production stages within China ($\uparrow U^M_{ft} - U^X_{ft}$). Moreover, the widening of the span of production stages is not driven by where along the production chain firms operate: Similar results obtain for $U^M_{ft} - U^X_{ft}$ when we condition on the downstreamness of firm's output, U^X_{ft}, in Column 4.

We next examine the role of firm size in Table 5. In Panel A, we use log total nominal sales as a comprehensive measure of firm scale. The results are not sensitive to using real sales instead, constructed using industry-specific deflators based on firms' primary industry of activity. In Panel B, we proxy firm size with log worldwide exports as reported in the comprehensive CCTS customs records. We obtain similar estimates if we instead use real CCTS exports (computed with the same industry deflators as above) or exports as reported in ASIF. Finally, in Panel C we take log employment as a quantity-based indicator of production scale.

Across all measures of firm size, we consistently observe that firms import inputs further upstream and shift exports further downstream as they grow bigger (Columns 1 and 2). While both adjustments are highly significant (with the exception of the employment measure in the case of U_{ft}^X), the change in U_{ft}^M is markedly bigger than that in U_{ft}^X - about 6 times, 2.5 times and 7 times based on sales, exports and employment respectively. These patterns contribute to the span of production stages $U_{ft}^M - U_{ft}^X$ widening quickly with firm size, both unconditionally and conditionally on where along the supply chain the firm is anchored as proxied by U_{ft}^X (Columns 3 and 4).

The implied economic magnitudes of these relationships are sizeable. For example, a rise in productivity (as measured by TFP Levinsohn-Petrin) from the 10th to the 90th percentile is associated with 0.033 higher U_{ft}^M, negligible changes in U_{ft}^X, and 0.035 greater $U_{ft}^M - U_{ft}^X$. The corresponding numbers for a one-standard-deviation expansion in total sales (total exports) are 0.030 (0.039), 0.005 (0.016) and 0.035 (0.55).

We evaluate the importance of firm experience in Table 6. In Panel A, we consider firm age as an agnostic, holistic measure of general experience with production and sales operations. To accommodate entrants, we work with log(age +1). In Panel B, we focus on experience specifically with production for and sales to foreign markets. For a firm active in year t, we obtain the log of its cumulative past exports through year t-1. While there is potential left censoring of this variable for firms that began exporting prior to 2000, this concern is alleviated by the fact that the number and trade volume of Chinese exporters was limited prior to WTO entry in 2001; firm fixed effects also implicitly control for the presence of such left censoring. The results are very similar if we instead use symmetrically constructed cumulative past imports to capture experience with foreign suppliers.

The evidence indicates that as companies mature and become more experienced participants in global trade, they tend to expand the number of production stages they conduct by importing more upstream inputs, without significantly or sizeably adjusting the downstreamness of their exports (Columns 1-3). A firm that is twice as old on average performs 0.38 more manufacturing steps. This is independent of how downstream a firm's output is positioned (Column 4).

We have performed several robustness checks on the stability of these results. First, all findings hold when omitting the controls for firms' capital and skill intensity. The baseline specifications with these controls should be interpreted with a grain of salt to the extent that productivity, size and experience are primitives that determine firm operations including skill and capital use. These baseline estimates nevertheless suggest that expansion into more production stages is associated with lower capital intensity and higher skill intensity.

Second, we have confirmed that the results are not driven by firms' differential participation in processing vs. ordinary trade. Recall that the customs data record whether each transaction occurs under the formally recognized processing or ordinary trade regimes, such that we can calculate the share of processing exports in a firms' total exports. This produces a continuous measure between 0 and 1 since most firms conduct both ordinary trade (exporting under their own brand name) and processing trade (exporting under contract with a foreign buyer). The baseline findings for firm productivity, size and experience are robust to controlling for this export processing share.[19]

Third, the results in Tables 4-6 are robust to alternative samples. The baseline includes all firm-years with positive imports and exports in the matched CCTS-ASIF panel for 2000-2006. Qualitatively similar patterns obtain in the restricted balanced panel of firms that export and import in each year in 2000-2006. The estimates for U_{ft}^M and U_{ft}^X are also comparable in larger samples of respectively all importer-years (regardless of export status) and all exporter-years (regardless of import status). Lastly, the regressions that proxy firm size and experience with CCTS trade variables produce stable results for the supraset of all exporter-importer-years in the full 2000-2014 CCTS panel.

Lastly, the baseline findings hold under alternative approaches to measuring firms' average import and export upstreamness. Our baseline measures relies on the most detailed input-output tables available for China, which cover 135 sectors in 2007. We observe similar patterns when we instead construct U_{ft}^M and U_{ft}^X starting from rougher Chinese I/O tables available for 2002, when we rely on much more disaggregated US I/O tables available for 2002, or when we consider only manufacturing sectors in the Chinese 2007 I/O tables.

4.2.2 IV causality (in progress)

4.3 Firm assets, costs and value added

We next establish that changes in firms' global production line position are accompanied by systematic adjustments in their value added, input usage, cost structure, and asset composition. We estimate variants of specification (6) using different indicators for firm operations in place of Y_{ft}.

Firm Fact 2: *When firms span more production stages (in China), they increase value added*

[19] Appendix Table 3 reports regressions in which the export processing share enters as the main firm attribute Z_{ft} in specification (5). Firms that conduct more processing trade span more production stages $U_{ft}^M - U_{ft}^X$ in China. Consistent with our findings for firms' trade experience, this may signal that producing on behalf of a foreign buyer engenders knowledge transfer that enables firms to internalize neighboring manufacturing steps. On the other hand, processing contracts specify the use of imported inputs and the choice of exported outputs that the Chinese processor and the foreign buyer have jointly agreed to, such that observed trade behavior may not reflect the processor's active decision but rather the foreign partner's influence over the processor's production line position.

in production proportionately with output and do not change their export intensity.

We examine the relationship between firms' global production line position and the amount of value they add in production in Panel A of Table 7. In Columns 1 and 2, we find that companies with more upstream imported inputs and more downstream exports have considerably higher log real value added. These two patterns are of comparable economic magnitude, although the correlation with U^X_{ft} is imprecisely estimated. As a result, value added rises sharply as the distance between the position of firms' imports and exports in global supply chains widens: Based on the estimates in Column 3, a 1-step wider spread in $U^M_{ft} - U^X_{ft}$ is associated with 3.55% higher value added. These patterns hold robustly when using nominal value added, upstreamness measures based on alternative I/O tables, or alternative regression samples.

In light of *Firm Fact 1*, we next explore whether the relationship between value added and production staging reflects an associated scaling up of firm operations. In Column 4, we condition on log firm sales to capture the gross value of a firm's output. Value added indeed moves in step with total sales, with a point estimate close to 1. Moreover, this proportional adjustment fully explains the unconditional correlation between value added and $U^M_{ft} - U^X_{ft}$, as the coefficient on the latter is now a precisely estimated 0.

While value added grows with the span of firm operations in global production lines, their export intensity does not. Panel B of Table 7 confirms that within firms over time, the share of exports in total sales does not shift with the upstreamness of a firm's imports, the downstream of its exports, or the gap between the two. This indicates that different factors govern firm's production line decision and the export orientation of their sales.

Firm Fact 3: *When firms span more production stages (in China), they increase total input purchases proportionately with output and do not change their imported-input intensity.*

We next consider how firms' input sourcing behavior co-moves with their global production line staging. Panel C of Table 7 reveals that firms significantly increase their total input purchases when they broaden the scope of manufacturing steps they complete in China. This occurs both when they import from abroad inputs that are further upstream and when they export abroad outputs that are further downstream, although the latter is not statistically significant. Widening $U^M_{ft} - U^X_{ft}$ by 1 step is thus associated with 3.47% higher input purchases. As with value added, this entirely reflects an expansion in firms' output scale, and it is fully explained when we condition on log sales.

While firms adjust their total input purchases along with their global production line position, the balance of their domestic and foreign inputs remains unchanged. Panel D of Table 7 establishes that the share of imported inputs in total inputs does not vary systematically with firms' import upstreamness, export downstreamness, or difference between the two.In other words, while various factors such as availability, cost and quality may determine firms' optimal mix of domestic and imported intermediates, these factors appear orthogonal to input upstreamness and firms' location in the supply chain. These findings are stable across upstreamness measures based on alternative I/O tables and alternative regression samples.

Together, *Firm Facts 2* and *3* strongly suggest that when Chinese firms import more upstream inputs and export more downstream outputs, they do not simply outsource to domestic suppliers production tasks that were previously completed by foreign suppliers. Instead, they internalize these manufacturing stages and complete them in-house. They also do not alter their sales strategy across domestic and internatonal markets. One implication is that U^M_{ft} and U^X_{ft} not only measure the upstreamness of firms' foreign inputs and sales, but are arguably informative proxies for the upstreamness of all their purchased inputs and produced outputs.

Firm Fact 4: *When firms span more production stages (in China), they increase the level and share of their fixed costs and assets.*

We finally characterize the relationship of firms' production line position to their asset and cost structure. In Panels A and B of Table 8, we consider respectively the log level of net fixed plant, property and equipment and its share in total book-value assets. These measures reflect how important the stock of long-term capital is to firm operations in an absolute and in a relative sense. In Panels C and D, we study instead the log value of inventories and their value relative to total assets. Outstanding inventories of inputs and outputs constitute a flow of short-term fixed costs of manufacturing and maintaining supply capacity.

We consistently find that when firms manage more production stages (in China), they maintain more fixed assets and incur higher fixed costs. In particular, the value and asset share of fixed assets and inventories all rise with the upstreamness of production inputs U^M_{ft} and with the span of production tasks $U^M_{ft} - U^X_{ft}$ conditional on output downstreamness U^X_{ft}, but are not significantly correlated with U^X_{ft}. A 1-step expansion along the supply chain is associated with 1.65% higher investment in fixed assets and 2.82% higher inventory holdings. Qualitatively similar results obtain in robustness checks with alternative upstreamness measures and regression samples. These patterns are consistent with firms incurring higher sunk and fixed costs when they complete more production tasks.

Together, the results for firms' value added, input purchases, asset and cost structure constitute strong evidence that an expansion in $U^M_{ft} - U^X_{ft}$ reflects the internalization of more production stages within firm boundaries. Since we do not observe the domestic production network or the product composition of firms' domestic intermediates and sales, we cannot directly establish whether Chinese firms that change the upstreamness of their imports and exports outsource previously offshored production tasks to domestic suppliers and buyers. However, we fail to find a smoking gun to this effect (i.e. imported-input intensity and export intensity are both invariant to $U^M_{ft} - U^X_{ft}$), and instead document prima facie signals to the contrary (i.e. value added, input expenditures and fixed costs and assets all rise with $U_{ft}^M - U_{ft}^X$).

4.4 Firm profits and profitability

We conclude by evaluating how firms' produciton line position relates to performance in terms of profits and profitability. We estimate specification (6) for several profitability metrics Π_{ft}.

