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The connection between imported intermediate inputs and exports: Evidence from Chinese firms☆

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ABSTRACT

We use Chinese manufacturing firm data to estimate the causal effect of increased imported intermediate input use on firm export outcomes. To account for the endogeneity of import decisions, we pursue an IV strategy that utilizes instruments for import costs connected to intermediate input import tariffs, exchange rates, and firm differences in fixed trade costs. We find that firms that expanded their intermediate input imports expanded the volume and scope of their exports. Further, we find that the benefit of imported inputs differed along a number of dimensions including initial trade status, import source country, export destination, firm ownership, and industry R&D intensity. Although increased imports of intermediates boosted exports by all firms, we find that the effects were largest when they were purchased by private firms or firms that started out as non-traders. In addition, intermediate inputs from the higher-income G7 countries were especially helpful in facilitating firm exports to the presumably more-demanding G7 export markets. Taken together, these results suggest that product upgrading facilitated by technology or quality embedded in imported inputs helped Chinese firms to increase the scale and breadth of their participation in export markets.

1. Introduction

It is widely believed that China's WTO entry, with its promised market opportunities and guarantees, spurred the exceptional growth in China's exports. However, much less noted is the fact that China's imports grew almost as rapidly as China's exports. Indeed, in 2002 — China's first full year as a WTO member — China's imports of intermediate inputs by manufacturing firms grew at a rate (58.3%) that exceeded its rate of manufacturing export growth (47.7%). Thus, while the rapid growth of China's imports and exports might be uncorrelated, the coincidence of these trends raises an important question. How has increased use of imported intermediate inputs contributed to Chinese firms' improved export participation and performance?

In general, the benefit of utilizing a variety of inputs is well-known. The seminal work by Ethier (1982) rigorously but simply demonstrated the benefits of input variety arising from the finer division of labor. The empirical relevance of this theoretical insight has been supported by Amiti and Konings (2007), Goldberg et al. (2010), Lileeva and Trefler (2010), Yu (2013), and Gopinath and Neiman (2013), who have demonstrated how imported inputs enhance firm productivity. Further, aggregate level evidence from Acharya and Keller (2009) and micro level evidence from Halpern et al. (2015), Kugler and Verhoogen (2009), Bas and Strauss-Kahn (2014) and Fan et al. (2015) recognizes the role of imported intermediates in facilitating firm improvements as firms avail themselves of new technologies embodied in the inputs.

Nonetheless, the literature to date has paid more limited attention to the effect of imported inputs on firm export decisions. For example, while research on firm productivity has noted that importing and exporting firms are more productive than non-trading firms, study is needed to determine whether the connection between imports and

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exports is causal, rather than a joint byproduct of firm productivity in a heterogeneous firm setting.[3] To advance this literature, our paper studies the causal effect of firm-level intermediate input imports on firm-level export outcomes. To do this, we track the activities of Chinese manufacturing firms between 2002 and 2006. We rely on exogenous changes in the relative costs of foreign inputs, including intermediate input import tariff changes, exchange rate movements, and firm-specific differences in fixed trade costs, to instrument for firm changes in the use of imported inputs, thus identifying the causal effect of increased use of imported intermediate inputs on firm export performance.

Our analysis reveals a number of robust links between firm-level imports and exports. First, we find that Chinese firms that increased their use of imported intermediates increased their exports, an effect we observe whether firm import activity is measured by firm transition to import, increased expenditure on imported inputs, or an expanded range of imported inputs. Further, the effects are economically significant. For example, our full sample IV estimates demonstrate that a 1% increase in the value of imported inputs boosted a firm's export value by 1.6%.

Second, even when firms face equal costs of import, the use of imported inputs may yield heterogeneous benefits. In particular, if the technology and quality embedded in imported inputs are primary drivers of the trade connection, imported inputs may have provided the largest benefits to firms whose capabilities were more distant from the technological or quality frontier. Thus, firms' responses to new import opportunities may depend on their previous trade decisions, current level of trade engagement or their organizational form.[4] For this reason, we first delineate the responses for two key firm subgroups based on the firms' trade involvement at the start of the sample: non-traders who were uninvolved in export or import, and traders who were involved in both import and export from the beginning. We find that increased import has a positive and significant effect on export by both firm groups, though the strongest effects involve firms that started as non-traders. We then study how the strength of the firm-level import–export connections was related to ownership, finding that private firms experienced stronger benefits from importing than did state-owned enterprises, or firms controlled by foreign owners. This difference is economically meaningful, as the benefit experienced by private firms is always 20% or greater in magnitude than the benefit experienced by foreign-owned firms.

Finally, to gain further insights into the mechanisms linking firm import expansion to firm export growth, we compare the benefits of imported inputs by source country as they relate to the export destinations and industry-level R&D intensity. In particular, if improved access to imported inputs enables firms to upgrade their products for export and to increase their range of exported products, we expect that imported inputs from technologically developed countries will provide the strongest benefits to exports to more-demanding high-income destinations, and that the benefits will be largest for firms operating in sectors which are most technologically dependent. In support of the technological conjecture, we document that imported inputs from high-income countries had the greatest effect in boosting firm exports to customers in high-income destinations, and the strongest effects were for firms which were active in the most R&D-intensive sectors.

Our paper contributes to a number of literatures. First, our work advances the literature on trade liberalization and firm outcomes by establishing a more direct connection between imported input use and firm exports. The possibility of such a connection is suggested by previous work such as Amiti and Konings (2007), Kasahara and Lapham (2013), Goldberg et al. (2010), Bas (2012) and Bas and Strauss-Kahn (2014), which note a connection between industry-level tariff liberalization, imported inputs and firm productivity, though their projects do not include firm-level information on imported intermediates. A connection is also suggested by Damijan et al. (2014) who uncover an association between Slovenian firms' imports and firm export scope, and by Damijan and Kostev (2010) who note a relation between Spanish firms' imports and their entry into export. We are able to evaluate this question more directly since we identify causal effects through the application of an instrumental variables approach to detailed Chinese firm-level import data. While there are a number of similarities between our project and the work of Fan et al. (2015), who demonstrate the importance of imported intermediates for firms that were already importers, our work provides an extended perspective by investigating the effects for a broader range of firms, the majority of whom did not begin as importers.

Our work also contributes to the recent literature on quality heterogeneity and trade. For example, observation of firm-level data from a number of countries has revealed marked variation in product unit values across export destinations. Consistent with a quality explanation, many of these projects, including Manova and Zhang (2012a, 2012b), Bastos and Silva (2010), Görg et al. (2010) and Martin (2012), who present firm product export prices for Chinese, Portuguese, Hungarian and French firms, respectively, demonstrate that export product prices are increasing in destination country GDP per capita. More important, in addition to the cross-sectional correlation between export prices and destination country income, other projects have shown how demand shocks have led firms to change their product quality. Among these projects, Verhoogen (2008) shows how competition introduced by currency shocks caused Mexican firms to improve product quality, while Amiti and Khandelwal (2013) provide evidence from US import data which suggests that firms upgraded their product quality when tariff reductions in their home markets increased the competition in their domestic market. Moreover, import-led quality upgrading by Chinese firms is particularly plausible given Manova and Zhang's (2012a, 2012b) observation that Chinese firm export prices were higher for firms that procured higher priced inputs, and Bastos et al.'s (2014) work with Portuguese firm data, which shows that an exogenous increase in the average destination market income caused firms to export higher priced goods, and to use higher-cost inputs. Since our analysis finds that the export expansion benefits of intermediate input imports from high-income developed countries were particularly strong in the case of high-income destined export markets, particularly for Chinese firms in R&D-intensive sectors, our results suggest that intermediate input imports supported quality upgrading.[5]

Our results also provide insights into the nature of technological diffusion. In particular, while the literature has long shown that international R&D spillovers are related to imports, the presence of firm identifiers in our data set allows us to verify that the benefits of imported inputs accrued disproportionately to private Chinese firms, who were at a technological disadvantage, rather than being captured by multinational firms that were active in China.[6] Further, since the benefits accruing to private firms were particularly large when the inputs were purchased from richer and more technologically advanced countries, and were especially valuable in providing support in export to richer destinations, our estimates provide further evidence in support of the idea that imported inputs, as carriers of technology and quality, boost the export capability of importing firms.

[3] A few papers have started to investigate the link between imported inputs and exports, for example, see Bas and Strauss-Kahn (2014), Bas (2012), and Kasahara and Lapham (2013). However, in the absence of detailed measures of imported inputs, the results from this literature are based on correlations with industry tariff changes, rather than observed changes in firm-level usage of imported intermediates.

[4] For example, Lileeva and Trefler (2010) suggest a complementarity between firm innovation and export due to the fact that the fruits of innovation can be more broadly applied when firms sell in both domestic and export markets.

[5] Our finding is also related to Bustos (2011) evidence of input-driven quality upgrading, which is based on connection between import tariff liberalization and Argentine firm innovation.

[6] The Chinese technological gap by firm ownership is documented by Brambilla's (2009) work that reveals that private Chinese firms developed only 50% as many new products as were developed by multinational firms. See Keller (2010) for a comprehensive discussion of international trade and spillovers.

Finally, our work sheds light on the exceptional output and productivity growth of Chinese firms. In particular, Brandt et al. (2012) note that a number of favorable conditions in China's manufacturing sector, including China's entry to the WTO, may have contributed to the rapid productivity growth of Chinese firms between 1998 and 2006. Thus, by showing that firms' ability to increase imports helped firms to expand their exports, our work suggests that China's trade liberalization contributed to the high productivity growth achieved by many Chinese firms during this period.

The rest of this paper is organized as follows. Section 2 introduces our data and provides some background on recent import and export developments in China. Section 3 provides a theoretical framework for our empirical investigation. Section 4 describes our empirical strategy, which is followed by our empirical results in Section 5. To demonstrate the robustness of the results, Section 6 describes our work with a number of alternative specifications which investigate alternative explanations for our findings. Section 7 concludes.

2. Data

Our data set is formed by combining firm-level operating data on Chinese manufacturing firms with firm-level customs data on trade transactions for the years 2002 to 2006. The first data source, Chinese customs data on imports and exports, provides detailed information on the universe of China's trade transactions. In addition to firm identifiers, this data set includes information on important transaction characteristics including customs regime (e.g., processing trade or ordinary trade), 8-digit HS product code, transaction value, quantity, and source or destination country. The firm identifiers in the customs data set allow us to construct firm-level measures of export, and imported intermediate inputs.[7]

The second data source for our project is the firm-level surveys of manufacturing enterprises conducted by China's National Bureau of Statistics. This data set provides extensive information on Chinese firm operations, including firm employment, assets, ownership type (e.g., state-owned enterprise, foreign invested firm, or private firm), sales value, R&D expenditure and industry. Although the two data sets use different firm identifiers, both include extensive firm contact information (e.g., company name, telephone number, contact person, zip code) which allow us to generate firm-level observations that encompass the trade and operational activities of the Chinese firms. While the trade data set also includes the activities of retail and wholesale traders, by matching the trade data to firms in the manufacturing survey, we restrict our sample to manufacturing firms.[8] Further, since we follow Lileeva and Trefler (2010) by categorizing firms based on their international trade involvement at the beginning of the sample, we restrict our sample to firms that remained active through the full 2002 to 2006 sample period.[9] Two further data sets used in the paper are: 1) tariff data from the WTO which provides information on China's import tariffs and those of other WTO member countries, and 2) bilateral real exchange rate data from the Penn World Tables.[10] Fuller discussion of the data sets, our matching procedure and variable construction are included in Appendix.

Table 1
Chinese industry tariffs and R&D.

Industry name	CIC 2-digit code (1)	Tariff rate (%) (2)	Tariff reduction (%) (3)	R&D (4)
Food processing	13	9.792	17.452	0.0004
Food manufacture	14	14.115	21.778	0.0009
Beverages	15	9.602	28.683	0.0016
Tobacco	16	7.555	46.868	0.0035
Textiles	17	9.356	30.002	0.0014
Apparel, footwear and hats	18	13.489	35.654	0.0005
Leather, fur, and feather products	19	8.758	20.292	0.0003
Timber, wood, bamboo, rattan, palm and straw products	20	2.156	26.873	0.0004
Furniture	21	8.667	29.646	0.0007
Paper and paper products	22	4.958	10.512	0.0005
Printing, reproduction of recording media	23	8.385	31.256	0.0010
Articles for culture, education and sporting activities	24	9.918	17.737	0.0014
Processing of petroleum, coke and fuel	25	5.267	7.418	0.0008
Raw chemical materials	26	6.558	18.975	0.0027
Drugs	27	7.093	12.434	0.0087
Chemical fibers	28	8.392	26.443	0.0019
Rubber	29	10.767	13.890	0.0009
Plastics	30	9.444	29.708	0.0008
Non-metallic mineral goods	31	7.079	16.504	0.0015
Smelting and pressing of ferrous metals	32	1.737	5.495	0.0016
Smelting and pressing of non-ferrous metals	33	2.360	8.074	0.0014
Metal products	34	7.272	10.342	0.0013
General purpose machinery	35	7.035	11.079	0.0045
Special purpose machinery	36	7.349	14.051	0.0059
Transport equipment	37	8.895	17.150	0.0053
Electrical machinery and equipment	39	6.992	16.485	0.0049
Computers and electronic equipment	40	3.520	19.349	0.0093
Measuring instruments and machinery for cultural activity and office work	41	5.591	19.927	0.0109
Artwork	42	10.030	23.493	0.0006

Notes: Column 2 reports the median 4-digit CIC (Chinese Industrial Classification) industry tariff rate (2002–2006 average) within each CIC 2-digit industry. Column 3 reports the median 4-digit CIC industry tariff reduction during 2002–2006 in percentage terms relative to its level in 2002 for each 2-digit industry. In Column 4 R&D provides the mean value of R&D intensity measures for the 4-digit CIC industries within each 2-digit industry.

