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ESCAPING IMPORT COMPETITION AND DOWNSTREAM TARIFFS

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ABSTRACT

We propose and provide evidence for a new source of gains from trade: Firms invest in product differentiation to escape import competition. In the data and in the model, these investments are associated with increases in measured productivity, introduction of new goods, and shifts to skill-intensive sectors. Investment in differentiation downstream leads upstream firms to also invest in differentiation. For China, these "downstream tariff" reductions lead to big increases in measured productivity for upstream suppliers. The effect on measured productivity is larger for upstream than for downstream firms, and we explain this difference theoretically through heterogeneous changes in markups.

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1 Introduction

There is a long and venerable literature that emphasizes the gains from opening up to trade. Much of those gains are consumer-side benefits from greater variety and lower prices. A more recent literature emphasizes the positive effect of global competition in weeding out the less efficient firms and expanding the market share of the most efficient competitors (Melitz (2003)).

Surprisingly, there is not much theory explaining the positive effect of reductions to trade barriers on the performance of import-competing firms. Empirical studies are roughly in line with the marked absence of theory on this point. Evidence to date on the effect of unilateral tariff or quota reductions on firm productivity is mixed (see, Tybout (2003) for a comprehensive review). Yet policy makers and trade economists in general do believe that trade reforms improve the performance of domestic competitors. If forced to give a reason why, a number of economists might vaguely resort to "x-inefficiency" or "dynamic gains from trade."

This paper aims to, at least in part, narrow the gap between policy maker's perceptions and the academic literature. On the empirical side, we augment a standard regression of firm productivity on tariffs by considering tariff changes in the firm's own sector (output tariffs), its upstream sector (input tariffs), and its downstream sector (downstream tariffs). The first two tariff measures are common in the literature, while the concept of downstream tariffs is novel. Using firm-level data from China spanning the years of its accession to the WTO in 2001, we provide evidence that reductions in all three tariff measures increase firm productivity, and that the effect of downstream tariffs is larger than the effect of output tariffs. A literature pioneered by Javorcik (2004) identifies input linkages as the primary source of productivity spillovers from multinational firms, and we bring these insights to the context of trade reform.

To explain this positive effect of international trade on the productivity of import competing firms and their input suppliers, we develop a model where firms may invest to differentiate their variety to escape import competition. A firm that invests creates a new market niche where it enjoys greater monopoly power. In our preferred interpretation, Chinese firms invest in differentiation by tailoring their goods to domestic tastes or improving non-tradable services offered with products. For example, the cell phone company Symbio prevented the expansion of Apple in China by catering its services to the Chinese market. Shortly after the Chinese WTO accession, the automobile company Chery introduced several new, small car models with a much greater variety of optional features and made replacement parts readily available. One can interpret the last two changes as a provision of non-tradable services since it is difficult for firms producing cars abroad to offer a customized car features, and a wide range of replacement parts.

Mechanically, the model features heterogeneous firms and variable markups with nested CES preferences à la Atkeson and Burstein (2008). Each firm chooses between producing a variety in a less-differentiated nest where the elasticity of substitution between varieties is high, or paying a fixed cost to invent a new nest where it holds monopoly power and faces a low elasticity of substitution. In a cross-section, investment in product differentiation is a non-monotonic function of firm productivity. If the firm is very unproductive, its sales are too small to pay for the fixed cost. If the firm is very productive relative to its competitors, then it will hold near monopoly power in the non-differentiated nest. It does not invest in differentiation because its markup is high without it. This result is reminiscent of the U-shaped impact of competition on innovation found in Aghion et al. (2005) and Aghion et al. (2015). Our use of CES preferences brings their results closer to data and to standard trade literature.

In mapping the model to data, we assume that a reduction in a sector-specific tariff increases competition in the less-differentiated nest. In line with the examples above, the interpretation is that differentiated goods are less tradable, because they cater to Chinese tastes or are enhanced with non-tradable services. To be clear, it is not an assumption on the quality of Chinese relative to foreign goods. Under this assumption, tariff reductions increase investments in product differentiation and decrease markups for a given level of differentiation. So, tariffs have an ambiguous effect on the measured productivity of import-competing firms: They increase with their investments in product differentiation, but they decrease with the drop in markups.¹ Assuming that differentiated downstream firms use only differentiated inputs, investments downstream increase the incentives for upstream firms to invest. The markups of upstream firms, however, do not decrease, because markups depend mostly on market shares which do not decrease for upstream firms. In this fashion, the model explains why in the data the effect of tariff reductions on productivity is larger for upstream firms than for firms directly competing with imports. We also prove that firms in the market equilibrium under invest in differentiation relative to the planner's preferred choice. So, the trade-induced investment in product differentiation constitutes a gain from trade not previously identified in the literature.

We provide further evidence for the theory in the case of China. The years between 1998 and 2007 witnessed many policy shifts as China embarked on significant trade reform.

 $^{^{1}}$ A revenue-based measure of TPF, such as ours, is an estimate of the ratio of revenue to costs. It is best mapped to the markup in trade models. Our model has predictions for revenue-based TFP and not for quantity TFP because products are differentiated across firms and within firm across time. See Foster et al. (2008) for a discussion.