Firm Fact 5: *When firms span more production stages (in China), they earn higher profits and do not change their profitability margins.*

We consider different measures of profit levels and profit margins in Table 9. In Panel A, we study log total real profits from operations, after applying industry-specific output deflators.In Panel B, we analyze the profit-to-sales ratio as an indicator of the profit margin relative to the value of gross output. This speaks to profitability at different production line positions of firms' output, regardless of how many manufacturing stages of this output are completed in-house. In Panel C, we take instead the profit-to-value added ratio. This captures profitability relative to the value the firm adds in production once all purchased intermediates have been accounted for. In Panel D, we turn to returns on assets (ROA) defined as profits relative to total assets. While the previous measures can be seen as reflecting short-term profitability from current production and sales, ROA signals the long-term profitability of firm assets and implicitly of the stock of investment.

We find that firms earn systematically higher profits when they complete more production stages in global value chains. At the same time, the evidence indicates that profits scale up with firms' overall activity, such that all three profit margins are unaffected by expansions or contractions along the production line. These results are robust to considering nominal profit measures, production line positions based on alternative I/O tables, or alternative samples. These conclusions are consistent with entrepreneurs maximizing total profits from operations rather than profit margins *per se*.

5 Towards A Conceptual Framework

The empirical analysis has uncovered new stylized facts about the joint evolution of Chinese firms' attributes, production line position, production activities, and performance over the firm lifecycle. We propose here a conceptual framework that can rationalize these facts and give them an internally consistent economic interpretation. We develop this in a stylized, partial-equilibrium setting. It assumes for example that the firm takes certain market conditions as given, such as the price of intermediate goods at different stages of completion. Our purpose is to highlight in as basic a framework as possible some key trade-offs for understanding a firm's span of production stages, that more complete models – incorporating considerations related for example to market power – can build on in future.

5.1 Setup

The production of final goods in any given industry requires the completion of a continuum of stages. These stages are uniquely sequenced due to technological reasons; for example, the tires of a car need to be ready before the rolling chassis can be assembled. We index the production stages by $u \in [1, \infty)$, where a higher u refers to a stage that is more upstream (i.e., positioned earlier in the production sequence). In particular, the most upstream stage at the start of the production line is indexed by $u = \infty$, while the most downstream stage – the completed final good – is indexed by $u = 1$. We adopt this convention to be consistent with the nature of the empirical measure of upstreamness we have used in the prior sections, even though it may be slightly uncomfortable that a lower u means production of the good is nearer its completion.

We consider the decision problem of a firm that is active in one particular industry, over the measure of production stages to perform in-house. The output of a firm that has chosen its span of production stages to be between $u = U^M$ and $u = U^X$ is given by:

$$q = \theta \left(\int_{U^X}^{U^M} x(u)^{\alpha} du + q_M^{\alpha} \right)^{\frac{\rho}{\alpha}}, \tag{7}$$

where $1 \leq U^X < U^M$ and $\alpha, \rho \in (0, 1)$. Here, q_M is the quantity of the semi-finished good that has been completed up to stage U^M, which the firm purchases as an intermediate input; to be clear, all stage inputs for $u \in [U^M, \infty)$ have already been built into this intermediate input when it is purchased. The production stages from $u = U^M$ and $u = U^X$ are then performed in-house, with the firm choosing the quantity $x(u)$ of inputs for each of these stages.[20] The output q that the firm generates is in turn a semi-finished good that has been completed up to stage U^X. While the model is agnostic about where intermediate input q_M is purchased from or where output q is sold, it is natural in the context of China for us to associate U^M and U^X with the firm-level import and export upstreamness measures that we constructed earlier.

In (7), the intermediate input q_M and the in-house inputs $x(u)$ are combined in a CES manner, with elasticity of substitution equal to $1/(1-\alpha) > 1$.[21] The parameter $\rho \in (0, 1)$ captures the degree to which the output of the firm is subject to decreasing returns to scale. Given the price-taking assumptions that we adopt below, ρ needs to be strictly smaller than 1 in order for the size of the firm to be uniquely pinned down.

The productivity of the firm is given by θ. To fix ideas, one can think of θ as coming from a

[20] We have emphasized the sequentiality of the production stages in the setup, to be in keeping with prior modeling work on production chains such as Harms et al. (2012), Costinot et al. (2013), and Antràs and Chor (2013). One can however interpret the production function in (7) as one in which all stages $u \in [U^X, U^M]$ are performed simultaneously by the firm, such that the insights we derive do not depend crucially on the timing of production stages.

[21] This CES formulation of the production function over stage inputs is similar to that in Antràs and Chor (2013) and Alfaro et al. (2019).

productivity draw that the firm receives upon its successful entry into the industry (Melitz 2003), which reflects the efficiency of its assembly technologies and/or the effectiveness of its management practices. For our purposes, we will treat θ as a firm-specific attribute and consider comparative statics with respect to it, to explore how the span of stages the firm performs would respond to exogenous shocks to its productivity. A richer dynamic framework would seek to model more systematically the evolution of this productivity over the firm lifecycle, an issue which we abstract from here. Note that θ can be interpreted alternatively as a quality term, with changes in θ reflecting shocks to market demand for the firm's output.

We assume for simplicity that the firm is small within the industry and that it takes prices as given. There is moreover an open competitive market for semi-finished goods at all stages of completion $u \in [1, \infty)$, with $p(u)$ being the corresponding price schedule. We posit that $p'(u) < 0$: the market price of a more upstream good is lower, as these embody fewer completed production stages. As an example, this means that there is a market price for the raw rubber to manufacture four tyres, and that this is lower than the purchase price for a set of completed tyres.[22]

The firm incurs two costs for each production stage $u \in [U^X, U^M]$ that it performs in-house: (i) a variable cost, $c(u)$, per unit of the stage input $x(u)$; and (ii) a per period fixed cost $f(u)$, which applies as long as $x(u) > 0$. One can view $c(u)$ as the cost of labor inputs that are required to produce each unit of the stage input $x(u)$. In turn, the $f(u)$ can be interpreted as an overhead usage cost of assets and equipment necessary for the execution of the production stage u.[23] For convenience, we will assume that both $c(u)$ and $f(u)$ are differentiable functions.

The firm's profit function is thus given by:

$$\pi = p(U^X)q - p(U^M)q_M - \int_{U^X}^{U^M} c(u)x(u)du - \int_{U^X}^{U^M} f(u)du, \tag{8}$$

this being the revenue from sales of the stage-U^X good, less the cost of q_M units of the stage-U^M intermediate input, as well as the variable and fixed costs for the in-house stages ($u \in [U^X, U^M]$). Given knowledge of its productivity level θ, the firm then chooses: (i) the cut-off stages, U^M and U^X; (ii) the quantity q_M of the upstream intermediate input to purchase; and (iii) the quantity of $\{x(u)\}_{u=U^X}^{u=U^M}$ for each in-house stage input. These decisions are made to maximize the firm's profits as specified in (8). We will focus for simplicity on a situation where the firm's profit-maximization problem yields an interior solution.

[22] In practice, some inputs might need to be tailored or customized to the specific needs of the firm. Antràs and Chor (2013) and Alfaro et al. (2019) study the implications of such specificity for production chains under incomplete contracts, where firm payoffs are pinned down by a bargaining process rather than market prices.

[23] This could alternatively reflect the per-period amortized sunk costs of the firm.

5.2 Firm behavior

We explore with this setup how an increase in a firm's productivity can impact the optimal span of stages that it engages in. A shock to θ would lead a profit-maximizing firm to re-evaluate the positions of its cut-off stages (i.e., U^X and U^M), while accordingly adjusting the quantity q_M of the upstream intermediate to procure and the quantities $x(u)$ of in-house stage inputs to put in. We focus on understanding the conditions under which these firm-level responses would be consistent with the empirical patterns documented in Sections 3 and 4 for the global production line position of Chinese firms.

Holding all else constant, a positive shock to productivity θ would raise the firm's output and hence its revenues. In principle, this would make it feasible for the firm to conduct a larger range of production stages in-house, by purchasing a more upstream intermediate input (i.e., increasing U^M), and/or by assembling a product that is closer to the final good (i.e., decreasing U^X). Intuitively, an increase in U^M would lower the price $p(U^M)$ of the more upstream intermediate input that must be purchased (since $p'(u) < 0$), but this needs to be compared against the variable and fixed costs that would be incurred by the firm if performing the inframarginal stages in-house. Similarly, a decrease in U^X means that the firm would be able to fetch a higher price $p(U^X)$ for selling a more finished good, but this needs to be weighed against the additional variable and fixed costs of performing more downstream stages in-house.

The framework from Section 5.1 helps to shed light on these key trade-offs that will ultimately govern whether it is optimal for the firm is expand its set of production stages following an increase in θ. As currently set up, the model is fairly general in terms of the predictions it can generate with regard to how U^X and U^M might shift. As should be clear though, what is important is to understand the behavior of the firm's revenue and cost structure in the neighborhood of its initial cut-off stages. We now spell out a set of sufficient conditions under which an increase in firm productivity would lead to a widening in the span of stages performed, consistent with what we have seen in the Chinese data.

As we establish in the Theory Appendix, the first-order conditions associated with the firm's profit-maximization problem imply the following:

Proposition 1 *Suppose that: (i) $\rho > \alpha$; and (ii) $\frac{c(U^X)x(U^X)}{p(U^X)q}$, $\frac{f(U^X)}{p(U^X)q}$, $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$, $\frac{f(U^M)}{p(U^M)q_M}$ are sufficiently small. In response to a positive shock to its productivity θ, a firm will:*

1. *expand its span of production stages ($\frac{d(U^M-U^X)}{d\theta} > 0$) by purchasing a more upstream intermediate input ($\frac{dU^M}{d\theta} > 0$) and by selling output further downstream ($\frac{dU^X}{d\theta} < 0$); and*
2. *purchase a larger quantity of the more upstream intermediate input ($\frac{dq_M}{d\theta} > 0$) and increase the quantity of all in-house stage inputs ($\frac{dx(u)}{d\theta} > 0$ for all $u \in [U^X, U^M]$).*

The sufficient conditions lend themselves to an intuitive interpretation. For Proposition 1 to hold, we require first that the firm's production function not be subject too strongly to decreasing returns to scale (condition (i)). This provides a baseline technological reason for a firm that has become more productive to raise its output, which it can achieve in part by expanding the span of stages it performs. Put otherwise, this implies complementarity between the scale of the firm and its scope (as reflected in the span of stages conducted in-house). In turn, condition (ii) describes a set of circumstances under which a more productive firm would find it optimal to purchase a more upstream intermediate input, while selling a more downstream output. This will be the case so long as the firm has low variable and fixed costs in the neighborhood of its initial upstream cutoff stage U^M, relative to the costs incurred from purchasing the stage-U^M good as an intermediate input ($p(U^M)q_M$); this ensures that the firm would find it feasible to substitute towards performing more of these stages in-house.