Since we seek to provide precise information on the effects of imported inputs on firm export outcomes, we focus our analysis on Chinese ordinary exports.[11] Although we provide robustness checks based on processing trade outcomes to confirm the generalizability of our results for all forms of trade, our choice of sample is motivated by a number of factors. First, production decisions underpinning China's processing and ordinary exports are fundamentally distinct since processing exports, by definition, exist to facilitate the transformation of imported intermediates into exports. In contrast, Chinese firms engaged in ordinary export need to decide whether to import any of their inputs or to limit their sourcing of inputs to domestic sources. This distinction in production choices is manifested in previous research on Chinese firm trade, such as Koopman et al. (2012), Jarreau and Poncet (2012), Manova and Yu (2012), Manova and Zhang (2012b) and Wang and Yu (2012) which document stark differences in the sourcing choices associated with processing versus ordinary exports. Differences in processing trade sourcing choices may arise from factors such as the relative presence of long-term offshoring contracts, capacity constraints, and limits on input substitutability in processing operations. Indeed, the striking difference in ownership for these two trade regimes may

[7] Since firms may import consumption goods as well as intermediate inputs, we adopt Arkolakis', Demidova, Klenow and Rodriguez-Clare's (2008) and Koopman, Wang and Wei's (2012) use of UN BEC groups to identify imported intermediate inputs. The accuracy of the BEC classification is confirmed following Bas and Strauss-Kahn (2015) using information from processing trade. In particular, by definition, processing firms are engaged in the import of intermediate inputs. We document that roughly 90% of the products imported by China's processing trade firms correspond to intermediate goods as defined by BEC nomenclature.

[8] Further, to address noise or misreported data values in the manufacturing firm-level survey, the data were cleaned as in Feenstra, Li and Yu (2014).

[9] These are the firms that existed in the manufacturing survey dataset in 2006 and were established before 2002.

[10] Column 2 of Table 1 reports the average import tariffs for intermediate inputs for China's 2-digit industries while Column 3 reports the change in intermediate import tariffs over the sample period, 2002–2006.

[11] Our sample choice provides comparability with other papers in the literature including Bai, Krishna and Ma (2015) and Fan, Li and Yeaple (2015), which choose to focus on ordinary trade.

Table 2
Firm imports and firm export performance — descriptive statistics.

Panel A: export performance of importers vs. non-importers: all firms

Year	Non-importers				Importers			
	# Export products	# Export countries	# Product–country export pairs	Export value	# Export products	# Export countries	# Product–country export pairs	Export value
2002	0.34	0.46	0.86	83,576	3.91	4.37	9.89	1,125,912
2006	0.53	0.87	1.64	221,504	5.69	7.51	18.2	3,493,510

Panel B: export performance of importers vs. non-importers: exporters

Year	Non-importers				Importers			
	# Export products	# Export countries	# Product–country export pairs	Export value	# Export products	# Export countries	# Product–country export pairs	Export value
2002	2.44	3.37	6.24	606,031	4.72	5.28	11.9	1,358,989
2006	3.85	6.31	11.9	1,262,164	6.87	9.06	22.0	4,216,708

Panel C: changes in import and export outcomes (2002–2006) by 2002 trade status

Imported input tariff and RER changes in China	Non-importers in 2002				Non-exporters in 2002			
	Import entry (%)	Δ # Import products	Δ # Import countries	Δ # Product–country import pairs	Export entry (%)	Δ # Export products	Δ # Export countries	Δ # Product–country export pairs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Small tariff drop	4.42	0.18	0.09	0.24	7.44	0.30	0.52	0.95
Large tariff drop	7.02	0.30	0.15	0.37	11.9	0.57	0.76	1.50
Domestic input real depreciation	9.20	0.19	0.10	0.25	14.2	0.77	0.90	2.04
Domestic Input Real Appreciation	11.2	0.29	0.13	0.36	16.4	0.70	1.16	2.28

Notes: Imported input tariff changes measure industry-level changes in imported intermediate input tariffs. In Panel C they are defined as "small" or "large" based on the 2002 to 2006 4-digit industry input tariff change, relative to the median change. Imported input real exchange rate (RER) changes report industry-level changes between 2002 and 2006 of real exchange rates tied to industries' intermediate inputs. Across the 413 4-digit industries in the sample, roughly half of industries experienced domestic real appreciation, and hence a decrease in imported input costs.

shape the contractual and organizational differences — during our sample period, foreign-owned firms handled more than 80% of processing trade, while the vast majority of ordinary trade was handled by private firms in China. For this reason, export expansion by private firms engaged in ordinary export, who did not receive policy assistance that was comparable to that provided to SOEs or even to foreign-owned enterprises, is the basis of one of the more interesting elements in China's recent trade development. A final reason for focusing on ordinary trade was the presence of additional policy preferences extended to firms engaged in processing export in addition to the well-known import tariff exemptions (Defever and Riaño (2012)).

Summary statistics from our data set reveal a positive connection between firm intermediate input imports and firm exports.[12] If we define *importers* as firms that imported in at least one of the years between 2002 and 2006 and *non-importers* as those firms that did not import in any of those years, Table 2 Panel A shows that importers were more actively involved in export. For example, while the average non-importers served less than one unique product export–destination pair in 2002, the average product–destination export scope for importers was 9.89. The contrasting export scope for importers versus non-importers persisted through our period of analysis and was equally strong in 2006. Table 2 Panel A also reveals a stark contrast in export value: exports were much larger for importers than for non-importers. For example, in 2002 the average export value by non-importers was roughly 83 thousand dollars while the value for importers was roughly 13 times larger. In the next 4 years, while exports grew for all groups, the differential value of exports shipped by importers compared with non-importers rose faster to a multiple of 16.

Since non-importers may be more likely to direct their sales exclusively to the domestic market, the initial contrast in export outcomes is not entirely unexpected. Thus, it is important to note that the contrast between importers and non-importers remains, even if we restrict our comparison to the export outcomes for *exporters* which are defined as firms that engaged in ordinary export during at least one of our sample years. Among these exporters, Panel B in Table 2 indicates that the average product–country export scope for importers was almost twice as large as the product–country export scope for non-importers. Further, while the export value shipped by non-importers doubled in value between 2002 and 2006, the growth of exports by importers tripled. Thus, it is natural to ask whether the use of imported intermediates supported the exceptionally high level of export growth by Chinese firms.

Finally, while we note a strong correlation between firm imported intermediate use and superior export outcomes, we recognize that the correlation could reflect the joint import and export decisions of highly productive firms. Thus, as a means of evaluating whether imports may have contributed directly to firm export success we provide data on the correlation of changes in the costs of importing intermediate inputs, based on tariff and real exchange rate changes, and firm decisions to enter into import or export. To this end, Panel C of Table 2 provides information on the subset of firms that were non-importers (Columns 1–4) or non-exporters (Columns 5–8) in 2002.

Although China's entry to the WTO led to a general reduction in Chinese import tariffs on intermediate inputs, firms in some industries experienced larger reductions than did firms in other industries. Thus we can separate our sample according to the firms that experienced industry input tariff reductions that were larger or smaller in magnitude than the median input tariff reductions experienced by the 413 industries in our sample. Similarly, we also separate our sample of firms based on whether the firm's industry experienced a domestic appreciation or depreciation in real exchange rates tied to their imported intermediate inputs. We note that through the period of 2002 to 2006, around half of the 413 industries experienced domestic input real appreciation, and hence a decrease in the purchasing cost of imported inputs from foreign countries.

[12] Hereafter, unless otherwise noted, "import" refers to ordinary imports of intermediate inputs, excluding imports of consumption goods, while "export" refers to ordinary exports of all products by firms. Processing imports and exports will be discussed later separately.

Among the original non-importers, we see that firms that operated in industries with larger input tariff reductions were almost twice as likely to enter into import by 2006 as were firms that experienced smaller tariff reductions. Further, original non-importers exposed to larger input tariff reductions had stronger import activity in 2006, whether measured by import value, or counts of unique products or product–country import transactions, than did the original non-importers who experienced weaker reductions in input tariffs. For original non-exporters, Panel C of Table 2 also shows how export activity changed between 2002 and 2006 based on the changes in intermediate input import tariffs. Here the summary statistics show that the new export activity of the original non-exporters was 50% larger, whether measured by value, export products, or export product–country entry, for the firms that benefitted from the larger reductions in intermediate input import tariffs.

Turning to the impact of real exchange rates on the cost of procuring imported intermediate inputs, we observe similar patterns. Among the original non-importers, firms operating in industries that experienced domestic input real appreciation and hence a decrease in the purchasing cost of imported inputs, were more likely to enter into the import market and had stronger import activity than did firms in industries which experienced domestic input real depreciation. Among the initial non-exporters, firms in industries with domestic real appreciation were also more likely to participate in the export market and had stronger export activity on all dimensions aside from the number of exported goods than did firms in industries with domestic input real depreciation. This link is especially notable, since domestic real depreciation more generally enhances the competitiveness of China's exports. Thus, this result suggests that domestic real depreciation curtailed China's competitiveness at the industry level when the real depreciation occurred with respect to partner countries that were vital for the industry's sourcing of inputs.

In summary, the raw data clearly show that importers had greater export engagement than did non-importers. In addition, the data show that firms that were exposed to larger decreases in input import tariffs or experienced domestic input real appreciation were more likely to start importing, and were engaged at a higher level if they entered. They also show that non-exporters were more likely to enter export, and to export vigorously if they benefitted from larger input import tariff reductions or domestic input real appreciation. Since each of these correlations suggests that import activity improved firm export capability, they hint at a causal link between firm imports and firm export outcomes. To explore the causal connection more formally, we discuss the theoretical motivation for such a link and then provide our empirical assessment.

3. Theoretical motivation

Our study analyzes how exogenous changes in firm access to imported intermediate inputs affect firm export performance, noting that firm access to imported intermediate inputs may affect export performance through a number of channels. To illustrate these connections, we consider the standard profit maximization problem in which a firm evaluates the profits it may earn from its efforts in the export market, or $\max \pi_{EX} = r(q) - c(q)$. In this expression r is firm revenue, and c is firm cost, each of which is related to the firm's quantity of export, or q. The production function, $q = f(l, k, m_d, m_f)$ describes how the quantity of output produced by the firm depends on the firm's choice of labor l, capital k, and the level and diversity of the domestic and foreign inputs, m_d and m_f. The intermediate input vectors, m_d and m_f, might have a quantity of zero in equilibrium for some components. Each of the intermediate inputs is selected to maximize the firm's export profits.

When the firm selects its mix of inputs, the fixed and marginal costs for acquiring each input variety will influence the optimal input use. This is particularly important for imported inputs as to import each variety of input from each sourcing country, large fixed costs may be involved.[13] Moreover, credit constraints faced by firms may limit the amount of working capital available to firms and increase the effective costs associated with importing inputs.

If the costs of obtaining imported intermediate inputs change due to changes in import tariffs, real exchange rates or other exogenous changes to the fixed costs of importing, firms may respond by changing the set of imported intermediate inputs they utilize, or by changing their level of import for their existing imported intermediates. These cost changes may affect the use of imported inputs due to substitution between the imported inputs and domestic input varieties as the firm minimizes total production costs. Or if the firm faces binding credit constraints in obtaining working capital as in Feenstra et al. (2014), then lower import costs may relax these constraints, enabling the firm to procure more imported inputs.

Subsequently, these changes in the use of imported intermediate inputs will affect the equilibrium level of exports through at least two channels. First, the use of more and potentially higher quality imported intermediate inputs may increase the quality of output and thus increase the demand for the firm's products.[14] If so, this effect can be represented through a change in the *functional form* of the revenue term, $r(q)$. This improvement in output quality may be facilitated by the higher embedded quality in the newly imported intermediate inputs, as in Kugler and Verhoogen (2009) and Bas and Strauss-Kahn (2014), or may arise as the firm endogenously chooses to upgrade its output quality, as in Fan et al. (2015).

Second, the increase in imported intermediate inputs may affect firm output through the production function, f. The production technology may become more efficient due to increased division of labor, as in Ethier (1982) and Kasahara and Rodrigue (2008), or due to the superior quality of imported intermediate inputs relative to domestic inputs, as in Halpern et al. (2015), or a combination of the two as an overall improvement in firm's total factor productivity (Amiti and Konings (2007); Yu (2013) and Gopinath and Neiman (2013)).

To date, the existing literature has focused either on the productivity or quality contribution stemming from intermediate inputs, or has studied how input trade liberalization has fostered export. In our work we seek to connect these two strands of literature, by using exogenous changes in the relative costs of foreign inputs, such as import tariff cuts, exchange rate movements, and individual firm changes in fixed trade costs to identify the causal effect of increased access to foreign inputs on firm export performance. Further, by disaggregating our data along salient dimensions which recognize firm differences in the need for or access to technology, we seek to develop insights into the factors which influence the strength of the relationship.

4. Estimation framework

4.1. Estimating equation

We begin by presenting the empirical equation that we use to assess whether firm exports were related to the use of imported intermediate inputs. Our basic regressions relate the log of firm i's (in 4-digit CIC industry j) export value in year t, $\ln(Ex\_Value)_{ijt}$, to

[13] For example, Halpern, Koren and Szeidl's (2015) estimates based on a cross-section of Hungarian firms suggest that the mean (median) cost of importing an additional input variety was \$657 (\$443) in 1991 U.S. dollars.

[14] Koopman, Wang and Wei (2012) observe that China's processing firms involved in sophisticated sectors relied heavily on foreign intermediate imports. This suggests that imported intermediate inputs were essential for the production of more sophisticated products.

firm i's use of imported intermediate inputs, $\ln(\text{Im\_}Input)_{ijt}$, and a set of controls,[15]

$$\ln(Ex\_Value)_{ijt} = \alpha + \beta\ln(\text{Im\_}Input)_{ijt} + \gamma X_{ijt} + \sum\nolimits_t \delta_t + \varepsilon_{ijt} \tag{1}$$

Our primary interest is in estimating the effects of imported inputs on export through the coefficient β.[16] To account for the strong potential that unobserved firm-level time-invariant factors influenced each firm's decisions, our firm-period error term $\varepsilon_{ijt} = \zeta_{ij} + \eta_{ijt}$ includes firm fixed effects ζ_{ij} as well as an i.i.d. component η_{ijt}.[17] Our estimating equations also include time dummies, δ_t to control for time-varying determinants of export which affect all firms. To further characterize firm exports we include a vector of control variables, X_{ijt}. These controls allow us to account for industry-level factors, such as output export tariffs (facing Chinese firms in export destination markets) and output export real exchange rates, which are constructed as in Amiti and Konings (2007).[18] In particular, the output export tariff measure is constructed as:

$$ExDuty_{jt} = \sum\nolimits_{p=1}^{P_j^x}\sum\nolimits_{c=1}^{C_j^x}\left(\left(\frac{EX_{pcj}^{2002}}{\sum\nolimits_{p=1}^{P_j^x}\sum\nolimits_{c=1}^{C_j^x}EX_{pcj}^{2002}}\right)\tau_{pct}\right), \tag{2}$$

where EX_{pcj}^{2002} is the export value of 6-digit product p exported by firms in 4-digit CIC industry j to the country c in 2002, and P_j^X and C_j^X are the sets of exported products and destination countries, respectively, by firms who were active in the industry j in 2002. The *ad valorem* tariff imposed on product p by export destination country c in year t is τ_{pct}.[19] Similarly, the output export real exchange rate is defined as:

$$ExRER_{jt} = \sum\nolimits_{c=1}^{C_j^x}\frac{EX_{cj}^{2002}}{\sum\nolimits_{c=1}^{C_j^x}EX_{cj}^{2002}}RER_{ct}, \tag{3}$$

where RER_{ct} is the real exchange rate between China and country c in year t, expressed as units of China baskets per basket of foreign country c, obtained from Penn World Table, and EX_{cj}^{2002} is the export value shipped by firms in industry j to country c in 2002.

4.2. Instruments

To estimate the causal effect of improved imported input access on firm export performance through an instrumental variables approach (IV), we introduce measures which capture exogenous changes in the relative costs of foreign inputs. These include input import tariffs, input import real exchange rates, and fixed import costs which may emerge as the firm enters or exits from other related activities, such as processing trade. Similar to the output export tariffs and real exchange rates, the input import tariff and real exchange rate variables are created by using 2002 trade-weights. Specifically, the input import tariff and input import real exchange rate in industry j in year t are:

$$\text{ImDuty}_{jt} = \sum\nolimits_{p=1}^{P_j^M}\left(\left(\frac{IM_{pj}^{2002}}{\sum\nolimits_{p=1}^{P_j^M}IM_{pj}^{2002}}\right)\tau_{pt}\right), \tag{4}$$

$$\text{ImRER}_{jt} = \sum\nolimits_{c=1}^{C_j^M}\frac{IM_{cj}^{2002}}{\sum\nolimits_{c=1}^{C_j^M}IM_{cj}^{2002}}RER_{ct}. \tag{5}$$

Here, the time-varying 6-digit product tariffs (τ_{pt}) are levied by China on each imported input p in year t according to the tariff code, IM_{pj}^{2002} is the ordinary import value of the 6-digit product p in the set of P_j^M products imported by firms who were active in 4-digit CIC industry j in 2002,[20] and IM_{cj}^{2002} denotes the import value of inputs sourced from country c in the set of importing source countries C_j^M by firms that were active in industry j in year 2002.[21] Appendix Table 1 reports the summary statistics for the industry instruments over our 5-year sample, as well as the related industry-level measures for output export tariffs and real exchange rates.

Our use of industry weights is motivated by a number of factors. First, if the Chinese data provided information on all firm product inputs, whether of domestic or foreign origin, we could produce firm-level tariff measures as in Lileeva and Trefler (2010) based on the import tariffs for the full range of firm inputs. However, since we only have product detail for inputs purchased through firm-level imports, this is not feasible. Second, as Amiti and Konings (2007) caution, constructing firm-level tariffs based on firms that are active in the beginning year may introduce issues stemming from selection bias. Thus, the majority of our project instead relies on industry-based measures of input import tariffs and real exchange rates.[22]

As shown in Section 3, when all possible constraints are considered, in equilibrium, if the costs of obtaining imported intermediate inputs drops, whether due to falling import tariffs (falling ImDuty_{jt}) or domestic input real appreciation (falling ImRER_{jt}), firms may respond by

[15] To facilitate comparison across specifications and to support our use of a balanced panel of firm activity, our measures of imports and exports are ln(1 + Import Value) and ln(1 + Export Value). This avoids the loss of observations for firm-years where firm exports and/or imports are of zero value if ln(Export Value) and ln(Import Value) are used to measure trade activity. Other log variables are constructed similarly. Our key coefficient estimates are almost identical, whether we add 1, 0.1, or 0.01 when we construct our import and export value terms.

[16] The majority of our analysis, which focuses on the effect of firm-level ordinary imports of intermediate inputs on firm-level ordinary exports, includes industry-level instruments which are constructed based on weights tied to ordinary trade activities. However, when we present results based on Chinese firm-level processing export outcomes, the regression specification is changed by 1) replacing the independent variable with firm-level import of processing inputs, and 2) constructing industry-level instruments using weights taken from processing trade activities, rather than weights based on the ordinary trade.

[17] Since a number of our control variables are measured at the 4-digit industry level, all regressions include standard errors clustered at the industry level. Although our use of firm fixed effects in estimation controls for any time-invariant firm factors, we also experiment in our robustness checks with specifications that include time-varying firm characteristics such firm size and total factor productivity.

[18] We also experimented with the inclusion of industry-time measures of final goods tariffs in China (an import competition variable suggested by Amiti and Konings (2007)), and of China's global export supply by industry. However, since the coefficients on these variables never attain significance, and because their inclusion does not affect our variables of interest, we only display coefficients for a few of these variables in our robustness table, Table 9.

[19] Our export weights sum over the ordinary HS6 exports of all firms involved in each of the 4-digit CIC industries. This and all other tariff measures in the paper use WTO data, http://tariffdata.wto.org/ReportersAndProducts.aspx.

[20] Production techniques and the relative reliance on imported inputs differ for ordinary and processing exporters. Thus, for our dependent variables based on ordinary exports, we use firm-level ordinary imports at the 6-digit level to construct our import tariff weights. Similarly, although processing exporters do not pay tariffs on their imported inputs, in our regression specifications which pertain to processing exports we construct the hypothetical import tariff using the 6-digit processing imports as weights and China's import tariff that was applied to non-processing importers.

[21] Since the general strength of China's currency affected both import costs and export competitiveness, we examined the correlation between our 4-digit measures of industry input import exchange rate and output export exchange rate. If these measures were only driven by national trends, they would have a perfect negative correlation. However, when we regress our industry input import exchange rates on industry output export real exchange rates controlling year and 2-digit industry fixed effects, the coefficient on the output export real exchange rate is insignificant (p-value is 0.92). Thus, it appears that the differential country compositions of industry imports and industry exports, which determine the country set and country weights that are used in the formation of our exchange rate measures, are sufficiently distinct to identify both incentives for input import, and the opportunities for output export at the industry level.

[22] We also use firm-level measures of input import tariffs and real exchange rates in our robustness checks, though the use of firm-level measures limits our sample to firms that were actively engaged in import from the beginning year. Since the use of firm-level instruments does not change the estimates perceptibly, they are omitted for compactness.

expanding their utilization of imported intermediate inputs at the intensive and/or extensive margin. We thus expect to see a negative association between the two input cost variables and the use of imported intermediates.

Our instrument set also includes an indicator variable which takes a value of one if the firm was also engaged in processing import. The motivation for including this variable is the possibility that the fixed cost of ordinary import may be lower if the firm is also involved in the import of parts for its separate processing operations. Notably, since our estimating specification includes firm fixed effects, the coefficient on this variable is identified by within-firm switches in processing trade status over time rather than the time-invariant firm predisposition to be involved in export. Thus, this variable indicates how a firm's entry to or exit from processing import affected the firm's use of intermediates imports for production of goods that were exported through the distinct and separate ordinary export channels. In support of our hypothesis, that firms benefit from lower international sourcing costs for ordinary trade if they are involved in processing import, our empirical findings uniformly reveal a strong positive effect of firm processing import activity on firm ordinary import of inputs.[23] Our data suggest that these costs may have a locational component, as our later work shows that firm processing imports sourced from G7 countries have an especially strong effect on firm import of ordinary imports from G7 countries, while firm processing imports sourced from non-G7 countries have the most pronounced effect on firm ordinary imports purchased from non-G7 countries.[24]

4.3. Heterogeneity in previous trade status

Since firm investments in importing inputs may enhance a firm's capability to serve both domestic and foreign consumers, we expect that import and export decisions will be complementary. For this reason, we focus our work on firm responses by subgroups distinguished by prior trade engagement, evaluating along the way whether that firms that were not initially engaged in import or export respond differently to enhanced import opportunities than did firms that were already active in the international market.[25] The groups we identify include the set of firms which were not engaged in import or export in the start year (2002) of the sample, i.e., the initial non-traders ($I=E=0$) and the contrasting set of firms that were already active in import and export in the first year of the sample, i.e., the initial traders ($I=E=1$).[26]

5. Estimation

Our goal is to study the link between firm intermediate input imports and the expansion of firm exports. To account for the endogeneity of firm input choices, we employ an instrumental variables approach which recognizes the influence of trade liberalization, changes in real exchange rates and firm differences in import costs on firm choices of imported intermediate usage. The attention of our estimation focuses first on the simple connection between firm intermediate input imports and firm export responses for our full sample of firms, as well as for our firms when categorized by their degree of initial trade engagement. Next, to understand the factors underpinning the connection, we explore how the strength of the relationship is related to the origin of the imports, the destination of exports, firm ownership and industry characteristics such as R&D intensity.

5.1. Baseline results

Columns 1–3 of Table 3 report the estimates from our instrumental variables regressions which assess how firm ordinary exports responded to firm ordinary imports. The top and middle panels of Table 3 present the second and first stage results based on IV estimation of Eq. (1), respectively, while the bottom panel provides the results from OLS estimation. Estimates based on the full sample are provided in Column 1, while Columns 2 and 3 report estimates separately for each of the firm groups defined by the firms' initial trade engagement.

Table 3
Firm imported intermediate inputs and firm exports: IV estimates.