This arguably provides a reasonable description of the situation faced by Chinese firms in the early years of the country's trade liberalization, particularly in industries that were reliant on imported intermediate inputs (with few available substitutes among domestic suppliers) to facilitate their manufacturing processes. Similarly, Proposition 1 also requires that the variable and fixed costs associated with the downstream cut-off stage U^X be sufficiently low, relative to the revenues received from selling a stage-U^X good, in order to make it profitable to shift more stages at this margin in-house.

Relationship to Stylized Facts: It is useful to connect Proposition 1 with the empirical findings reported earlier. First, the predictions for how U^X, U^M and hence $U^M - U^X$, each respond to exogenous increases in firm productivity line up with Firm Fact 1. To the extent that more productive firms also exhibit a larger volume of total sales and are more likely to survive over time, the proposition can further rationalize the empirical patterns for firm size and experience and their strong correlattion with the firm-level upstreamness measures (Firm Fact 1).[24]

Second, Proposition 1 also points to a plausible explanation for the evolution of the overall import and export upstreamness of China's trade flows (Macro Trends 1-2). If there has been an underlying secular trend towards rising productivity among Chinese firms – as has been documented for example by Brandt et al. (2012) for this same time period – the pattern of a rising U^M and a falling U^X would be replicated in the aggregate.[25] The framework would further be consistent with state-owned enterprises being able to operate a wider span of stages compared to private domestic firms (Macro Trend 3), if SOEs are better able to finance the necessary fixed costs due to their

[24] In the Chinese firm-level dataset we build, we indeed find a positive correlation between log TFP and log sales (with the correlation coefficient varying between 0.27 and 0.79, depending on the TFP measure). The log TFP LP and log TFP OP measures also correlate positively with our age proxy for firm experience (log one plus firm age), although the magnitude of this correlation is smaller (and even negative) for the more basic log value added per worker measure; see Appendix Table 2.

[25] This steady increase in TFP over time is readily corroborated in the firm-level measures we constructed.

more ready access to credit from domestic state-owned banks.

We derive several additional implications from the firm's profit-maximization problem. Notice that with an increase in firm productivity θ, profits π in (8) would rise even if U^X, U^M, q_M and the $x(u)$'s were held fixed at their original values. It follows immediately that the firm's profits necessarily rise after taking into account any profit-maximizing adjustments that the firm would make to these key choice variables.

The solution to the firm's problem also pins down its input and cost structure. Under the conditions spelled out in Proposition 1, it is straightforward to see that following an increase in θ, the firm's total fixed costs, $FC \equiv \int_{U^X}^{U^M} f(u)du$, would rise, given that U^M increases while U^X decreases. For a similar reason, and bearing in mind that $\frac{dx(u)}{d\theta} > 0$, the firm's total variable costs $VC \equiv \int_{U^X}^{U^M} c(u)x(u)du$ incurred across its in-house stages would also increase.

We turn next to the firm's value added, defined as total revenues less intermediate input purchases, $VA \equiv p(U^X)q - p(U^M)q_M$. Notice that VA is also equal to the sum of the firm's profits, total fixed costs (FC), and total variable costs (VC). Since these last three terms all increase with firm productivity, one can conclude that value added also rises. Lastly, the effect on the total outlay on intermediates, $p(U^M)q_M$, is more subtle: With a higher U^M, the market price of the intermediate input is lower (since $p'(u) < 0$), but this would also induce the firm to demand a higher quantity q_M of it. We show formally in the appendix that under the parameter conditions in Proposition 1, it is the latter force that dominates, so that the firm's total spending on the upstream intermediate input rises.

We summarize the results from this preceding discussion as:

Proposition 2 *Suppose that the same sufficient conditions as in Proposition 1 hold, so that a positive productivity shock leads a firm to expand its range of production stages, $U^M - U^X$. This would be accompanied by:*

1. *an increase in the firm's profits, π;*
2. *an increase in the firm's value added, VA;*
3. *an increase in the firm's total in-house variable costs, VC;*
4. *an increase in the firm's total per period fixed costs, FC; and*
5. *an increase in the firm's purchases of intermediate inputs, $p(U^M)q_M$.*

Relationship to Stylized Facts: We should emphasize that Proposition 2 helps to rationalize Firm Facts 2-5 as correlations among joint outcomes of the firm's profit maximization problem. This is in contrast to Proposition 1, which speaks directly to a causal relationship running from an increase in firm productivity to outcomes describing its production line position.

Firm Fact 5 is consistent with the first result in Proposition 2 that firm profits rise when firms choose to span a wider segment of the production chain. In turn, Firm Facts 2-4 together suggest that Chinese firms are indeed substantively undertaking more production stages in-house when they import inputs further upstream and export output further downstream: If they were instead simply substituting foreign suppliers with domestic suppliers, it would be harder to account for the rise in value added and fixed costs within firms. Put otherwise, the correlations in Proposition 2 are in line with the idea that expanding into more production stages is associated with incurring more fixed and variable costs (Firm Fact 4), purchasing more intermediate inputs (Firm Fact 3), and adding more value in production (Firm Fact 2).[26]

In short, this stylized model provides a framework for thinking through the forces that affect a firm's span of production stages, associated production activities, and performance. It is moreover capable of generating a pattern of shifts in the production line position of firms' inputs and output that is consistent with what we have documented for China during its period of rapid growth.

6 Conclusion

Global value chains have fundamentally transformed international trade and development in recent decades. The fragmentation of production across countries has raised important policy questions about the new challenges and opportunities for individual firms and aggregate economies, amidst growing concerns about the slow structural transformation in some underdeveloped countries and the uneven distribution of the gains from trade across nations.

We shed light on these questions by examining how firms position themselves in global production lines and how this position evolves with firm productivity and performance over the firm lifecycle. We study China, the second largest and fastest growing economy, to uncover new empirical evidence and formalize novel economic insights that inform how GVCs and structural transformation can go hand in hand.

First, we document a sharp rise in import upstreamness, stable export downstreamness, and rapid expansion in production stages conducted in China over the 1992-2014 period, both in the aggregate and within firms over time. Second, we show that firms span more production stages as they grow more productive, bigger and more experienced. This expansion is accompanied by a rise in value added and profits at constant profit margins. Finally, we illustrate with a stylized model that these patterns can be attributed to complementarities between economies of scope and scale along production chains.

Our findings point to several promising avenues for future research. Our firm-level analysis

[26] Though we have also explored several measures of profitability such as the profit-to-sales ratio in the empirics, how this measure would shift with an increase in firm productivity is in principle ambiguous since both profits and sales would each rise. One would need additional assumptions in order to pin down the direction of change.

can offer micro-foundations for future studies of the aggregate implications of global production sharing. Indeed, panel data for 1995-2014 reveals that countries' GVC participation bears a complex relationship with trade activity and GDP per capita (see Appendix Table 4). We construct the weighted average upstreamness of countries' imports and exports in the aggregate, using reference input-output production tables for the US. Both in the cross-section and within countries over time, spanning wider segments of global production chains is associated with higher export levels and annual export growth rates, but lower long-term export growth. At the same time, specializing in fewer GVC segments is correlated with higher GDP per capita yet lower annual income growth and flat long term growth across countries. Within countries over time, on the other hand, narrow GVC positionining comes with higher income levels and, if anything, lower annual income growth.

From a conceptual standpoint, our parsimonious model captures key trade-offs in firms' decision where to locate along the production chain, but leaves much scope for extensions to richer economic environments. For example, a fuller consideration of firm dynamics could inform how firms make endogenous decisions to invest in innovation or build up production experience that can systematically affect their productivity, production staging and performance in subsequent periods. A fuller model could also accommodate endogenous price setting along production lines, as well as distinguish between upstream input sourcing and downstream output sales at home versus abroad. Such extensions would inform rent sharing and the distribution of gains from trade across firm boundaries and country borders.

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Data Appendix

[TO BE ADDED]

Theory Appendix

Proof of Proposition 1: Recall that the firm's profit function in (8) is given by:

$$p(U^X)q - p(U^M)q_M - \int_{U^X}^{U^M} c(u)x(u)du - \int_{U^X}^{U^M} f(u)du.$$

The firm's choice variables are: the quantity of the stage-U^M intermediate input to purchase, q_M; the input levels for the production stages that are performed in-house, $x(u)$ for all $u \in [U^X, U^M]$; as well as the identities of the cutoff stages, U^X and U^M.

The respective first-order conditions are:

$$p(U^X)\rho\theta^{\frac{\alpha}{\rho}}q^{\frac{\rho-\alpha}{\rho}}q_M^{\alpha-1} = p(U^M), \tag{9}$$

$$p(U^X)\rho\theta^{\frac{\alpha}{\rho}}q^{\frac{\rho-\alpha}{\rho}}x(u)^{\alpha-1} = c(u), \tag{10}$$

$$-p(U^X)\frac{\rho}{\alpha}\theta^{\frac{\alpha}{\rho}}q^{\frac{\rho-\alpha}{\rho}}x(U^X)^{\alpha} + p'(U^X)q + c(U^X)x(U^X) + f(U^X) = 0, \text{ and} \tag{11}$$

$$p(U^X)\frac{\rho}{\alpha}\theta^{\frac{\alpha}{\rho}}q^{\frac{\rho-\alpha}{\rho}}x(U^M)^{\alpha} - p'(U^M)q_M - c(U^M)x(U^M) - f(U^M) = 0. \tag{12}$$

Note in particular that (10) holds for all stages $u \in [U^X, U^M]$. In what follows, we assume that the profit-maximizing outcome is an interior solution.

In order to understand how the firm's choice over the span of production stages is affected by θ, we totally differentiate the above system of equations. Equations (9) and (10) imply:

$$\frac{p'(U^X)}{p(U^X)}dU^X + \frac{\alpha}{\rho}\frac{d\theta}{\theta} + \frac{\rho-\alpha}{\alpha}\frac{dq}{q} + (\alpha-1)\frac{dq_M}{q_M} = \frac{p'(U^M)}{p(U^M)}dU^M, \text{ and} \tag{13}$$

$$\frac{p'(U^X)}{p(U^X)}dU^X + \frac{\alpha}{\rho}\frac{d\theta}{\theta} + \frac{\rho-\alpha}{\alpha}\frac{dq}{q} + (\alpha-1)\frac{dx(u)}{x(u)} = 0. \tag{14}$$

A quick inspection of these two prior equations yields:

$$\frac{dx(u)}{x(u)} = \frac{dq_M}{q_M} + \frac{1}{1-\alpha}\frac{p'(U^M)}{p(U^M)}dU^M. \tag{15}$$

Note that $\frac{dx(u)}{x(u)} - \frac{dq_M}{q_M} < 0$ if $dU^M > 0$, since $p'(u) < 0$. Holding all else constant, shifting the U^M cutoff stage upstream results in a lower price $p(U^M)$ relative to $c(u)$, and hence in an increase in the use of the stage-U^M intermediate input relative to in-house stage inputs $x(u)$.