	Dependent variable: Ln(Ex_Value)			
	Ordinary trade			Processing trade
	All	$I=E=0$	$I=E=1$	$I=E=1$
Second Stage of IV regression	(1)	(2)	(3)	(4)
Ln(Im_Value)	1.653***	2.107***	1.220***	0.949***
	(0.152)	(0.214)	(0.092)	(0.026)
Ln(ExDuty)	0.003	0.047	0.161	−0.020
	(0.035)	(0.039)	(0.131)	(0.075)
Ln(ExRER)	0.344*	0.542**	1.227*	−0.052
	(0.194)	(0.236)	(0.654)	(0.493)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	534,858	411,695	47,453	90,698
First stage IV statistics				
KP-stat	88.648	74.914	78.742	57.296
KP *p*-value	0.000	0.000	0.000	0.000
Hanson J *p*-value	0.664	0.401	0.193	0.516
C-statistic	0.653	0.897	3.29	0.064
C-stat *p*-value	0.419	0.344	0.072	0.800
First stage of IV regression				
Ln(ImDuty)	−0.041	−0.069**	0.152	−0.143
	(0.028)	(0.029)	(0.152)	(0.149)
Ln(ImRER)	−0.306***	−0.103	−2.338***	−0.114
	(0.095)	(0.119)	(0.532)	(0.445)
Current processing-importer	1.502***	2.239***	1.270***	
	(0.082)	(0.204)	(0.077)	
Current ordinary-importer				1.843***
				(0.088)
Ln(ExDuty)	0.004	−0.014	−0.151	−0.036
	(0.021)	(0.015)	(0.099)	(0.094)
Ln(ExRER)	0.044	0.004	−0.918*	0.846
	(0.097)	(0.101)	(0.529)	(0.589)
OLS results				
Ln(Im_Value)	0.189***	0.354***	0.218***	0.670***
	(0.006)	(0.012)	(0.012)	(0.011)
Ln(ExDuty)	0.016	0.028	0.030	−0.040
	(0.028)	(0.036)	(0.099)	(0.072)
Ln(ExRER)	0.418**	0.500**	0.520	0.149
	(0.178)	(0.241)	(0.448)	0.050

Notes: Column 1 is based on the full sample. Column 2 [$I = E = 0$] is limited to the group of non-trader firms that did not export or import in the first sample year. Column 3 [$I = E = 1$] is based on the trader firms that both imported and exported in the initial sample year. Column 4, which can be considered a counterpart regression to Column 3, is based on processing exports by firms that were involved in processing import and export in the initial sample year. "Current processing-importer" ("current ordinary-importer") is a binary variable set to one for firms that were processing (ordinary) importers in the year. Clustered standard errors, based on 4-digit CIC industry codes, are reported in (). Coefficient *p*-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[23] Brandt and Morrow (2015) find that the share of product-level trade is bi-modally distributed. For each product, the majority of firms engage in either processing or ordinary trade, rather than a random mix of the two. The fact that the choice to import via processing trade activity is firmly tied to products, suggests that firm decisions to import inputs to support processing trade for some products they produce may lower their import costs more generally in support of other products that they export through ordinary trade.

[24] We also experimented with an alternative specification which used lagged values of the processing import indicator as an instrument. We omit these results for compactness, since these estimates are almost identical to those based on a contemporary processing import indicator.

[25] Lileeva and Trefler's (2010) work on firm export and R&D decisions provides a theoretical foundation for thinking about complementarity and the justification for analyzing firms according to subgroups based on initial trade status.

[26] Although our choice of firm groups does not span the full set of active firms, the firms included in our comparison groups represent 85.8% of the full sample of firms.

When we apply our estimating equation to our full sample, our IV results indicate that firm imports of intermediate inputs stimulated firm exports leading to a 1.65% increase in export value for each 1% increase in import value.[27] Next, we examine the subgroups in our data set, to determine if the strength of firm responses was influenced by the firms' previous trade experience. When we classify firms by their initial levels of trade engagement, we find that the strongest effect of imported inputs on the level of exports was observed among the firms that were in the original group of non-trader firms ($I=E=0$). In comparison, while the effect of imported intermediates on the initial trader group ($I=E=1$) is smaller than it is for the firms in the initial non-trader group, it is notable that the coefficient on the import variable is still statistically greater than one in magnitude. In other words, while the use of imports has a particularly large effect on exports when firms make the extensive margin decision to switch from domestic sourcing to global sourcing, we find that the use of the imported intermediates had a powerful impact on the exports by each of the groups of firms in our sample.

Each of our estimates involves a first stage which tests how firm use of imported inputs was related to our instruments. While this first stage is not the basis of our study, we note that our instruments perform according to our predictions. Namely, we generally find that firm-level imports were positively associated with domestic input real appreciation in China, firm engagement in processing trade, and reductions in China's industry-level import tariffs. The values of our Kleinberg–Paap Wald tests reject the null of weak instruments in Table 3, and in each of our later tables. Further, the validity of our instrument choice is confirmed by the fact that our Hansen tests do not reject our over-identifying restrictions. Finally, since our use of the processing import variable is novel, we use *a* c-test to evaluate the null that our new instrument is exogenous. As the test statistics in Table 3 show, we are not able to reject the null that the processing import variable used in the first stage is exogenous.[28]

When firms are distinguished by their initial trade engagement, our first stage results also reveal interesting differences in the factors that influence import decisions. In particular, we find that tariff changes had a notable effect on imported intermediate use by the initial non-traders ($I=E=0$), while the higher-frequency changes in the cost of importing intermediates, as measured by industry-level real exchange rates, was a more influential factor influencing the import sourcing levels of initial traders ($I=E=1$).

Our third instrument, the processing import indicator, shows strong positive effects on the import values for the full sample and for each of the subgroups. Further, we find that processing import activity has a more powerful effect on firms that started as non-traders ($I=E=0$) than on firms that were traders ($I=E=1$). This effect thus might suggest that the fixed cost of adding additional trade activities is lower for firms that already gained trade information and/or experience in other venues. Alternatively, if there are fixed costs associated with international sourcing, our finding suggests that the costs of international sourcing benefit from scope economies. Nonetheless, the fact that this variable is positive and significant, even for firms that were engaged in trade, suggests that firms benefit from economies of scope in their trade activities.

Since aggregate data reveal that the share of processing export in China's total export declined during our period of study, the inclusion of the processing import variable has a further benefit. When we observe increases in firm-level ordinary exports, we need to verify that the increase represents something other than a reclassification of ongoing trade transactions. If firms were simply switching their form of export, we would observe a coincidence between a firm's cessation of processing trade and its initiation of ordinary trade. For example, we might observe a firm exporting MP3 players in all years, but under different regimes: the firm could export those MP3 players under the processing regime in the earlier years and switch to ordinary exports in the later years. If firms were switching from processing to ordinary trade, this would automatically generate a positive correlation between the appearance or expansion of ordinary intermediate imports and the appearance or expansion of ordinary exports. However, if this mechanism were responsible for our second stage estimates, we would predict that the coefficient on the processing import variable in the first stage should be negative. In stark contrast with the clear prediction based on a switching hypothesis, our first stage results reveal strong and significant positive coefficients on the processing activity variables.

While we focus on the links between imported inputs and export outcomes, our regression estimates provide further insight into firm export decisions. First, Chinese firm exports benefit from real depreciation of the Chinese currency. For example, the full sample estimates, provided in Column 1 of Table 3, suggest that a 10% real deprecation allowed firms to expand their exports by 3.4%. In contrast, we do not uncover a statistically identified relationship between foreign tariffs on China's exports (*Exduty*) and Chinese export. However, the absence of an identified effect may be due to the fact that there was only limited variation in destination country tariffs during our period of estimation. Finally, while we do not report the values of the coefficients for the year effects, we find that the year effects grow strongly over the period of estimation, in line with the general expansion of Chinese exports during the 2000s.

While our results suggest that firms expanded their exports, in part as a consequence of the new opportunities provided by the use of imported intermediate inputs, our primary sample is focused on ordinary exports. Thus, it is important to ask whether our findings apply to processing trade decisions as well. To evaluate this question, we apply our main estimating equation to firm-level data on imported processing inputs and processing exports. Further, since processing trade differs from ordinary trade, we generate tariffs and exchange rate measures for this exercise which are tied to the sourcing patterns for imported inputs and the export destinations targeted by firms involved in processing export. Last, to mirror our earlier specification, and to allow for the possibility that import sourcing for one mode of trade may reduce the costs of import sourcing for other types of trade, we include an ordinary trade indicator variable in the first stage.

Column 4 of Table 3 shows the results for processing firms who were traders in the original year. Similar to ordinary trade, our results show that imported inputs facilitated processing exports. Though the effect is smaller in magnitude than the one observed for ordinary trade, the coefficients retain strong statistical significance. In the processing trade regressions the coefficient on imported intermediate inputs is statistically indistinguishable from one in value, which suggests that production in processing zones may be characterized by an inflexible Leontief production process. For example, each computer assembled in a processing zone involves the import of a foreign processor chip. Lastly, it is important to note that our evaluation of processing trade enables us to validate our assumption about the effects of tariffs on sourcing choices. In particular, since processing trade is exempt from

[27] Though the coefficients from OLS estimation reveal a positive correlation between firm imports and firm exports, we report OLS coefficients in Table 3 for informational purposes only due to the inherent endogeneity of firm sourcing decisions, which we statistically confirm. We suspect that attenuation bias due to measurement error contributes to the downward bias in the OLS estimates. In particular, although we would like to test how firm import use contributes to firm export, the fact that many firms use a number of different imported inputs, precludes the creation of a firm-level import quantity measure. Thus, if aggregate demand for imported inputs rises, due to cost, demand or other shocks, the observed increase in the value of imported intermediates may be tied to increases in price as well as increases in quantity. As a result, if import value increases overstate the actual increase in the use of imported inputs quantity, the resulting OLS coefficients will be biased downward.

[28] To further test our processing import instrument, we experimented with omitting the processing import variable from the 1st stage, or moving the processing import variable to the 2nd stage of our specification. In either of these alternative specifications, the coefficients on our imported intermediate input variable remain highly significant, though the coefficients are slightly smaller in magnitude. We do not discuss our test diagnostics in our later tables, since they all are similar to Table 3 in their confirmation of the validity and strength of our instrument choices.

Table 4
Alternative imported intermediate input measures and firm exports: IV estimates.

Second stage of IV regression	Dependent variable: Ln(Ex_Value)			
	(1)	(2)	(3)	(4)
	Non-trader	Non-trader	Trader	Trader
	(I = E = 0)	(I = E = 0)	(I = E = 1)	(I = E = 1)
Current importer	21.014***		13.677***	
	(1.518)		(0.941)	
# Im_prod_cty		2.616***		0.400***
		(0.478)		(0.058)
Ln(ExDuty)	0.033	0.050	0.309**	0.260
	(0.045)	(0.068)	(0.149)	(0.240)
Ln(ExRER)	0.621**	0.643*	0.957	2.377**
	(0.266)	(0.343)	(0.769)	(1.096)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	305,605	305,605	47,453	47,453
First stage IV statistics				
KP-stat	56.907	45.888	78.659	44.552
KP *p*-value	0.000	0.000	0.000	0.000
Hanson J *p*-value	0.373	0.256	0.624	0.267
First stage of IV regression				
Ln(ImDuty)	−0.008**	−0.034	0.018	0.439
	(0.003)	(0.035)	(0.022)	(0.737)
Ln(ImRER)	−0.016	−0.249*	−0.184***	−7.971***
	(0.014)	(0.130)	(0.059)	(2.103)
Current processing-importer	0.233***	1.869***	0.115***	3.806***
	(0.015)	(0.317)	(0.008)	(0.539)
Ln(ExRER)	0.005	0.007	−0.025**	−0.711
	(0.011)	(0.110)	(0.010)	(0.552)
Ln(ExDuty)	−0.001	−0.014	−0.063	−5.706**
	(0.002)	(0.024)	(0.053)	(2.719)
OLS results				
Current importer	3.800***		1.914***	
	(0.115)		(0.123)	
# Im_prod_cty		0.130***		0.019***
		(0.018)		(0.001)
Ln(ExRER)	0.651**	0.659**	0.047	0.016
	(0.288)	(0.305)	(0.102)	(0.102)
Ln(ExDuty)	0.032	0.030	0.474	0.478
	(0.045)	(0.047)	(0.456)	(0.468)

Notes: Imported intermediate inputs are measured by: a) current importer (1 if firm imported inputs in year *t* and zero otherwise), and b) # Im_prod_cty (the number of product and country combinations imported by the firm). Non-traders (I = E = 0) refers to the firms that were not involved in import or export at the start of the sample, while trader (I = E = 1) refers to the firms that were both exporting and importing at the beginning of the sample period. "Current processing-importer" is a binary variable set to one for firms that were processing importers in the year. Clustered standard errors, based on 4-digit CIC industry codes, are reported in (). Coefficient *p*-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

tariffs, we expect that firms will not increase their processing imports as China's import duties declined. Our first stage estimates confirm this expectation.