Next, we totally differentiate the definition of q from (7):

$$\frac{dq}{q} = \frac{d\theta}{\theta} + \frac{\rho}{\alpha}\frac{x(U^M)^\alpha dU^M - x(U^X)^\alpha dU^X + \int_{U^X}^{U^M} \alpha x(u)^\alpha \frac{dx(u)}{x(u)} du + \alpha q_M^\alpha \frac{dq_M}{q_M}}{(q/\theta)^{\frac{\alpha}{\rho}}}. \tag{16}$$

From the first-order condition (10), one obtains:

$$\frac{\rho}{\alpha}\frac{1}{(q/\theta)^{\frac{\alpha}{\rho}}}x(u)^\alpha = \frac{1}{\alpha}\frac{c(u)x(u)}{p(U^X)q}, \text{ for both } u = U^X \text{ and } u = U^M \tag{17}$$

Substituting these last expressions into (11) and (12), one further obtains:

$$p'(U^X)q = \frac{1-\alpha}{\alpha}c(U^X)x(U^X) - f(U^X), \text{ and} \tag{18}$$

$$p'(U^M)q_M = \frac{1-\alpha}{\alpha}c(U^M)x(U^M) - f(U^M). \tag{19}$$

These last three expressions, (17), (18) and (19), that hold at any profit-maximizing outcome by the firm are useful substitutions to bear in mind. In particular, our baseline assumption that $p'(u) < 0$ implies that $\frac{1-\alpha}{\alpha}c(u)x(u) - f(u) < 0$ is necessarily satisfied at $u = U^X$ and $u = U^M$ if such an interior solution to the firm's profit-maximization problem is to exist.

Making use of (17), (18) and (19), as well as the expression for $\frac{dx(u)}{x(u)}$ from (15), one can simplify equation (16) for $\frac{dq}{q}$ to obtain:

$$\frac{dq}{q} = \frac{d\theta}{\theta} + \rho\frac{dq_M}{q_M} - \frac{1}{\alpha}\frac{c(U^X)x(U^X)}{p(U^X)q}dU^X + \frac{1}{1-\alpha}\left[\frac{f(U^M)}{p(U^X)q} + \rho\frac{p'(U^M)}{p(U^M)}\right]dU^M. \tag{20}$$

We will later substitute this expression for $\frac{dq}{q}$ into equation (13).

As a next step, we totally differentiate the first-order condition (12) for U^M:

$$\frac{p'(U^X)}{p(U^X)}dU^X + \frac{\alpha}{\rho}\frac{d\theta}{\theta} + \frac{\rho-\alpha}{\alpha}\frac{dq}{q} + \alpha\frac{dx(U^M)}{x(U^M)}$$
$$= \frac{p'(U^M)q_M\frac{dq_M}{q_M} + c(U^M)x(U^M)\frac{dx(U^M)}{x(U^M)} + [p''(U^M)q^M + c'(U^M)x(U^M) + f'(U^M)]dU^M}{p'(U^M)q_M + c(U^M)x(U^M) + f(U^M)} \tag{21}$$

Using (14), one can see that the left-hand side of (21) is exactly equal to $\frac{dx(U^M)}{x(U^M)}$. We now replace $\frac{dx(U^M)}{x(U^M)}$ with the expression from (15) on both sides of (21). After some manipulation, one obtains:

$$\frac{dq_M}{q_M} = \frac{1}{f(U^M)}\left[\Phi^M - \frac{1}{\alpha}c(U^M)x(U^M)\frac{p'(U^M)}{p(U^M)}\right]dU^M, \tag{22}$$

where $\Phi^M \equiv p''(U^M)q_M + c'(U^M)x(U^M) + f'(U^M)$. This last equation directly relates $\frac{dq_M}{q_M}$ to dU^M.

It moreover follows immediately from (15) that:

$$\frac{dx(u)}{x(u)} = \frac{1}{f(U^M)}\left[\Phi^M - \frac{1}{1-\alpha}\frac{(p'(U^M))^2 q_M}{p(U^M)}\right] dU^M. \tag{23}$$

We now substitute $\frac{dq_M}{q_M}$ from (22) and $\frac{dq}{q}$ from (20) into (13). Making use of (18) and (19) to simplify the resulting expressions, one obtains:

$$\frac{d\theta}{\theta} = AdU^X + BdU^M, \text{ where:} \tag{24}$$

$$A \equiv \frac{1}{p(U^X)q}\left[-\frac{1-\rho}{\rho}c(U^X)x(U^X) + f(U^X)\right], \text{ and} \tag{25}$$

$$B \equiv (1-\rho)\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} - \frac{\rho-\alpha}{\rho(1-\alpha)}\frac{f(U^M)}{p(U^X)q}. \tag{26}$$

To obtain a second equation relating dU^X and dU^M, we totally differentiate the remaining first-order condition (11):

$$\frac{p'(U^X)}{p(U^X)}dU^X + \frac{\alpha}{\rho}\frac{d\theta}{\theta} + \frac{\rho-\alpha}{\alpha}\frac{dq}{q} + \alpha\frac{dx(U^X)}{x(U^X)}$$
$$= \frac{p'(U^X)q\frac{dq}{q} + c(U^X)x(U^X)\frac{dx(U^X)}{x(U^X)} + [p''(U^X)q + c'(U^X)x(U^X) + f'(U^X)]dU^X}{p'(U^X)q_X + c(U^X)x(U^X) + f(U^X)}. \tag{27}$$

We simplify this in a manner analogous to (21), by recognizing that the left-hand side is equal to $\frac{dx(U^X)}{x(U^X)}$. After further replacing $\frac{dq}{q}$ on the right-hand side with the corresponding expression from (20) and simplifying, one arrives at:

$$\frac{d\theta}{\theta} = CdU^X + DdU^M, \text{ where:} \tag{28}$$

$$C \equiv \frac{1}{\alpha}\frac{c(U^X)x(U^X)}{p(U^X)q} - \frac{\Phi^X}{p'(U^X)q}, \text{ and} \tag{29}$$

$$D \equiv \left[(1-\rho) + \frac{f(U^X)}{p'(U^X)q}\right]\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} - \frac{1}{1-\alpha}\frac{f(U^M)}{p(U^X)q}. \tag{30}$$

Solving (24) and (28) simultaneously yields:

$$\frac{dU^M}{d\theta} = \frac{A-C}{AD-BC}, \text{ and} \tag{31}$$

$$\frac{dU^X}{d\theta} = \frac{D-B}{AD-BC}, \tag{32}$$

with:

$$A - C = \frac{\Phi^X}{p'(U^X)q} + \frac{(1 - \frac{1}{\alpha} - \frac{1}{\rho})c(U^X)x(U^X) + f(U^X)}{p(U^X)q}, \text{ and} \tag{33}$$

$$D - B = \frac{f(U^X)}{p'(U^X)q}\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} - \frac{\alpha}{\rho(1-\alpha)}\frac{f(U^M)}{p(U^X)q}. \tag{34}$$

It will be useful to define $E \equiv \frac{(1-\frac{1}{\alpha}-\frac{1}{\rho})c(U^X)x(U^X)+f(U^X)}{p(U^X)q}$ to save some notation, so that:

$$\begin{aligned} AD - BC &= \left[(1-\rho)\left(\frac{\Phi^X}{p'(U^X)q} + E\right) + A\frac{f(U^M)}{p'(U^X)q}\right]\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} \\ &\quad - \left[\frac{\rho-\alpha}{1-\alpha}\left(\frac{\Phi^X}{p'(U^X)q} + E\right) + \frac{\alpha}{\rho(1-\alpha)}A\right]\frac{f(U^M)}{p(U^X)q} \end{aligned} \tag{35}$$

As a first step towards signing $A - C$, $D - B$, and $AD - BC$, we make reference to the second-order necessary conditions for U^X and U^M: The second-derivative of the profit function with respect to U_X and separately with respect to U_M each need to be negative when evaluated at the local turning point in order to ascertain that we have a local maxima. (More formally, for the Hessian matrix to be negative semi-definite, its diagonal entries each need to be negative.) Differentiating the left-hand side of (11) with respect to U^X and the left-hand side of (12) with respect to U^M, and making extensive use of (18) and (19) as substitutions, one can show that these second-order necessary conditions reduce to:

$$\Phi^M > \frac{\rho-\alpha}{\rho\alpha^2}\frac{c(U^M)^2x(U^M)^2}{p(U^X)q}$$

and:

$$\frac{\Phi^X}{p'(U^X)q} > \frac{2}{\alpha}\frac{c(U^X)x(U^X)}{p(U^X)q} - \frac{\rho-\alpha}{\rho\alpha^2}\frac{c(U^X)x(U^X)}{p(U^X)q}\frac{c(U^X)x(U^X)}{p'(U^X)q}.$$

In other words, Φ^M and $\frac{\Phi^X}{p'(U^X)q}$ need to be bounded from below. Note that both of these lower bounds are positive, given that $\rho > \alpha$ and $p'(U^X) < 0$. In particular, this implies: $\Phi^M, \frac{\Phi^X}{p'(U^X)q} > 0$.

Examining (33), suppose that $\frac{c(U^X)x(U^X)}{p(U^X)q}$ and $\frac{f(U^X)}{p(U^X)q}$ are both small, relative to $\frac{\Phi^X}{p'(U^X)q}$; this is a condition that can be adopted, since Φ^X depends on p'', c' and f', and assuming that $\frac{c(U^X)x(U^X)}{p(U^X)q}$ and $\frac{f(U^X)}{p(U^X)q}$ are small does not *per se* impose restrictions on the behavior of p'', c' and f'. With this assumption, we have $A - C > 0$. Next, consider (34). Notice from (23) and (19) that:

$$\frac{1}{x(u)}\frac{dx(u)}{dU^M} = \frac{p(U^M)q_M}{f(U^M)}\left[\frac{\Phi^M}{p(U^M)q_M} - \frac{1}{1-\alpha}\left(\frac{\frac{1-\alpha}{\alpha}c(U^M)x(U^M) - f(U^M)}{p(U^M)q_M}\right)^2\right]. \tag{36}$$

If $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$ and $\frac{f(U^M)}{p(U^M)q_M}$ are sufficiently small, at least relative to $\frac{\Phi^M}{p(U^M)q_M}$, then it would follow that $\frac{1}{x(u)}\frac{dx(u)}{dU^M} > 0$. (Once again, an assumption that $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$ and $\frac{f(U^M)}{p(U^M)q_M}$ are small does not by itself impose restrictions on the behavior of $\Phi^M = p''(U^M) + c'(U^M)x(U^M) + f'(U^M)$.) Bearing in mind that $p'(U^M) < 0$ in the denominator of the first-term on the right-hand side of (34), it follows that $D - B < 0$. Turning to (35), with $\frac{c(U^X)x(U^X)}{p(U^X)q}$ and $\frac{f(U^X)}{p(U^X)q}$ being sufficiently small, one has that A and E are small too. An assumption that $\frac{f(U^X)}{p(U^M)q_M}$ is small would imply that $\frac{f(U^X)}{p(U^X)q}$ is small too (since $p(U^M)q_M \leq p(U^X)q$, if the firm is to operate with non-negative profits); the magnitude of the expression on the entire second line of (35), would thus be small too. We now apply the expression for $\frac{1}{x(u)}\frac{dx(u)}{dU^M}$ just derived in (36) in the first line of (35), together with the stipulation that $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$ and $\frac{f(U^M)}{p(U^M)q_M}$ are sufficiently small so that $\frac{1}{x(u)}\frac{dx(u)}{dU^M} > 0$. It follows that the sign of the entire expression that is on the first line of equation (35) is pinned down by $(1-\rho)\frac{\Phi^X}{p'(U^X)q}\frac{p(U^X)q}{f(U^M)}\frac{\Phi^M}{p(U^X)q}$, which is positive.

With $AD - BC > 0$, $A - C > 0$ and $D - B < 0$, (31) and (32) then imply that $\frac{dU^M}{d\theta} > 0$ and $\frac{dU^X}{d\theta} < 0$. Moreover, since $\frac{1}{x(u)}\frac{dx(u)}{dU^M} > 0$, we have: $\frac{dx(u)}{d\theta} > 0$. Last but not least, since $\Phi^M > 0$, one can see from (22) that $\frac{dq_M}{d\theta} > 0$. This establishes both parts of Proposition 1.

Proof of Proposition 2: As discussed in the main text, a firm's profits will strictly increase after a positive shock to θ if it were to leave U^X, U^M, q_M and all the $x(u)$'s unchanged at their initial values. It follows from a revealed preference argument that the profits of the firm must strictly increase after any further adjustments in its choice variables are made.

Under the sufficient conditions for Proposition 1 to hold, $\frac{dU^M}{d\theta} > 0$ and $\frac{dU^X}{d\theta} < 0$ together mean that the firm's total fixed costs, $FC \equiv \int_{U^X}^{U^M} f(u)du$ would increase. This is simply because fixed costs are being incurred for a wider span of production stages. Since we also have $\frac{dx(u)}{d\theta} > 0$, it further follows that the firm's total variable costs $VC \equiv \int_{U^X}^{U^M} c(u)x(u)du$ would increase. The firm's value added, $VA \equiv p(U^X)q - p(U^M)q_M$, is equal to its profits plus total fixed costs, FC, and total variable costs, VC, incurred. Since each of these three prior variables rises in response to an increase in productivity, the firm's value added also rises.

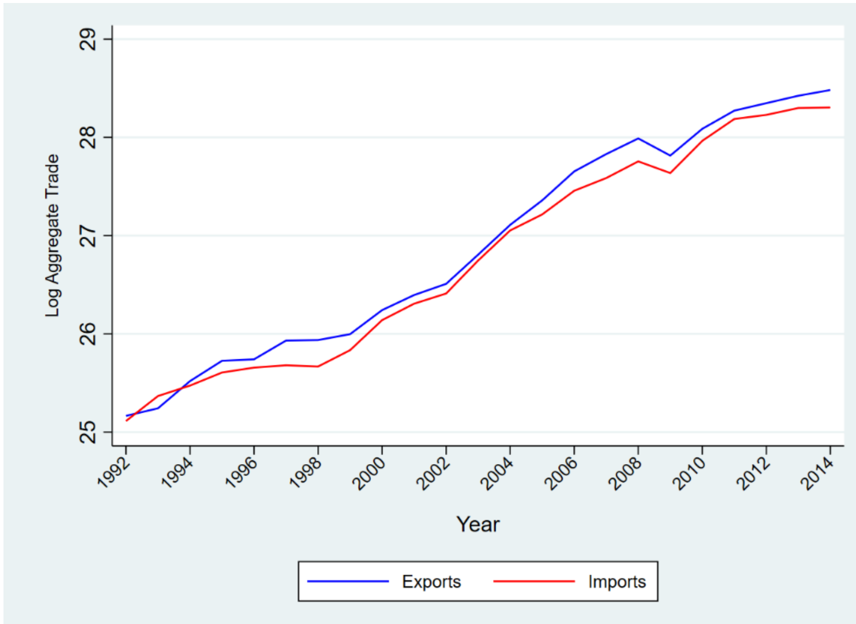
Last but not least, how the firm's payments for upstream intermediate inputs changes is determined by:

$$\frac{p'(U^M)}{p(U^M)}\frac{dU^M}{d\theta} + \frac{1}{q_M}\frac{dq_M}{d\theta} = \frac{1}{x(u)}\frac{dx(u)}{d\theta} + \frac{1}{f(U^M)}\frac{\alpha}{1-\alpha}\frac{(p'(U^M))^2 q_M}{p(U^M)} - c(U^M)x(U^M)\frac{p'(U^M)}{p(U^M)},$$

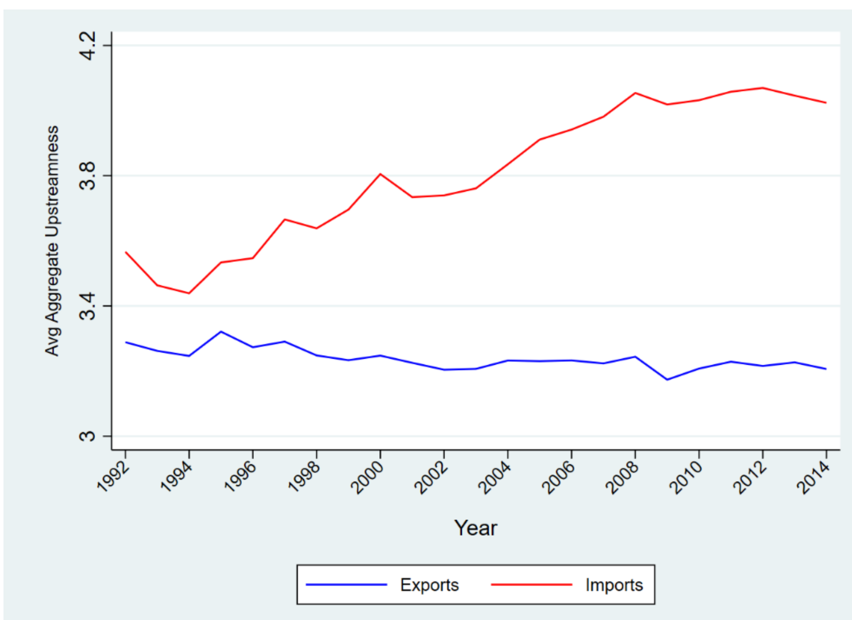
where we have made use of (19), (22), and (23) to obtain this last expression. Since $\frac{1}{x(u)}\frac{dx(u)}{d\theta} > 0$ and $p'(U^M) < 0$, we have that $p'(U^M)q_M$ also increases when θ rises.

Figure 1
Trends in China's Aggregate Trade and Global Production Line Position

A: Log Total Trade (nominal, USD)

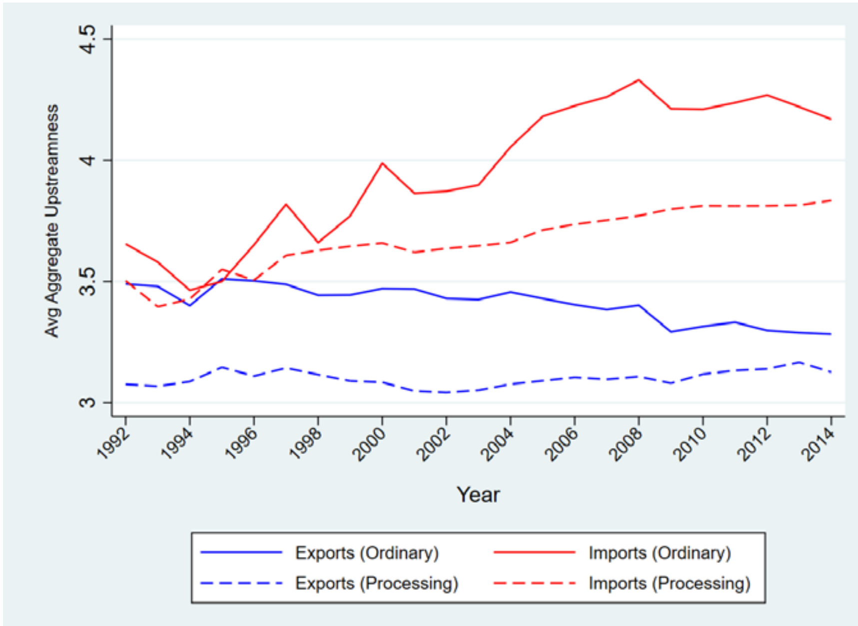


B: Import and Export Upstreamness



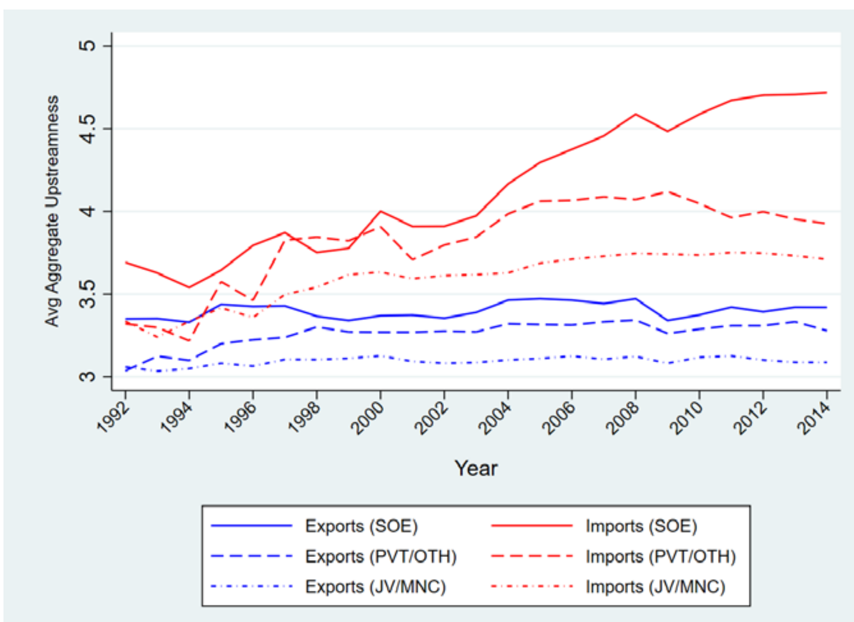
Notes: Authors' own calculations based on Chinese Customs Trade Statistics. Aggregates are based on data at the province or city level for 1992-1999 and data at the firm level for 2000-2014.

Figure 2
Trends in Aggregate Upstreamness by Customs Trade Regime



Notes: Authors' own calculations based on Chinese Customs Trade Statistics. Aggregates are based on the trade regime status of each trade transaction.