5.2. Import status, input diversity and export

To check whether the association between intermediate input imports and exports is sensitive to our measure of imports, we experimented with alternative import measures in Table 4.

First, to determine whether the extensive margin decision to import is positively associated with export outcomes, we measured import activity via an indicator variable for current import status, *Current Importer*[29] As the results in Columns 1 or 3 demonstrate, import activity has a positive and highly significant effect on firm exports whether the firm started as a trader or non-trader. Next, since import diversity may facilitate firm export, if the use of a wide range of input varieties elevates firm productivity or improves product quality, we tested in Columns 2 and 4 how import variety, measured by the count of country–product pairs, affected export outcomes.[30] Comparison of the results based on the non-traders with the results from the trader firms reveals qualitatively similar results, though the coefficients on firm import status or firm input variety are somewhat smaller for this group of firms. Thus it appears that improved access to imported inputs may have paid off, in part, due to the importance of inputs for firm entry to export.

5.3. Import status, input diversity and export scope

By dividing our sample into subgroups based on firms' import and export engagement at the beginning of the sample period, we have found evidence that increases in imports are especially helpful in increasing exports by firms that were previously non-traders (I = E = 0). However, since we also find that imports were associated with export expansion by traders (I = E = 1), we now examine whether the effects appear to be related solely to intensive margin increases in goods export, or whether there is evidence that the use of imported inputs led to an expansion in export varieties.

Our results, which are displayed in Table 5, demonstrate two features related to export scope. First, initial non-trader firms that chose to enter into import, and initial trader firms that avoided the cessation of import, expanded their range of export products, as measured by the number of distinct 6-digit products exported by the firms. Further, when firms increased the number of import varieties they imported as measured by the count of unique items at the country–product level, this too was found to contribute to increases in export variety. While both of these effects were strongest for the group of firms that started out as non-traders, the fact that we also observe this effect among firms that started as traders, demonstrates that this connection is not driven solely by firm extensive margin changes from non-trader to trader status.

5.4. Firm ownership and the effect of imported inputs on exports

While our initial results reveal a strong connection between firm imported intermediate inputs and firm export outcomes, our general results may obscure how organizational form influenced the sensitivity of firm exports to firm imported inputs. Thus, the next set of regressions divides the data into four ownership groups: 1) private (PRI), 2) Hong Kong, Macao or Taiwan (HMT) owned, 3) state-owned enterprise (SOE), and 4) foreign-owned enterprises (FIE). The formation of these ownership indicators allows us to create interaction terms to assess how the benefits of imported intermediate use differed by ownership. As before, based on the firms' initial trade activities we compare the firms that were initial non-traders (I = E = 0) with firms that were initial traders (I = E = 1). We continue to use our base specification which tests how import use contributes to export values, as well as our scope specification which tests how firm-level increases in product–country import variety affected firm export scope. In line with our original specifications, our estimates measure the causal effect of expanded imported intermediate use across firms distinguished by their form of ownership.

The most noticeable difference in our coefficient estimates is the relative strength of effect of imported intermediates on the export

[29] Identification of the "Current Importer" variable differs for the non-trader versus trader firms. Among non-trading firms, the effect of "Current Importer" status on export levels is identified through firms which switched from non-import to import. In contrast, the effect of "Current Importer" status among trader firms is identified by the changes in exports by firms that ceased to import, as compared with those that continued to import.

[30] We worked with three measures of import variety: 1) the number of distinct HS 6-digit products imported by the firm, 2) the count of countries the firm sourced from, and 3) the diversity of unique country-products imports of the firm. Universally, we find that increases in imported input variety were associated with increases in firm exports. For compactness of the paper, we only report the results based on country-product counts.

Table 5
Imported intermediate inputs and export variety: IV estimates.

	Dependent variable: #Ex_prod			
	Non-traders (I = E = 0)		Traders (I = E = 1)	
	(1)	(2)	(3)	(4)
Second stage of IV regression				
Current importer	12.652***		16.739***	
	(2.089)		(1.871)	
# Im_prod_cty		1.552***		0.494***
		(0.400)		(0.091)
Ln(ExDuty)	0.013	0.017	0.583*	0.526**
	(0.021)	(0.030)	(0.205)	(0.261)
Ln(ExRER)	−0.015	−0.004	1.889***	3.647***
	(0.176)	(0.204)	(1.221)	(1.391)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	411,695	411,695	47,453	47,453
First stage IV statistics				
KP-stat	55.972	43.684	78.659	44.552
KP *p*-value	0.000	0.000	0.000	0.000
Hanson J *p*-value	0.199	0.163	0.599	0.629

Notes: The dependent variable, #Ex_prod is the count of distinct HS6 products exported by the firm. The imported intermediate input measures are: a) current importer (1 if firm imported inputs in year *t* and zero otherwise) and b) # Im_prod_cty (the number of product and country combinations imported by the firm). Non-traders (I = E = 0) refers to the firms that were not involved in import or export at the start of the sample, while traders (I = E = 1) refers to the firms that were both exporting and importing at the beginning of the sample period. Clustered standard errors, based on 4-digit CIC industry codes, are reported in (). Coefficient *p*-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6
Imported intermediate inputs and firm exports: impacts by firm ownership and initial trade activity, IV Estimates.

	Non-Traders (I = E = 0)		Traders (I = E = 1)	
Dependent variable	Ln(Ex_Val)	#ExpProd	Ln(Ex_Val)	#ExpProd
	(1)	(2)	(3)	(4)
Firm ownership interaction terms				
[Import measure (IM)]	Ln(Im_Value)	#Im_prod_cty	ln(Im_Value)	#Im_prod_cty
Private * IM	2.510***	3.017***	1.486***	1.036***
	(0.315)	(0.756)	(0.270)	(0.287)
HMT * IM	1.760***	1.780***	1.089***	0.431***
	(0.273)	(0.684)	(0.180)	(0.114)
SOE * IM	1.873***	1.313***	1.382***	0.777***
	(0.183)	(0.368)	(0.158)	(0.196)
FIE * IM	2.075***	0.814***	1.148***	0.367***
	(0.311)	(0.307)	(0.123)	(0.077)
Ln(ExDuty)	0.041	0.020	0.114	0.448*
	(0.038)	(0.028)	(0.133)	(0.251)
Ln(ExRER)	0.523**	−0.029	1.009	3.031**
	(0.235)	(0.211)	(0.673)	(1.314)
N	411,695	411,695	47,453	47,453
Year FE	Yes	Yes	Yes	Yes
Firm ownership trend	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
First stage IV statistics				
KP-stat	35.383	16.539	23.752	41.610
KP *p*-value	0.000	0.001	0.000	0.000
Hanson J *p*-value	0.496	0.207	0.210	0.601

Notes: The dependent variables are firm export value ln(Ex_Val) and the count of distinct HS6 products exported by the firm, #Ex_prod. The imported intermediate input measures are: a) ln(Im_Value), the log value of firm imported intermediates, and b) # Im_prod_cty (the number of product and country combinations imported by the firm). Non-traders (I = E = 0) refers to the firms that were not involved in import or export at the start of the sample, while traders (I = E = 1) refers to the firms that were both exporting and importing at the beginning of the sample period. Clustered standard errors, based on 4-digit CIC industry codes, are reported in (). Coefficient *p*-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

outcomes for private firms. In each of the four specifications in Table 6, the response observed for private firm exports is at least 20% larger in magnitude than the responses observed for any other group. The premium effect is particularly large in our regressions reporting how increased import variety contributed to increases in export variety in Columns 2 and 4, as the benefit accruing to private firm was roughly 3 times or greater the effect for foreign-owned firms. Thus, it appears that private firm export expansion was intimately tied to increased access to a wider array of imported inputs. As with our earlier analyses, we confirm that the benefits of expanded imported inputs were larger for the firms that were non-traders at the beginning of the estimation period, as compared with the firms that were already active in both import and export.

5.5. Industry R&D intensity, import source and firm export responses

While our panel regressions strongly confirm that increasing firm intermediate imports boosted firm exports, and reveal that the effects are especially strong for private Chinese firms, it is natural to ask whether specific mechanisms are responsible for this connection. One pathway that seems particularly worthy of exploration is the possibility that embedded technology or quality transmitted via imported intermediate inputs supported firm export expansions.[31] Since imported inputs are likely to differ in terms of their embedded technology or quality level, inputs with a higher technology or quality level will provide a greater contribution to productivity or to the quality upgrading of outputs, and thus may contribute more to export expansion.

Since Chinese trade data do not provide direct information on the technological sophistication or quality level embedded in individual firm's intermediate imports, we draw inferences based on source country income.[32] Thus, we test whether inputs imported from higher-income countries were particularly helpful in supporting firm export performance by introducing separate import measures in our main specification, Eq. (1), which enable us to observe how the benefits of inputs sourced from higher-income G7 countries compared with the benefits of intermediate inputs sourced from non-G7 countries. Further, in contrast with our previous regressions which presented results based on aggregate firm export outcomes, we now classify our firms' exports according to destination, G7 and non-G7, under the hypothesis that firms may have a more difficult challenge in meeting the quality levels that are required of firms exporting to high-income G7 destinations. As a result, in Table 7 we have two annual export observations for each firm, based on each firm's exports to G7 and non-G7 destinations.

Among the firms that begin as non-traders (I = E = 0), we find that imports from non-G7 locations facilitated exports to the G7 and non-G7 alike, although the use of non-G7 inputs had a stronger effect on exports destined for non-G7 destinations. In contrast, for the same group of firms, we identify a positive effect of G7-sourced inputs on G7-destined exports, but no effect of G7 imported inputs on non-G7 firm exports. In other words, intermediate inputs sourced from the higher-cost and higher-income countries appear to provide a stronger increase in firm ability to access the presumably more-demanding G7 export markets.

Examination of the initial traders (I = E = 1) reveals that the import–export connection related to the use of non-G7 imports was positive and significant, though weaker than it was for the non-trader subsample. This suggests that non-G7 imports assist firm in entering export markets, but are less useful for facilitating export expansion, possibly since they are less beneficial in any product upgrading efforts. In contrast, when we examine the effects of developed (G7) country

[31] Keller and Yeaple's (2013) analysis of multinational import and sales decisions supports the view that imported intermediate inputs provide a mechanism for the conveyance of embodied technology.
[32] Bas and Strauss-Kahn's (2015) examination of product-level price data suggests that the import of higher quality inputs facilitates the export of higher quality (higher unit export value) exports, and the imported input quality upgrading is especially strong for imports sourced from developed countries.

Table 7
Imported intermediate inputs and firm exports: effects by import source, IV estimates.

Second stage of IV regression	Non-traders (I = E = 0)		Traders (I = E = 1)	
Dependent variable	Ln(G7 Ex_Value)	Ln (nonG7 Ex_Value)	Ln(G7 Ex_Value)	Ln (nonG7 Ex_Value)
	(1)	(2)	(3)	(4)
Ln(G7 Im_Value)	0.456*	−0.449	0.707***	0.425***
	(0.261)	(0.300)	(0.100)	(0.087)
Ln(nonG7 Im_Value)	1.647***	2.411***	0.422***	0.549***
	(0.304)	(0.397)	(0.091)	(0.102)
Ln(ExDuty)	0.039	−0.002	−0.071	0.100
	(0.030)	(0.038)	(0.131)	(0.115)
Ln(ExRER)	0.252	0.447**	1.533**	−0.072
	(0.199)	(0.215)	(0.649)	(0.612)
N	411,695	411,695	47,453	47,453
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
First stage IV statistics				
KP-stat	31.438	31.438	58.686	58.686
KP *p*-value	0.000	0.000	0.000	0.000
Hanson J *p*-value	0.480	0.594	0.511	0.945
First stage of IV regression	First stage results for Columns 1 and 2		First stage results for Columns 3 and 4	
Set 1: dependent variable	Ln(G7 Im_Value)		Ln(G7 Im_Value)	
Ln(ImDuty)	−0.046**		0.141	
	(0.023)		(0.143)	
Ln(ImRER)	−0.066		−2.386***	
	(0.093)		(0.487)	
curr_processing G7importer	0.985***		1.117***	
	(0.095)		(0.077)	
curr_processing nonG7importer	0.731***		0.381***	
	(0.109)		(0.075)	
Ln(ExRER)	−0.043		−0.521	
	(0.077)		(0.508)	
Ln(ExDuty)	−0.013		−0.012	
	(0.013)		(0.101)	
Set 2: dependent variable	Ln (nonG7 Im_Value)		Ln (nonG7 Im_Value)	
Ln(ImDuty)	−0.032		0.057	
	(0.021)		(0.147)	
Ln(ImRER)	−0.086		−1.737***	
	(0.085)		(0.527)	
curr_processing G7importer	0.512***		0.368***	
	(0.081)		(0.076)	
curr_processing nonG7importer	1.213***		1.176***	
	(0.144)		(0.079)	
Ln(ExRER)	0.017		−0.685	
	(0.077)		(0.543)	
Ln(ExDuty)	−0.003		−0.088	
	(0.013)		(0.104)	

Notes: The dependent variables are firm G7 and non-G7 export value, ln(G7 Ex_Value) and ln(nonG7 Ex_Value). Firm G7 and non-G7 imported intermediate input measures are ln(G7 Im_Value) and ln(nonG7 Im_Value). Non-traders (I = E = 0) refers to the firms that were not involved in import or export at the start of the sample, while traders (I = E = 1) refers to the firms that were both exporting and importing at the beginning of the sample period. Clustered standard errors, based on 4-digit CIC industry codes, are reported in (). Coefficient *p*-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

imported intermediates on the group of trader firms, we find the effect is now positive for all export destinations, and stronger in value than it was in the regressions representing initial non-trader firms. Again, this suggests that developed country imports underpin export expansion, presumably by enabling firms to export products of better quality, or by enabling firms to export a wider range of products.

Each of our estimating equations in Table 7 involves two first stage regressions, associated with the two independent variables: imported intermediates from G7 countries and imported intermediates from non-G7 countries. While our specification of these first stage regressions is almost identical to our original specifications, the new specification requires a change in our treatment of the processing import indicator. In particular, if the benefits of trade experience are location specific, or if the costs of sourcing have a location-specific component, we expect that processing imports from non-G7 (G7) locations will have a stronger effect in lowering the cost of engaging in ordinary import from non-G7 (G7) locations. Thus, we generated two indicator variables denoting whether the firm had processing imports sourced from G7 and from non-G7 locations, respectively. In line with this prediction, our first stage results are strongly suggestive of such a location based component. In particular, while we find that processing import status of any form had a positive effect on firm ordinary import, consistent with our hypothesis we find that processing import from G7 countries had a larger effect on ordinary imports from G7 countries while non-G7 processing imports exerted a stronger effect on non-G7 ordinary intermediate imports.

The differential benefits of G7 versus non-G7 intermediate imports could be tied to technology differences. Namely, if imported intermediates sourced from the richer countries of the G7 are better conveyors of quality, technology or design features that facilitate product development and product improvement, then the effect of imported intermediates from developed countries will provide strongest export expansion to firms that operate in the sectors which derive the greatest benefit from the import of high-income country inputs. As a result, if technology is a key factor in the differential, we can test whether use of sophisticated G7 imported inputs delivered a greater boost to exports in sectors that were most influenced by technology. Of the measureable industry characteristics in our data set, industry R&D intensity is a prime candidate for representing the degree to which the embedded technology or quality contained in imported inputs affected the strength of this connection. In other words, if firms in R&D-intensive industries are more reliant on the embedded technology or quality contained in imported inputs, imported inputs may be especially important in facilitating export expansion in industries which involve higher levels of R&D, and this effect should be most pronounced when firms export to more challenging high-income export destinations.

To determine whether sectoral R&D intensity differences affect the import–export connection, we add interactions between firm imported intermediate inputs by source country development levels and measures of industry R&D intensity to our estimation specification.[33] Our interaction terms are based on industrial R&D intensity, as measured by industry R&D expense as a fraction of industry sales (*R&D*).[34] As in our previous tests, we continue to analyze G7 and non-G7 firm export outcomes separately. Our results in Table 8 Column 1 show that the benefit of using G7-source inputs in R&D-intense industries was especially strong for the case of G7 exports Column 1. Moreover, non-G7 imported inputs were less valuable in promoting G7 exports than they were in promoting exports to lower-income non-G7 destinations, and the reduced benefit of non-G7 inputs, was especially noticeable in the case of high R&D industry exports to G7 destination countries. Thus, while we do not have direct evidence on the mechanisms that drive our results, these differential effects provide strong support for our conjecture that imported inputs are especially valuable in conveying technology, design or quality features that support export to high-income destinations, and that the payoff to this use of imports is especially high in R&D-intensive industries.

Finally, to gain further insight into the potential mechanisms related to the transmission of technology or quality, we experimented with additional cuts of our data, which we report in the lower panels of Table 8. First, we repeated the analysis on the subset of firms that were privately

[33] It is not possible to add time-varying firm R&D intensity measures as regressors, since the manufacturing survey did not collect information on this item until 2004.

[34] Because the distribution of R&D intensity across industries in China is highly skewed (see Appendix Fig. 1), our high R&D intensity indicator variable is set to one for all firms in industries that were at the 90th percentile and above. Though we also estimated our results through the use of a second industry R&D indicator that was set to one for all firms that operated in industries that were at or above the 75th percentile in terms of industry R&D intensity, we do not report the results since the conclusions were unchanged by our choice of industry R&D measure.

Table 8
The effects of imported intermediate inputs — impacts by import source and industry R&D intensity — IV estimates, results by subsample.

Second stage of IV regression — imported intermediate coefficients		
Dependent variable	Ln(G7 Ex_Value)	Ln (nonG7 Ex_Value)
	(1)	(2)
Full sample		
Ln(G7 Im_Value)	0.756***	0.119
	(0.131)	(0.096)
* High R&D	0.203***	0.109
	(0.075)	(0.085)
Ln(nonG7 Im_Value)	0.656***	1.165***
	(0.118)	(0.185)
* High R&D	−0.235***	−0.131
	(0.084)	(0.096)
Subsample A: private firms		
Ln(G7 Im_Value)	1.303***	0.420
	(0.304)	(0.296)
* High R&D	−0.067	0.432
	(0.426)	(0.556)
Ln(nonG7 Im_Value)	0.915***	1.643***
	(0.327)	(0.392)
* High R&D	0.034	−0.353
	(0.418)	(0.534)
Subsample B: initial traders ($I = E = 1$)		
Ln(G7 Im_Value)	0.703***	0.455***
	(0.094)	(0.082)
* High R&D	0.177***	0.007
	(0.062)	(0.065)
Ln(nonG7 Im_Value)	0.389***	0.560***
	(0.079)	(0.089)
* High R&D	−0.181***	−0.018
	(0.067)	(0.070)
Subsample C: initial non-traders ($I = E = 0$)		
Ln(G7 Im_Value)	0.878***	−0.453*
	(0.293)	(0.267)
* High R&D	0.079	0.502
	(0.274)	(0.379)
Ln(nonG7 Im_Value)	1.156***	2.308***
	(0.257)	(0.370)
* High R&D	−0.419	−0.685
	(0.292)	(0.442)

Notes: The dependent variables are firm G7 and non-G7 export value, ln(G7 Ex_Value) and ln(nonG7 Ex_Value). Firm G7 and non-G7 imported intermediate input measures are (G7 Im_Value) and ln(nonG7 Im_Value) The high R&D indicator is set based on the 90th percentile of the R&D distribution: the high R&D indicator variable is set to one for all industries whose firms were in the top 90% of R&D intensity as measured by R&D expenditures relative to sales. Non-traders ($I = E = 0$) refers to the firms that were not involved in import or export at the start of the sample, while traders ($I = E = 1$) refers to the firms that were both exporting and importing at the beginning of the sample period. Clustered standard errors, based on 4-digit CIC industry codes, are reported in ( ). Coefficient p-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

owned. In this group of firms, we find that the benefit of G7 source inputs had a more powerful effect on private firms' exports to G7 countries than did non-G7 imported intermediate. In contrast, when private firms exported to non-G7 locations, only non-G7 imports had a statistically significant positive and strong relationship. Since the coefficient magnitudes for private firms were larger than they were for the full sample, the estimates suggest that technology transfer was particularly important for China's private firms which were younger and smaller on average, and therefore, less likely to have extensive technological resources. In the bottom two subsamples of Table 8, we search for differential effects depending on the firms' initial trade status. Here we find differences linked to trader status that are reminiscent of our findings in Table 7: high-income G7 intermediate imports were especially helpful in facilitating exports to the G7 by non-traders, or globally by the trader group. Further, we find that the additional benefit of high-income intermediate inputs in high R&D-intensive industries is most evident in the case of exports to G7 countries by initial trader firms. Thus, it appears that imports contributed to ongoing firm export growth by existing traders who were upgrading their products for export to high-income destinations.

6. Robustness checks

To confirm the stability of our results, we ran a number of robustness checks that investigate the robustness of our results to changes in our estimating specification, controls for other sources of shocks, use of alternative instruments for our IV strategy, or re-estimation of our framework for informative subgroups of our data sample. Each of these experiments is discussed in turn.

6.1. Alternative specifications

6.1.1. Evolving firm or industry capability

The correlation between imported intermediate inputs and exports could be endogenously determined if firm capability or productivity evolves over time. If so, year-to-year changes in firm productivity would influence firm export opportunities over time, which could explain the tandem movement of firm imports and exports. For this reason, we re-estimate the baseline specification from Table 3, with the inclusion of time-varying firm TFP.[35] Since our new results, which are displayed in Alternative 1 of Table 9 do not lead to revised coefficients for our imported intermediate input variables, we conclude that the connection between firm-level imports and exports is not driven by time-variation in firm productivity.[36]

6.1.2. Alternative tariff instruments

In our core analysis, we use 2002 industry import patterns to determine the weights we use to form our tariff instruments. To check whether our choice of the base year influences our results, we also estimated our main specification using 2006 weights to generate new industry tariff measures. Notably, our estimated coefficients for imported intermediates, Alternative 2 in Table 9, are virtually identical to our original estimates.

6.1.3. Processing export

Exporters in China have the decision whether to engage in ordinary export, and/or to set up facilities that support processing export. Since processing exporters are able to avoid all import tariffs, it is clear that China's tariff liberalization had an effect on the relative attractiveness of ordinary versus processing trade, as is discussed and analyzed in Brandt and Morrow (2015). Due to the reduced attractions of organizing through the processing regime, it is crucial that we confirm that our estimation results are tied to the expansion of ordinary export rather than the simple reclassification of existing processing trade flows to ordinary export.

To rule out responses related to the reclassification of ongoing processing trade transactions, we work with a number of informative subsamples that allow us to consider the firm organization question directly. First, we estimated our basic equation using the sample of firms that were not involved in processing trade in year 2002. Since this subsample of firms had no processing trade, we can verify that the strong connection between intermediate input import and export, reported in Alternative 3 of Table 9, is not a figment of trade reclassification.

Second, we focus on specific industry groups to rule out the possibility that our observations were driven by the closure of processing firms, who were supplanted by other firms who did the exact same activities under the ordinary designation. To this end, Alternative 4 in Table 9 re-estimates our relationship for the subgroups of firms that

35 To implement this test, we use the time-varying firm-level Olley–Pakes TFP measures which were used in the analysis of Feenstra, Li and Yu (2014).

36 The robustness of our coefficient on imported intermediate inputs is also maintained if we use other measures related to firm productivity such as firm sales or current output, alone, or in combination with employment.

Table 9
Robustness checks — key second stage coefficients.

Dependent variable	ln(Ex_Value)	
	Non-traders (I = E = 0)	Traders (I = E = 1)
Second stage IV results	(1)	(2)
	Alternative 1: addition of firm TFP	
ln(Im_Value)	2.122***	1.249***
	(9.58)	(12.05)
ln(TFP)	−0.008	−0.078*
	(−.083)	(−1.68)
	Alternative 2: tariff and RER measures based on 2006 import weights	
ln(Im_Value)	2.105***	1.215***
	(10.03)	(13.54)
	Alternative 3: firm subsample excluding firms involved in processing export in 2002	
ln(Im_Value)	2.147***	1.108***
	(9.56)	(8.60)
	Alternative 4: industry subsample [ordinary exports > 50% of industry exports]	
ln(Im_Value)	2.029***	1.386***
	(9.57)	(7.61)
	Alternative 5: private firms in industry subsample [ordinary exports > 50% of industry]	
ln(Im_Value)	2.655***	1.679**
	(6.30)	(2.13)
	Alternative 6: additional control for export demand shocks	
ln(Im_Value)	2.107***	1.220***
	(9.83)	(13.21)
ln(Industry Export_4-Digit)	0.00701	−0.0147
	(0.27)	(−0.28)
	Alternative 7: additional control for export demand shocks — excluding largest 10% of exporters	
ln(Im_Value)	2.163***	1.230***
	(9.13)	(10.96)
ln(Industry Export_4-Digit)	0.0158	0.0493
	(0.58)	(0.70)
	Alternative 8: additional control for import competition	
ln(Im_Value)	2.107***	1.221***
	(9.90)	(13.14)
ln(Import Competition)	0.0794	−0.0668
	(1.42)	(−0.49)
	Alternative 9: subsample excluding firms involved in multi-sector export	
ln(Im_Value)	2.119***	1.234***
	(10.03)	(12.91)

Note: Each regression follows the standard format from Table 3, with the specification changes or subset restrictions noted in each Alternative description. Total industry export demand is measured by ln(4-digit Industry Export). Import competition measures the effects of trade liberalization on import competition by reporting the change in China's product import tariffs, weighted by the importance of each product in an industry's exports. Clustered standard errors, based on 4-digit CIC industry codes, are reported in ( ). Coefficient p-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

were active in industries that were the most heavily involved in ordinary trade, even at the beginning of the estimation period. Whether we use the reported criteria, in which 50% or more of industry exports were exported via ordinary export, or the more stringent restriction to industries in which 75% or more of industry exports were exported via ordinary export, the estimated benefit of imported inputs is robust, and if anything, slightly stronger than the benchmark values.