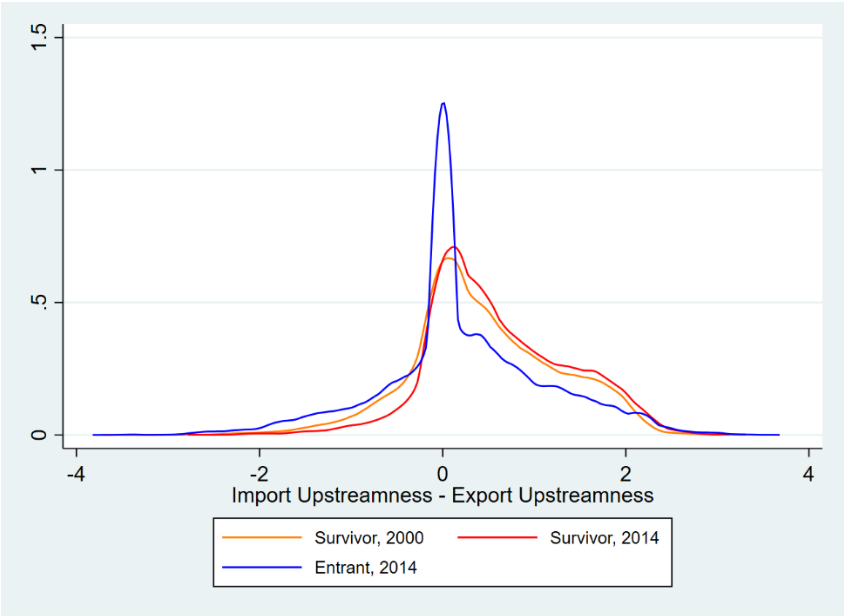
Figure 3
Trends in Aggregate Upstreamness by Firm Ownership Type



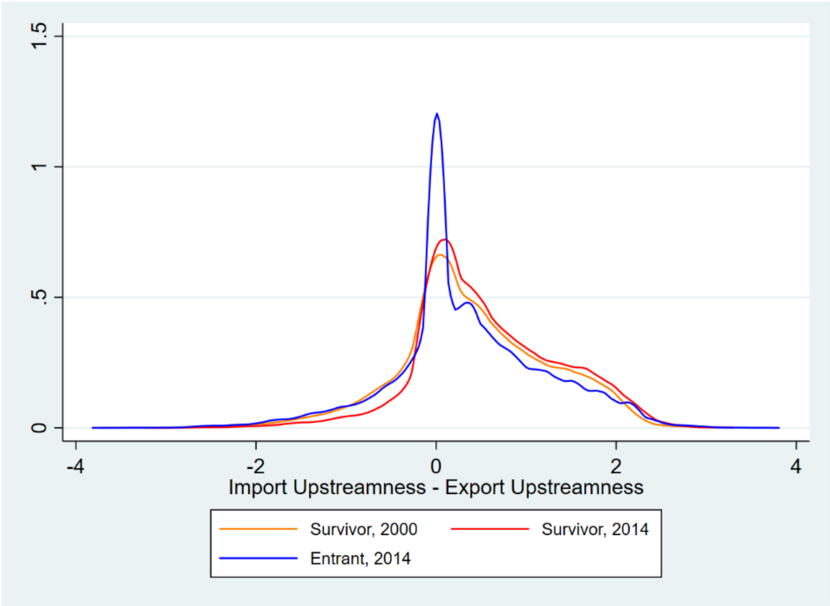
Notes: Authors' own calculations based on Chinese Customs Trade Statistics. Ownership type is deduced from the sixth digit of CCTS firm codes: "SOE" = state-owned enterprises, "PVT/OTH" = private and all other enterprises, "JV/MNC" = joint venture and multinational companies.

Figure 4
Patterns in Firm Upstreamness: Survivors vs. Entrants

A: Survivor & Entrant Status Based on Continuous Activity

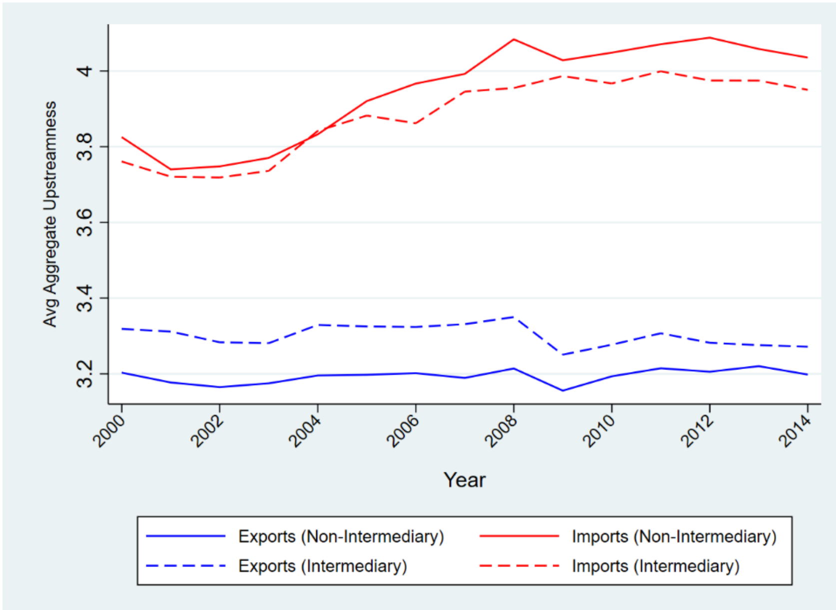


B: Survivor & Entrant Status Based on First & Last Year



Notes: Authors' own calculations based on Chinese Customs Trade Statistics. Kernel density plots of the difference between import and export upstreamness at the firm level. In Figure 4A, the sample comprises 5,646 survivor firms that export and import in each year in 2000-2014 and 26,450 entrant firms that reported export and import activity in 2014 but not in 2013. In Figure 4B, the sample comprises 6,982 survivor firms that export and import in 2000 and in 2014 and 91,465 entrant firms that export and import in 2014 but not in 2000.

Appendix Figure 1
Trends in Aggregate Upstreamness by Firm Intermediary Status



Notes: Authors' own calculations based on Chinese Customs Trade Statistics. Intermediary status is deduced from firm names following a word search algorithm.

Table 1: Firm-Level Production and Trade Activity, 2000-2014

	CCTS 2000-2014			ASIF 2000-2007			ASIF-CCTS 2000-2006		
	N	**Mean**	**St Dev**	**N**	**Mean**	**St Dev**	**N**	**Mean**	**St Dev**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: CCTS trade statistics									
All Traders	532,704 exporters, 422,818 importers								
Log Exports	2,385,331	13.15	2.33						
Log Imports	1,628,806	12.05	2.96						
Import upstreamness (U_M)	1,628,806	3.60	0.83						
Export upstreamness (U_X)	2,385,331	3.29	0.78						
Two-way Traders	259,439 firms						56,322 firms		
Log Exports	1,060,154	13.77	2.39				174,073	14.13	2.12
Log Imports	1,060,154	12.19	3.03				174,073	12.85	2.82
Import upstreamness (U_M)	1,060,154	3.68	0.76				174,073	3.70	0.75
Export upstreamness (U_X)	1,060,154	3.25	0.77				174,073	3.24	0.79
Import-Export Upstreamness (U_M - U_X)	1,060,154	0.42	0.89				174,073	0.46	0.89
Processing Exports / Total Exports	1,060,154	0.39	0.45				174,073	0.52	0.44
Processing Imports / Total Imports	1,060,154	0.55	0.46				174,073	0.71	0.41
Private Domestic Firm (PVT)	1,060,154	0.31	0.46				174,073	0.14	0.35
State-Owned Enterprise (SOE)	1,060,154	0.05	0.21				174,073	0.05	0.23
Joint Venture (JV)	1,060,154	0.20	0.40				174,073	0.35	0.48
Foreign-Owned MNC Affiliate (MNC)	1,060,154	0.44	0.50				174,073	0.46	0.50
Panel B: ASIF production statistics				539,985 firms					
Log Total Sales				1,875,361	9.81	1.65	174,073	10.76	1.44
Log Employment				1,875,361	4.72	1.15	174,073	5.49	1.17
Log Total Assets				1,875,529	9.62	1.50	174,073	10.65	1.50
Log Real VA per Worker				1,717,353	3.71	1.54	166,074	3.91	1.38
Log TFP LP				1,319,849	6.50	1.38	165,299	6.86	1.24
Log TFP OP				1,319,849	0.76	0.87	161,641	1.28	0.89
Log (Age+1)				1,867,812	2.01	0.89	173,797	2.03	0.67
Log Value Added				1,875,104	8.10	2.16	174,073	8.97	2.22
Log Total Inputs				1,087,069	9.46	1.71	174,073	10.46	1.50
Imports / Total Inputs							173,830	407	75,808
Log Wage				1,862,573	2.32	0.72	173,836	2.66	0.65
Log Net Fixed Assets per Worker				1,859,593	3.51	1.36	173,536	3.73	1.43
Net Fixed Assets / Total Assets				1,871,630	0.33	2.17	173,997	0.31	0.21
Inventories / Total Assets				1,871,630	0.19	0.17	173,997	0.20	0.16
R&D Expenditure / Total Sales				1,134,623	0.0028	0.76	103,363	0.00	0.05
Advertising Expenditure / Total Sales				1,144,165	0.0014	0.05	104,423	0.00	0.02
Log Profits				1,875,533	4.91	3.29	174,073	5.60	3.76

Notes: Summary statistics are reported separately for the full CCTS 2000-2014 panel of non-intermediary firm-years that export and/or import; the full CCTS 2000-2014 panel of non-intermediary firm-years that both export and import; the full ASIF 1999-2007 panel of firms; and the baseline matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. All variables are defined in the text.

Table 2: Industry-Level Upstreamness, 2007 IO Tables

	25th	Median	75th	Mean	St Dev
Panel A: Industry upstreamness					
All 135 industries	2.343	3.060	3.950	3.161	1.118
Primary (IO industries: 1 to 10)	3.331	4.343	5.345	4.302	1.176
Manufacturing (IO industries: 11 to 91)	2.498	3.060	4.104	3.276	1.008
Services (IO industries: 92 to 135)	1.720	2.966	3.480	2.691	1.076

Panel B: Ten most and least upstream industries

Social welfare (IO129)	1.000
Public administration and social organizations (IO135)	1.026
Construction (IO95)	1.058
Sports (IO133)	1.060
Public facilities management (IO123)	1.074
Education (IO126)	1.212
Convenience food manufacturing (IO18)	1.269
Health (IO127)	1.269
Software industry (IO107)	1.275
Resident services (IO124)	1.382

Nonferrous metal alloying and smelting (IO61)	4.877
Pipeline transportation (IO101)	5.023
Coking (IO38)	5.095
Ferrous metal mining industry (IO8)	5.114
Chemical fiber manufacturing (IO47)	5.162
Scrap waste (IO91)	5.256
Coal mining and washing industry (IO6)	5.345
Basic chemical raw materials manufacturing (IO39)	5.375
Oil and gas exploration industry (IO7)	5.508
Nonferrous metal mining industry (IO9)	5.861

Notes: Computed from Chinese Input-Output Tables for 2007.