Finally, since private firms were most active in ordinary export, we repeated our analysis on private firms, to avoid inferences that are driven by changes in sample ownership composition across groups classified by trade regime. The responses of private firms, as reported in Alternative 5 of Table 9 yield estimated coefficients that are stronger than they were for the full sample equivalents. When combined with the fact that the vast majority of processing trade is conducted by foreign firms, this indicates that our observed connection between imported intermediates and exports does not appear to be driven by reclassification of trade flows from the processing to the ordinary trade regime.

6.1.4. Industry-level demand shocks

If firms respond to new export demand by increasing their imports and exports as they served the growing export market, time-varying shocks to export demand could explain our results. Although we do not believe our instruments are correlated with export demand shocks, Alternative 6 in Table 9 explicitly examines the effect of export demand shocks by adding a direct measure for industry-level export demand to the estimating specification. For this purpose we use aggregate contemporaneous exports by firms in the same industry as our measure of time-varying industry export demand. Notably, the estimated effect of imported inputs is virtually unchanged. Next, we repeat the test while excluding firms that had market shares among the top 10% of all Chinese firms engaged in export.[37] However, as Alternative 7 in Table 9 shows, the inclusion of industry export demand shocks, even in this revised sample, has no effect on key coefficients.

6.1.5. Trade liberalization and import competition

China's trade liberalization may have spurred inflows of competing imports that were similar to the goods produced in China. In turn, if increased import competition forced Chinese firms to increase their productivity to survive, this enhanced productivity may have also enabled Chinese firms to enter new export markets or expand their export participation.[38] To control for import competition effects tied to China's trade liberalization, we follow Amiti and Konings (2007) in creating a variable *Import Competition* which measures the import tariffs which applied to the products produced by Chinese firms in each industry. Effectively, we replace IM_{pj} in Eq. (4) with the export value of each product p exported by industry j. However, as Alternative 8 in Table 9 shows, in contrast with the strong effects observed by Amiti and Konings (2007) in the case of Indonesian firms, the *Import Competition* variable fails to attain significance in our estimates pertaining to Chinese firms. We speculate that the weak performance of the *Import Competition* variable may be due to the fact that Chinese firms had strong comparative advantage in many of their export goods, and were therefore not confronted by noticeable competitive effects in Chinese consumer markets when China's final goods tariffs declined.

6.1.6. Single sector exporters

In our main estimating specification, we link firm import value to firm export value, although presumably not all inputs are used in the production of every output, and the reliance of each output on imported inputs is likely to differ in proportion. Thus, when exporters are active in multiple sectors, the results are potentially shaped by very different responses related to firm-level product mix. To investigate whether output mix biases our estimates through measurement error, we re-estimated our key specification for the subgroup of firms that limited their exports to a single sector. By excluding firms engaged in multiple sector export, we reduce measurement error arising from firm shifts in output mix across sectors which differentially relied on imported inputs. For this exercise, we started by classifying export products as

[37] Among exporting firms, the median export share was 0.15%, while the average export share was 1.1%. We focus on the top 10% among all firms rather than the top 10% within each industry, since we are concerned with the potential sensitivity of our results to the decisions of the largest exporters, but not to the decisions of larger firms in industries that were populated by numerous small exporters.

[38] For related arguments, see Amiti and Konings (2007), Khandelwal and Topalova (2011) and Yu (2013).

belonging to one of twenty sectors.[39] We then estimated our coefficients using the subgroup of firms that limited their exports to a single sector. As the results in Alternative 9 of Table 9 show the results are very similar to our original baseline, which confirms that our key result is not driven by the presence of multi-sector exporters or by shifts in export composition.

6.2. Changes specification

While our data panel is based on annual observations, it is possible that firms require more than a year to realize the full benefits arising from their import of intermediate inputs. Thus we use the following changes specification to perform IV estimation:

$$\Delta\ln(\mathit{ExportValue})_{ij} = \alpha + \beta\Delta\ln(\mathrm{Im\_}\mathit{Inputs})_{ij} + \gamma\Delta X_{ij} + \sum\nolimits_j \lambda^j{}_j + \kappa_{ij} \quad (5)$$

The dependent variable, $\Delta\ln(\mathit{ExportValue})_{ij}$, is the log change in export value for 2006 compared with 2002 for firm i in industry j. The independent variable, $\Delta\ln(\mathrm{Im\_}\mathit{Inputs})_{ij}$, is defined similarly as the change in each firm i's log level of imported intermediate input value for 2006 compared with the log value of its imports in 2002. To implement the changes specification, we also generated changes measures for our instruments. Finally, as we implemented the changes specification, we experimented with the inclusion of additional control variables.

As Alternative 1 of Table 10 shows, the changes version of our original specification yields coefficient estimates that are almost identical to the baseline estimates. Next, to evaluate whether our results are affected by direct controls for time-varying firm heterogeneity, we next add firm-level changes in TFP, in Alternative 2, and further add 2-digit industry-time trends in Alternative 3. Our main result connecting imported inputs and firm export is still unchanged. Finally, in Alternative 4 we apply changes specification to the group of private firms. As with our earlier regressions, we find that the estimated benefits of imported inputs were stronger for private firms than they were for the full sample.

Table 10
Changes specifications — key variable results from second stage regressions.

Dependent variable	Δ ln(Ex_Value)	
	(I = E = 0)	(I = E = 1)
Second stage of IV regression	(1)	(2)
	Alternative 1: original specification in changes	
Δ ln(Im_Value)	2.116***	1.101***
	(28.97)	(17.63)
	Alternative 2: original specification in changes with addition of Olley–Pakes TFP changes variable	
Δ ln(Im_Value)	2.143***	1.102***
	(27.91)	(15.28)
Δ TFP	−0.0329**	−0.125**
	(−2.25)	(−2.46)
	Alternative 3: original specification in changes with addition of Olley–Pakes TFP changes variable and 2-digit industry controls	
Δ ln(Im_Value)	2.117***	1.242***
	(27.54)	(14.19)
Δ TFP	−0.196	−0.158***
	(−1.35)	(−2.85)
2-Digit industry effects	Yes	Yes
	Alternative 4: original specification in changes, private firm subsample	
Δ ln(Im_Value)	2.681***	1.695***
	(17.35)	(5.21)

Note: Each regression is based on the changes version of the regressions reported in Table 3. Further modifications are noted by Alternative. Clustered standard errors, based on 4-digit CIC industry codes, are reported in (). Coefficient p-values are: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Estimates labeled "NA" refer to groups which were not statistically identified.

7. Conclusions

Our paper uses firm-level trade and operational data from a large data set of Chinese manufacturing firms to test how imported inputs contribute to firm export activity. Since the use of intermediate inputs is not exogenous, we employ an instrumental variables strategy that utilizes input import tariffs, input real exchange rates and firm status in complementary activities, as firm measures of import costs. We find that increased use of imported intermediate inputs due to exogenous changes in the costs of purchasing foreign inputs contributed to the export growth of China's firms. In addition, we find that the strength of the effects differs across firms; when we classify firms by their original trade engagement at the beginning of the sample period, we find that the contribution of import value to firm exports was largest for the subgroup of firms that began as non-traders, though we also find strong positive effects even among the firms that were already involved in export.

Further exploration of our data reveals that the strength of the relationship between imported intermediate imports and firm exports differs systematically on a few important dimensions, which all suggest that export improvements occur when imports provide local firms with intermediate inputs of superior quality or technology. First, if we distinguish firms by ownership type, we find that private Chinese firms derived larger benefits from imported inputs than did foreign invested firms. Since private Chinese firms began the decade at a technological disadvantage relative to their foreign counterparts, the differential benefit suggests that China's increasing openness, due to improvements in access to imported inputs, facilitated productivity improvements by private Chinese firms. In addition, our paper provides evidence that intermediate inputs from the higher-income G7 countries were especially helpful in facilitating firm ability to access the presumably more-demanding G7 export markets, and that this effect was driven by actively trading firms in high R&D-intensive industries. Taken together, these results suggest that product upgrading facilitated by technology or quality embedded in imported inputs helped Chinese firms to increase the scale and breadth of their participation in export markets.

Appendix A

A.1. Primary data sets and matching procedure

China's National Bureau of Statistics (NBS) conducts an annual survey of manufacturing enterprises. When aggregated to the industry level, these data form the basis of the industrial statistics reported in China's Statistical Yearbook. Two types of firms are included in the survey: (1) all SOEs, and (2) non-SOEs with annual sales at or above five million *Renminbi*. From this data set, we attain information on individual firm operating statistics, such as firm employment and firm sales. This data set also provides information on the ownership structure of firms which allow us to assign firms to one of the following four designations: (1) State-Owned Enterprise, or SOE, (2) Private, (3) Hong Kong, Macau and Taiwan, or HMT, and (4) other non- HMT foreign.

[39] These sectors include food, minerals, chemicals, plastic, leather, wood, paper, textiles and apparel, footwear, ceramics, jewelry, iron, machinery, vehicles, instruments, arms, toys, arts, and service. For each firm, we defined the firm's primary export sector as the sector in which the firm exported the highest share of its export value. Using the classification of each firm's primary export sector, we were able to construct a cumulative distribution of the primary sector export share across firms. Appendix Fig. 2 shows that the vast majority of firms shipped almost all of their exports in a single sector. Only 20% of firms exported less than 95% of their exports in a single sector, while a slim minority, roughly 5% of firms, shipped less than 60% of their export value in a single sector.

Due to noise or misreporting in the data, the data are cleaned following the procedures of Feenstra et al. (2014).

We match the firm-level data from the 2002 to 2006 waves of the NBS data to the firm-level Chinese customs data which record all firm import and export transactions using China's 8-digit product codes, and which include information on the import country origin or export country destination. Observations that list China as the export destination or China as the source country for imports were excluded. Since the two data sets use different firm identification numbers, the first round of matching is based on the firm names provided in the two data sets. However, to confirm firm identity, and to maximize the number of successful matches while excluding spurious matches, the matching process is extended to a number of firm identifiers including zip code, phone number, street address and manager's name.

There are two ways to evaluate the success of the matching procedure. We first compare the matched vs. non-matched firms in the customs data set. On the export side, we matched 52% of the observed export transactions which comprised 80% of total export value. On the import side, we matched 64% of the import transactions, which accounted for 66% of total import value. Although these numbers may initially sound low, it is important to note that our focus on the activities of manufacturing firms is a factor that reduces our match rate. In particular, since we are matching our firms to manufacturing firms in the NBS data set, we are eliminating transactions that were conducted by intermediaries and wholesalers.[40]

The second and more accurate way to evaluate the matching process is to compare the matched vs. non-matched firms in the NBS data set. The NBS data set also reports each firm's total export value. For all firms that report positive export value in the data, we matched 77% of the total number of firms and 86% of the total export value of these firms. Since the NBS data set does not include firm import value it is not possible to evaluate the success of the match on import side. In sum, the matched sample coverage based on trade value compares favorably with the 75% value match reported in Bernard et al. (2009) for US firms.

A.2. Firm trade variables

For each of the years in our sample, we constructed firm-level trade measures by summing over the relevant firm import or export transactions. We first aggregate the data set to HS 6-digit level. On the export side, our measures of firm export performance include *Export Value*, the total value of firm exports in the year, the number of distinct HS 6-digit products exported by the firm, *#Ex_prod*, the diversity of destinations measured by the count of countries the firm export to, *#Ex_cty*, and the diversity of distinct country–products pairs exported by the firm, *#Ex_prod_cty*. Before we generated our firm-level import measures, we identified imported intermediate inputs following Arkolakis et al.'s (2008) work, that defines intermediate input imports as any imports of products belonging to the UN BEC groups, 41, 521, 111, 121, 21, 22, 31, 322, 42 and 53. As with the export data, we formed our annual firm-level measures of imported intermediate input value, *Import Value*, as the sum of all intermediate input import transaction values of the firm, the number of distinct HS 6-digit products imported by the firm, and the number of country-HS 6-digit products pairs imported by the firm, #Im_prod_cty.

A.3. Tariff measures and exchange rates

We collected tariffs from the WTO web site (http://tariffdata.wto.org/ReportersAndProducts.aspx) to construct each of our tariff-based measures. The key measures, representing the export duty and import duty applying to each firm, were constructed through the use of the formulas given by Eqs. (2) and (4). These measures characterize the barriers to the firm's export and the costs of importing inputs, based on the firm's primary industry. Later, in our robustness checks we also utilize a tariff-based measure, *Import Competition*, which is constructed as in Amiti and Khandelwal (2013). This measure tracks how China's trade liberalization, affected the level of Chinese tariffs levied on the products which were exported by Chinese firms. To capture the effects tied to real exchange rate changes, we collected bilateral real exchange rate data from the Penn World Table to construct industry intermediate input import real exchange rates and output export real exchange rates, using Eqs. (1) and (3).

A.4. Industry-level R&D

To study how the benefits of imported intermediate inputs are related to industry characteristics, we used the NBS data set to construct industry measures of R&D intensity following Kroszner et al. (2007). Our measure of R&D intensity (*R&D*) is the share of industrial R&D expenses over industrial sales by 4-digit CIC industry for the period 2005–2006.[41] Appendix Fig. 1, which shows the distribution of the R&D measure across 4-digit industries, shows that the majority of China's industries had very low R&D intensity. For this reason, when our analysis conducts tests which assign firms to high or low R&D intensity industries, we separate industries into high and low R&D intensity industries based on the R&D intensity of the industries above the 90th percentile. Column 4 of Table 1 shows the R&D intensities across 2-digit CIC industries. Consistent with general expectations regarding industry-level R&D intensity, we find that measuring instruments, computers, machinery and drugs had high R&D intensity while the leather, apparel, timber and furniture sectors were characterized as low R&D intensity.

A.5. Firm total factor productivity (TFP)

We use the Olley–Pakes TFP measures from Feenstra et al. (2014).

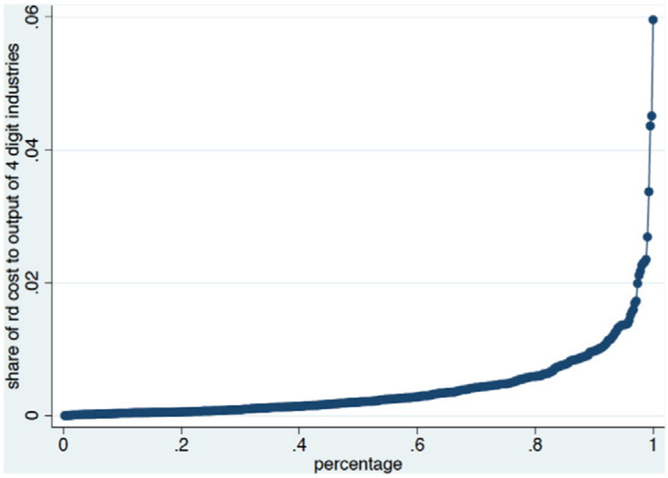
Appendix Table 1
Summary statistics for 4-digit CIC industry measures.

Variable	Obs	Mean	SD	Min	Max
Intermediate input import duty	2364	8.3113	5.845	0	102.963
Intermediate input import real exchange rate	2358	2.422	0.416	0.811	3.503
Output export duty	2394	5.259	8.079	0	123.195
Output export real exchange rate	2388	2.214	0.387	0.716	3.325

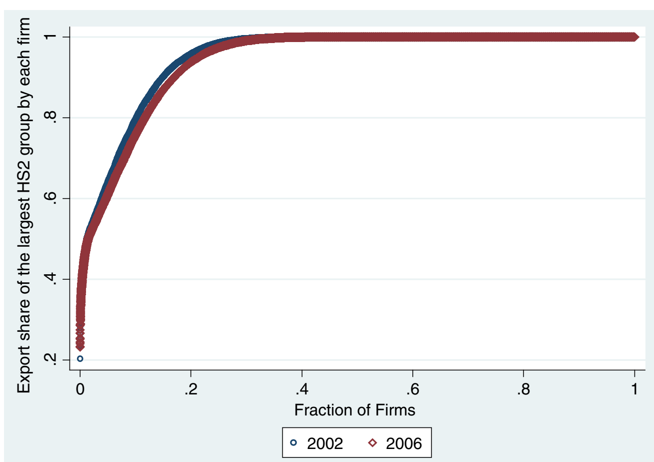
Note: These summary statistics are based on annual observations for the years 2002–2006, for the 4-digit CIC industries in our data set. Input import duty, output export duty, the input import real exchange rate and output export real exchange rate are constructed according to (2), (3), and (4) as described in the text.

[40] Following Ahn, Khandelwal and Wei (2011), we identify the set of intermediary firms based on Chinese characters that have the English-equivalent of “importer”, “exporter”, and/or “trading” in the firms' name.

[41] In contrast with Kroszner, Laeven and Klingebiel (2007) we are not able to measure R&D intensity as the median level of R&D expenses over sales in each 4-digit CIC industry. This is because many firms engage in no R&D and consequently the median levels for some Chinese CIC industries are zero.



Appendix Fig. 1. R&D distribution across 4-digit CIC industries. Note: The vertical axis displays industry-level R&D intensity measured by the ratio of industry R&D costs relative to industry output value. The horizontal axis is the fraction of industries whose R&D intensity reached or fell below the levels displayed on the vertical axis.



Appendix Fig. 2. Export share of the most important sector in firms' total exports. Note: The vertical axis displays the export share of a firm's most important sector in its total exports. The horizontal axis is the fraction of firms whose main sector export share met (or below) the levels displayed on the vertical axis.

References

Acharya, R.C., Keller, W., 2009. Technology transfer through imports. Can. J. Econ. 42 (4), 1411–1448.

Ahn, J.B., Khandelwal, A.K., Wei, S.-J., 2011. The role of intermediaries in facilitating trade. J. Int. Econ. 84 (1), 73–85.

Amiti, M., Konings, J., 2007. Trade liberalization, intermediate inputs, and productivity: evidence from Indonesia. Am. Econ. Rev. 97 (5), 1611–1638.

Amiti, M., Khandelwal, A.K., 2013. Import competition and quality upgrading. Rev. Econ. Stat. 95 (2), 476–490.

Arkolakis, C., Demidova, S., Klenow, P.J., Rodriguez-Clare, A., 2008. Endogenous variety and the gains from trade. Am. Econ. Rev. Pap. Proc. 98 (4), 444–450.

Bai, X., Krishna, K., Ma, H., 2015. How you export matters: export mode, learning and productivity in China. NBER Working Paper Vol. 21, p. 164.

Bas, M., 2012. Input-trade liberalization and firm export decisions: evidence from Argentina. J. Dev. Econ. 97 (2), 481–493.

Bas, M., Strauss-Kahn, V., 2014. Does importing more inputs raise exports? Firm-level evidence from France. Rev. World Econ. 150 (2), 241–275.

Bas, M., Strauss-Kahn, V., 2015. Input-trade liberalization, export prices and quality upgrading. J. Int. Econ. 95 (2), 250–262.

Bastos, P., Silva, J., 2010. The quality of a firm's exports: where you export to matters. J. Int. Econ. 82 (2), 99–111.

Bastos, P., Silva, J., Verhoogen, E., 2014. Export Destinations and Input Prices. CDEP-CGEG WP No. 13.

Bernard, A.B., Jensen, J.B., Schott, P.K., 2009. Importers, exporters, and multinationals: a portrait of firms in the U.S. that trade goods. In: Dunne, T., Jensen, J.B., Roberts, M.J. (Eds.), Producer Dynamics: New Evidence From Micro Data. The University of Chicago Press, Chicago, pp. 513–552.

Brambilla, I., 2009. Multinationals, technology, and the introduction of varieties of goods. J. Int. Econ. 79 (1), 89–101.

Brandt, L., Van Biesebroeck, J., Zhang, Y., 2012. Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing. J. Dev. Econ. 97 (2), 339–351.

Brandt, L., Morrow, P.M., 2015. Tariffs and the organization of trade in China. University of Toronto Working Paper.

Bustos, P., 2011. Trade liberalization, exports, and technology upgrading: evidence on the impact of MERCOSUR on Argentinian firms. Am. Econ. Rev. 101 (1), 304–340.

Damijan, J.P., Konings, J., Polanec, S., 2014. Import churning and export performance of multi-product firms. World Econ. 37, 1483–1506.

Damijan, J.P., Kostev, Č., 2010. Learning from trade through innovation: causal link between imports, exports and innovation in Spanish microdata. LICOS Discussion Paper Series 264/2010.

Defever, F., Riaño, A., 2012. China's pure exporter subsidies. CEP Discussion Papers, CEPDP1182.

Ethier, W.J., 1982. National and international returns to scale in the modern theory of international trade. Am. Econ. Rev. 72 (3), 389–405.

Fan, H., Li, Y.A., Yeaple, S.R., 2015. Trade liberalization, quality, and export prices. Rev. Econ. Stat. 97 (5), 1033–1051.

Feenstra, R.C., Li, Z., Yu, M., 2014. Exports and credit constraints under incomplete information: theory and evidence from China. Rev. Econ. Stat. 96 (3), 729–744.

Goldberg, P.K., Khandelwal, A.K., Pavcnik, N., Topaloval, P., 2010. Imported intermediate inputs and domestic product growth: evidence from India. Q. J. Econ. 125 (4), 1727–1767.

Gopinath, G., Neiman, B., 2013. Trade adjustment and productivity in large crises. Am. Econ. Rev. 104 (3), 793–841.

Görg, H., Halpern, L., Muraközy, B., 2010. Why Do Within Firm-Product Export Prices Differ Across Markets? Kiel Working Paper No. 1596

Halpern, L., Koren, M., Szeidl, A., 2015. Imported inputs and productivity. Am. Econ. Rev. 105 (12), 3660–3703.

Jarreau, J., Poncet, S., 2012. Export sophistication and economic growth: evidence from China. J. Dev. Econ. 97, 281–292.

Kasahara, H., Lapham, B., 2013. Productivity and the decision to import and export: theory and evidence. J. Int. Econ. 89 (2), 297–316.

Kasahara, H., Rodrigue, J., 2008. Does the use of imported intermediates increase productivity? Plant-level evidence. J. Dev. Econ. 87 (1), 106–118.

Keller, W., 2010. International trade, foreign direct investment and technology spillovers. In: Hall, B.H., Rosenberg, N. (Eds.), Handbook of the Economics of Innovation. Elsevier, North-Holland, pp. 793–829 (chapter 19).

Keller, W., Yeaple, S.R., 2013. The gravity of knowledge. Am. Econ. Rev. 03 (4), 1414–1444.

Khandelwal, A.K., Topalova, P., 2011. Trade liberalization and firm productivity: the case of India. Rev. Econ. Stat. 93 (3), 995–1009.

Koopman, R., Wang, Z., Wei, S.-J., 2012. Estimating domestic content in exports when processing trade is pervasive. J. Dev. Econ. 99 (1), 178–189.

Kroszner, R.S., Laeven, L., Klingebiel, D., 2007. Banking crises, financial dependence, and growth. J. Financ. Econ. 84 (1), 187–228.

Kugler, M., Verhoogen, E., 2009. Plants and imported inputs: new facts and an interpretation. Am. Econ. Rev. Pap. Proc. 99 (2), 501–507.

Lileeva, A., Trefler, D., 2010. Improved access to foreign markets raises plant-level productivity … for some plants. Q. J. Econ. 125 (3), 1051–1099.

Manova, K., Yu, Z., 2012. How Firms Export: Processing vs. Ordinary Trade with Financial Frictions. NBER Working Paper Vol. 18, p. 561.

Manova, K., Zhang, Z., 2012a. Export prices across firms and destinations. Q. J. Econ. 127 (1), 379–436.

Manova, K., Zhang, Z., 2012b. Multi-product firms and product quality. NBER Working Paper Vol. 18, p. 637.

Martin, J., 2012. Mark-ups, quality and transport costs. Eur. Econ. Rev. 56 (4), 777–791.

Verhoogen, E.A., 2008. Trade, quality upgrading and wage inequality in the Mexican manufacturing sector. Q. J. Econ. 123 (2), 489–530.

Wang, Z., Yu, Z., 2012. Trading partners, traded products and firm performances of China's exporter–importers: does processing trade make a difference? World Econ. 35 (12), 1795–1824.

Yu, Miaojie, 2013. “Processing trade, firm's productivity and tariff reduction: evidence from Chinese products.” *mimeo*, Peking University.