Table 3: Chinese Firms' Global Production Line Position over Time

Dep variable:	Full Sample		All Non-intermediaries		Two-Way Non-intermediaries		
	U_{ft}^{M}	U_{ft}^{X}	U_{ft}^{M}	U_{ft}^{X}	U_{ft}^{M}	U_{ft}^{X}	$U_{ft}^{M} - U_{ft}^{X}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	3.4415***	3.3063***	3.4005***	3.2996***	3.5396***	3.2558***	0.2838***
	[0.0036]	[0.0022]	[0.0039]	[0.0023]	[0.0040]	[0.0026]	[0.0046]
Year, 2001	-0.0025	-0.0009	0.0004	-0.0006	-0.0009	-0.0005	-0.0004
	[0.0033]	[0.0017]	[0.0036]	[0.0017]	[0.0037]	[0.0020]	[0.0041]
Year, 2002	0.0053	-0.0005	0.0114***	0.0020	0.0032	0.0013	0.0019
	[0.0038]	[0.0020]	[0.0040]	[0.0020]	[0.0041]	[0.0023]	[0.0047]
Year, 2003	0.0476***	-0.0027	0.0603***	0.0009	0.0332***	-0.0004	0.0337***
	[0.0039]	[0.0022]	[0.0042]	[0.0022]	[0.0043]	[0.0025]	[0.0049]
Year, 2004	0.0842***	-0.0019	0.0967***	-0.0010	0.0617***	-0.0018	0.0635***
	[0.0040]	[0.0023]	[0.0043]	[0.0023]	[0.0044]	[0.0027]	[0.0050]
Year, 2005	0.1237***	-0.0028	0.1408***	-0.0018	0.0898***	-0.0043	0.0940***
	[0.0041]	[0.0024]	[0.0043]	[0.0024]	[0.0045]	[0.0028]	[0.0052]
Year, 2006	0.1454***	-0.0091***	0.1680***	-0.0044*	0.1088***	-0.0045	0.1133***
	[0.0041]	[0.0024]	[0.0044]	[0.0024]	[0.0046]	[0.0029]	[0.0053]
Year, 2007	0.1864***	-0.0103***	0.2161***	-0.0101***	0.1526***	-0.0004	0.1530***
	[0.0042]	[0.0025]	[0.0045]	[0.0025]	[0.0047]	[0.0030]	[0.0054]
Year, 2008	0.2028***	-0.0168***	0.2382***	-0.0162***	0.1708***	-0.0098***	0.1806***
	[0.0042]	[0.0025]	[0.0045]	[0.0026]	[0.0047]	[0.0031]	[0.0055]
Year, 2009	0.2225***	-0.0161***	0.2626***	-0.0151***	0.1902***	-0.0086***	0.1987***
	[0.0043]	[0.0026]	[0.0046]	[0.0026]	[0.0048]	[0.0032]	[0.0056]
Year, 2010	0.2151***	-0.0155***	0.2566***	-0.0146***	0.1809***	-0.0044	0.1853***
	[0.0043]	[0.0026]	[0.0046]	[0.0027]	[0.0048]	[0.0032]	[0.0056]
Year, 2011	0.2151***	-0.0132***	0.2578***	-0.0124***	0.1798***	-0.0034	0.1832***
	[0.0044]	[0.0026]	[0.0046]	[0.0027]	[0.0049]	[0.0032]	[0.0057]
Year, 2012	0.2360***	-0.0082***	0.2807***	-0.0065**	0.1924***	0.0021	0.1904***
	[0.0044]	[0.0026]	[0.0046]	[0.0027]	[0.0049]	[0.0033]	[0.0057]
Year, 2013	0.2400***	-0.0073***	0.2862***	-0.0061**	0.1963***	0.0037	0.1926***
	[0.0044]	[0.0026]	[0.0047]	[0.0027]	[0.0050]	[0.0033]	[0.0058]
Year, 2014	0.2414***	-0.0111***	0.2876***	-0.0102***	0.1992***	0.0001	0.1991***
	[0.0045]	[0.0026]	[0.0047]	[0.0027]	[0.0050]	[0.0034]	[0.0059]
Firm FE	Y	Y	Y	Y	Y	Y	Y
N	1,850,592	2,697,170	1,628,806	2,385,331	1,060,154	1,060,154	1,060,154
R^2	0.7587	0.8856	0.7699	0.8986	0.7432	0.9102	0.7521

Notes: The sample comprises different subsets of firm-year observations in the 2000-2014 CCTS panel. All regressions include firm fixed effects. Standard errors are clustered by firm. ***, **, and * denote significance at the 1%, 5%, and 10% level.

Table 4: Firm Productivity and Global Production Line Position

Dep variable:	U_M (1)	U_X (2)	U_M - U_X (3)	U_M - U_X (4)
Panel A: Log real value added per worker				
Log VA per Worker	0.0045**	-0.0005	0.0049**	0.0045**
	[0.0019]	[0.0010]	[0.0021]	[0.0019]
U_X				-0.9454***
				[0.0108]
Capital Intensity	-0.0114***	0.0024	-0.0138***	-0.0115***
	[0.0029]	[0.0016]	[0.0033]	[0.0029]
Skill Intensity	0.0072**	-0.0001	0.0073*	0.0072**
	[0.0037]	[0.0019]	[0.0040]	[0.0036]
N	170,907	170,907	170,907	170,907
R^2	0.8113	0.9620	0.8403	0.8671
Panel B: TFPR Levinsohn-Petrin				
Log TFP LP	0.0108***	-0.0007	0.0115***	0.0108***
	[0.0023]	[0.0012]	[0.0026]	[0.0023]
U_X				-0.9420***
				[0.0111]
Capital Intensity	-0.0090***	0.0021	-0.0111***	-0.0091***
	[0.0030]	[0.0016]	[0.0034]	[0.0030]
Skill Intensity	0.0064*	-0.0004	0.0068	0.0064*
	[0.0038]	[0.0019]	[0.0042]	[0.0038]
N	165,135	165,135	165,135	165,135
R^2	0.8129	0.9627	0.8425	0.8686
Panel C: TFPR Olley-Pakes				
Log TFP OP	0.0050**	0.0005	0.0045*	0.0050**
	[0.0022]	[0.0011]	[0.0024]	[0.0022]
U_X				-0.9435***
				[0.0112]
Capital Intensity	-0.0107***	0.0022	-0.0129***	-0.0108***
	[0.0030]	[0.0016]	[0.0034]	[0.0030]
Skill Intensity	0.0075*	-0.0005	0.0080*	0.0075*
	[0.0039]	[0.0019]	[0.0042]	[0.0038]
N	161,494	161,494	161,494	161,494
R^2	0.8132	0.9629	0.8429	0.8689
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y

Notes: The sample comprises the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. Each panel reports a separate set of regressions using a different firm productivity measure. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. All columns include firm and year fixed effects.

Table 5: Firm Size and Global Production Line Position

Dep variable:	U_M (1)	U_X (2)	$U_M - U_X$ (3)	$U_M - U_X$ (4)
Panel A: Log sales				
Log Sales	0.0210***	-0.0035*	0.0245***	0.0212***
	[0.0031]	[0.0019]	[0.0036]	[0.0031]
U_X				-0.9465***
				[0.0106]
Capital Intensity	-0.0101***	0.0020	-0.0120***	-0.0102***
	[0.0029]	[0.0015]	[0.0032]	[0.0029]
Skill Intensity	0.0062*	0.0005	0.0058	0.0062*
	[0.0036]	[0.0018]	[0.0039]	[0.0036]
N	173,343	173,343	173,343	173,343
R^2	0.8098	0.9615	0.8392	0.8663
Panel B: Log exports				
Log Exports	0.0184***	-0.0073***	0.0257***	0.0188***
	[0.0020]	[0.0017]	[0.0026]	[0.0020]
U_X				-0.9437***
				[0.0107]
Capital Intensity	-0.0100***	0.0017	-0.0118***	-0.0101***
	[0.0029]	[0.0015]	[0.0032]	[0.0029]
Skill Intensity	0.0070*	0.0008	0.0063	0.0070*
	[0.0036]	[0.0018]	[0.0040]	[0.0036]
N	173,343	173,343	173,343	173,343
R^2	0.8100	0.9616	0.8395	0.8664
Panel C: Log employment				
Log Employment	0.0246***	-0.0034	0.0279***	0.0248***
	[0.0051]	[0.0029]	[0.0057]	[0.0051]
U_X				-0.9468***
				[0.0106]
Capital Intensity	-0.0046	0.0012	-0.0059*	-0.0047
	[0.0031]	[0.0017]	[0.0035]	[0.0031]
Skill Intensity	0.0122***	-0.0004	0.0126***	0.0122***
	[0.0037]	[0.0019]	[0.0041]	[0.0037]
N	173,343	173,343	173,343	173,343
R^2	0.8097	0.9615	0.8391	0.8662
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y

Notes: The sample comprises the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. Each panel reports a separate set of regressions using a different firm size measure. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. All columns include firm and year fixed effects.

Table 6: Firm Experience and Global Production Line Position

Dep variable:	U_M (1)	U_X (2)	$U_M - U_X$ (3)	$U_M - U_X$ (4)
Panel A: Age				
Log (Age+1)	0.1786***	-0.0092	0.1877***	0.1791***
	[0.0151]	[0.0076]	[0.0169]	[0.0151]
U_X				-0.9467***
				[0.0106]
Capital Intensity	-0.0126***	0.0022	-0.0148***	-0.0127***
	[0.0029]	[0.0015]	[0.0032]	[0.0029]
Skill Intensity	0.0053	0.0001	0.0053	0.0053
	[0.0036]	[0.0018]	[0.0039]	[0.0036]
N	173,132	173,132	173,132	173,132
R^2	0.8104	0.9616	0.8396	0.8667
Panel B: Cumulative past exports				
Log Cum Past Exports	0.0029***	-0.0003	0.0032***	0.0030***
	[0.0004]	[0.0002]	[0.0004]	[0.0004]
U_X				-0.9466***
				[0.0106]
Capital Intensity	-0.0120***	0.0022	-0.0142***	-0.0121***
	[0.0029]	[0.0015]	[0.0032]	[0.0029]
Skill Intensity	0.0078**	0.0001	0.0077*	0.0078**
	[0.0036]	[0.0018]	[0.0040]	[0.0036]
N	173,343	173,343	173,343	173,343
R^2	0.8098	0.9615	0.8392	0.8663
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y

Notes: The sample comprises the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. Each panel reports a separate set of regressions using a different firm experience measure. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. All columns include firm and year fixed effects.

Table 7: Firm Global Production Line Position, Inputs and Value Added

Dep variable:	Panel A: Log Value Added				Panel B: Exports / Total Sales			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
U_M	0.0350**				207.9			
	[0.0148]				[250.1]			
U_X		-0.0426	-0.0090	-0.0246		-7.31	189.7	211.6
		[0.0342]	[0.0365]	[0.0322]		[6.58]	[232.3]	[252.5]
$U_M - U_X$			0.0355**	-0.0062			208.2	250.5
			[0.0148]	[0.0132]			[250.3]	[287.9]
Log Sales				1.1679***				-1,082.8
				[0.0256]				[967.4]
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
K & H Intensity	Y	Y	Y	Y	Y	Y	Y	Y
N	170,907	170,907	170,907	170,907	173,212	173,212	173,212	170,776
R^2	0.7067	0.7067	0.7067	0.7557	0.2716	0.2715	0.2716	0.2752
Dep variable:	**Panel C: Log Total Inputs**				**Panel D: Imported Inputs / Total Inputs**			
U_M	0.0343***				-379.9			
	[0.0060]				[318.9]			
U_X		-0.0255	0.0073	-0.0036		-857.5	-1,207.5	-1,221.6
		[0.0164]	[0.0173]	[0.0102]		[1,267.4]	[1,538.1]	[1,582.5]
$U_M - U_X$			0.0347***	0.0058			-369.8	-359.6
			[0.0061]	[0.0039]			[304.9]	[330.8]
Log Sales				0.8086***				-487.4
				[0.0183]				[854.6]
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
K & H Intensity	Y	Y	Y	Y	Y	Y	Y	Y
N	170,907	170,907	170,907	170,907	173,162	173,162	173,162	170,733
R^2	0.8867	0.8867	0.8867	0.9415	0.1588	0.1588	0.1588	0.1588

Notes: The sample comprises the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. Each panel reports a separate set of regressions using a different measure of firm inputs and value added. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. All columns include firm and year fixed effects and control for log net fixed assets per worker and log wage.

Table 8: Firm Global Production Line Position, Asset and Cost Structure

Dep variable:	Panel A: Log Fixed Assets			Panel B: Fixed Assets / Total Assets		
	(1)	(2)	(3)	(4)	(5)	(6)
U_M	0.0164***			0.0053***		
	[0.0034]			[0.0009]		
U_X		-0.0100	0.0057		0.0004	0.0053**
		[0.0085]	[0.0091]		[0.0022]	[0.0023]
U_M - U_X			0.0165***			0.0053***
			[0.0034]			[0.0009]
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
K & H Intensity	Y	Y	Y	Y	Y	Y
N	173,343	173,343	173,343	173,343	173,343	173,343
R^2	0.9765	0.9765	0.9765	0.7596	0.7596	0.7596
Dep variable:	Panel C: Log Inventories			Panel D: Inventories / Total Assets		
U_M	0.0279***			0.0035***		
	[0.0103]			[0.0009]		
U_X		-0.0260	0.0007		-0.0023	0.0011
		[0.0231]	[0.0253]		[0.0020]	[0.0022]
U_M - U_X			0.0282***			0.0036***
			[0.0103]			[0.0009]
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
K & H Intensity	Y	Y	Y	Y	Y	Y
N	173,343	173,343	173,343	173,343	173,343	173,343
R^2	0.8005	0.8005	0.8005	0.7413	0.7413	0.7414

Notes: The sample comprises the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. Each panel reports a separate set of regressions using a different measure of firm asset and cost structure. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. All columns include firm and year fixed effects and control for log net fixed assets per worker and log wage.

Table 9: Firm Global Production Line Position and Profitability

Dep variable:	Panel A: Log Profits				Panel B: Profits / Sales			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
U_M	0.0717***				0.1676			
	[0.0246]				[0.2042]			
U_X		-0.0103	0.0577	0.0369		-0.0049	0.1539	0.1678
		[0.0585]	[0.0633]	[0.0599]		[0.0052]	[0.1897]	[0.2063]
U_M - U_X			0.0719***	0.0166			0.1678	0.1938
			[0.0246]	[0.0230]			[0.2044]	[0.2352]
Log Sales				1.5469***				-0.6346
				[0.0524]				[0.7623]
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
K & H Intensity	Y	Y	Y	Y	Y	Y	Y	Y
N	170,907	170,907	170,907	170,907	173,212	173,212	173,212	170,776
R^2	0.6574	0.6573	0.6574	0.6884	0.2507	0.2506	0.2507	0.2527
Dep variable:	**Panel C: Profits / Value Added**				**Panel D: Profits / Assets**			
U_M	0.1751				0.0018			
	[0.2200]				[0.0016]			
U_X		0.0173	0.1824	0.1941		0.0011	0.0028	0.0023
		[0.0547]	[0.2108]	[0.2236]		[0.0046]	[0.0049]	[0.0049]
U_M - U_X			0.1750	0.1964			0.0018	0.0004
			[0.2202]	[0.2446]			[0.0016]	[0.0016]
Log Sales				-0.6730				0.0405***
				[0.7919]				[0.0033]
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
K & H Intensity	Y	Y	Y	Y	Y	Y	Y	Y
N	165,432	165,432	165,432	165,432	170,887	170,887	170,887	170,887
R^2	0.2808	0.2807	0.2808	0.2824	0.5873	0.5873	0.5873	0.5930

Notes: The sample comprises the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. Each panel reports a separate set of regressions using a different measure of firm profitability. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. All columns include firm and year fixed effects and control for log net fixed assets per worker and log wage.

Appendix Table 1: Productivity, Size and Experience Correlations

Firm Characteristic	Log VA/L	Log TFP LP	Log TFP OP	Log Sales	Log Exports	Log Employment	Log (Age+1)	Log Cum Past Exports
Log VA/L	1.00							
Log TFP LP	0.62	1.00						
Log TFP OP	0.55	0.69	1.00					
Log Sales	0.43	0.79	0.27	1.00				
Log Exports	0.10	0.28	0.11	0.39	1.00			
Log Employment	-0.14	0.45	0.14	0.64	0.36	1.00		
Log (Age+1)	-0.02	0.16	0.05	0.20	0.04	0.28	1.00	
Log Cum Past Exports	0.05	0.15	0.08	0.20	0.40	0.23	0.30	1.00

Notes: This table reports two-way correlations among firm characteristics in the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import.

Appendix Table 2: Firms' Product Scope and Global Production Line Position over Time

Dep variable:	U_{ft}^{M}	U_{ft}^{X}	U_{ft}^{M} - U_{ft}^{X}
	# Traded Products		
	(1)	(2)	(3)
# Import Products	-0.0006***		-0.0005***
	[0.0001]		[0.0001]
# Export Products		-0.0001***	0.0003***
		[0.0000]	[0.0001]
Constant	3.5544***	3.2571***	0.2918***
	[0.0041]	[0.0026]	[0.0048]
Year, 2001	-0.0019	-0.0005	-0.0011
	[0.0037]	[0.0020]	[0.0041]
Year, 2002	0.0022	0.0014	0.0010
	[0.0041]	[0.0023]	[0.0047]
Year, 2003	0.0320***	-0.0004	0.0324***
	[0.0043]	[0.0025]	[0.0049]
Year, 2004	0.0601***	-0.0016	0.0619***
	[0.0044]	[0.0027]	[0.0050]
Year, 2005	0.0875***	-0.0040	0.0917***
	[0.0045]	[0.0028]	[0.0052]
Year, 2006	0.1054***	-0.0043	0.1100***
	[0.0046]	[0.0029]	[0.0053]
Year, 2007	0.1488***	-0.0001	0.1493***
	[0.0047]	[0.0030]	[0.0054]
Year, 2008	0.1667***	-0.0096***	0.1767***
	[0.0047]	[0.0031]	[0.0055]
Year, 2009	0.1849***	-0.0082***	0.1937***
	[0.0048]	[0.0032]	[0.0056]
Year, 2010	0.1766***	-0.0040	0.1807***
	[0.0048]	[0.0032]	[0.0057]
Year, 2011	0.1755***	-0.0029	0.1785***
	[0.0049]	[0.0032]	[0.0057]
Year, 2012	0.1879***	0.0025	0.1856***
	[0.0049]	[0.0033]	[0.0058]
Year, 2013	0.1915***	0.0041	0.1875***
	[0.0050]	[0.0033]	[0.0058]
Year, 2014	0.1947***	0.0007	0.1939***
	[0.0050]	[0.0034]	[0.0059]
Firm FE	Y	Y	Y
N	1,060,154	1,060,154	1,060,154
R^2	0.7434	0.9102	0.7522

Notes: The sample comprises the 2000-2014 panel of non-intermediary firm-years that both export and import. All regressions include firm fixed effects. Standard errors are clustered by firm. ***, **, and * denote significance at the 1%, 5%, and 10% level.

Appendix Table 3: Firm Processing Trade Share and Global Production Line Position

Dep variable:	U_M (1)	U_X (2)	$U_M - U_X$ (3)	$U_M - U_X$ (4)
Proc Exports / Exports	0.1765***	-0.0117	0.1882***	0.1771***
	[0.0119]	[0.0076]	[0.0137]	[0.0119]
U_X				-0.9455***
				[0.0105]
Capital Intensity	-0.0113***	0.0021	-0.0135***	-0.0115***
	[0.0029]	[0.0015]	[0.0032]	[0.0029]
Skill Intensity	0.0088**	0.0000	0.0088**	0.0088**
	[0.0036]	[0.0018]	[0.0039]	[0.0036]
N	173,343	173,343	173,343	173,343
R^2	0.8106	0.9615	0.8398	0.8668
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y

Notes: The sample comprises the matched CCTS-ASIF 2000-2006 panel of non-intermediary firm-years that both export and import. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. All columns include firm and year fixed effects.

Appendix Table 4: Countries' Global Production Line Position, Trade and Growth

Dep variable:	**ln Y_{ct}** (1)	**ln Y_{ct}** (2)	**$\Delta Y_{c,t \to t+1}$** (3)	**$\Delta Y_{c,t \to t+1}$** (4)	**$\Delta Y_{c,1995 \to 2014}$** (5)
Panel A: Y_{ct} = Export Activity					
U_M - U_X	0.235***	0.036**	-0.002	0.028***	-0.195***
	(14.30)	(2.26)	(-1.15)	(3.06)	(-3.42)
U_X	-0.374***	-0.039**	0.005	-0.044***	0.163**
	(-16.87)	(-2.31)	(1.51)	(-4.09)	(2.57)
Panel B: Y_{ct} = GDP per Capita					
U_M - U_X	-0.510***	0.306**	0.017***	-0.013	-0.051
	(-9.14)	(2.44)	(4.96)	(-1.31)	(-1.00)
U_X	0.105	0.757***	-0.011***	0.010	0.059
	(1.37)	(9.09)	(-2.59)	(0.96)	(1.00)
N	3,462	3,462	3,286	3,286	171
Year FE	Y	N	Y	N	--
Country FE	N	Y	N	Y	--

Notes: The sample comprises 171 countries in the WTF 1995-2014 panel. Standard errors are clustered by firm; ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. T-statistics reported in parentheses.