Average tariffs on manufacturing in China fell from 43 percent in 1994 to 9.4 percent in 2004, following China's accession to the WTO in 2001. Imports as a share of GDP doubled from 14% prior to WTO entry to 28% within several years. These significant changes in tariff policy combined with China's WTO entry allow us to identify the impact of domestic trade reforms on Chinese manufacturing firms. Since the reforms were guided by WTO mandates to create a more uniform tariff structure, tariff reductions were largest on goods with initially the highest tariff levels. We use initial tariffs as instruments for tariff changes. We also use tariff changes combined with input-output tables to separately measure the impact of trade reform on Chinese domestic input suppliers. We follow Olley and Pakes (1996) to construct measures of total factor productivity (TFP).

Our main empirical finding is a large and robust effect of tariff reductions on TFP of upstream firms mentioned above. The effect of tariff reductions on the TFP of importcompeting firms is also positive, but this is an effect that has been highlighted by other research on China and is not always present in other countries—consistent with ambiguous effect of tariffs on firm markups in the model. For corroborating evidence on investment in differentiation, we show that import-competing firms and their input suppliers respond to tariff cuts by introducing new products and systematically switching into sectors requiring more skilled labor. The introduction of new products contradicts recent models of multiproduct firms where tighter competition leads firms to drop their least-productive varieties, and switching to more skill-intensive sectors contradicts the classic Heckscher-Ohlin model where import competition should push China toward its unskill-intensive comparative advantage sectors.² Taken together, these findings support the proposed mechanism of investment in differentiation. Although there may be alternative explanations, the findings do not conform to standard models in the literature.

Section 2 reports reduced-form results on the productivity responses to falling tariffs. We analyze the effect of tariff reductions on a firm's own sector, on its upstream sectors and on its downstream sectors. We find significant gains to productivity (TFP) from tariff reforms in all three types of tariffs. In Section 3 we develop a theoretical model that describes the process of productivity growth for both output producers and upstream

²For recent models of multi-product firms, see Bernard et al. (2007), Bernard et al. (2011). Investment in product differentiation per se implies that the firm introduces a new product in the model. It may increase the demand for skills because it may involve design new products, new production processes and potentially new management strategies to improve customer services and firm-to-firm interactions. The effects of the reform in increasing the skill intensity of input suppliers is consistent with evidence in Verhoogen (2008) and Fieler et al. (2017) suggesting that skill-intensive firms disproportionately use skill-intensive inputs. Finally, the firm variables that we analyze, including the new-goods margin, has been used to analyze the effects of imported inputs on firms—e.g., Goldberg et al. (2009), Goldberg et al. (2010), Halpern et al. (2015).

suppliers. In Section 4, we report empirical results for markups, product shifting, and further extensions. The results highlight the opposite effects of tariffs on markups and innovation: markups fell for import-competing firms but they increased their innovative activity as shown by product switching. Section 5 reports the results of a number of robustness tests. Section 6 concludes.

2 The Impact of Tariffs on TFP

This section reports changes in total factor productivity (TFP) within firms as a function of tariffs in the firm's own sector (output tariffs), its upstream sectors (upstream tariffs), and in its downstream sectors (downstream tariffs). We describe the data in section 2.1. The method to measure TFP is in section 2.2 and empirical results are in section 2.3.

2.1 Data

The data are an annual survey of industrial firms collected by the Chinese National Bureau of Statistics. The data set is firm-level based and comprises *all* state-owned enterprises (SOEs), regardless of size, and *all* non-state-owned firms (non-SOEs) with annual sales of more than 5 million Yuan. We use a ten-year unbalanced panel dataset, from 1998 to 2007. These data have been extensively used in a number of papers, and for more details, we refer the reader to Du et al. (2012), Aghion et al. (2015), and Brandt et al. (2017).

The original dataset has 2,226,104 firm-year observations and contains identifiers that can be used to track firms over time. It includes firms in manufacturing, mining, electricity, gas, and water sectors. We keep only firms in manufacturing, the more tradable sector. We delete observations with missing values, or with zero or negative values for output, number of employees, capital, and the inputs. Due to incompleteness of information on official output price indices, which are reported annually in the official publication, three sectors are dropped from the sample.

The dataset contains information on output, fixed assets, total workforce, total wages, intermediate input costs, foreign investment, Hong Kong-Taiwan-Macau investment, sales revenue, and export sales. We classify firms as domestic or foreign-owned. Domestic firms are those with zero foreign capital in their total assets. About 77.5 percent of firms are classified as domestic and 22.5 percent as foreign-owned. We restrict the sample of domestic firms to firms with zero or a minority state ownership. The final sample has 991,440 observations.

The Chinese Input-Output table (2002) has 71 sectors, while the firm-level survey

has 4-digit industry classifications. To construct downstream tariffs below we aggregate the 4-digit classification up to these 71 sectors. For example, the furniture industry includes 5 four-digit sub-sectors. These are wood furniture manufacturing (2110), bamboo furniture manufacturing (2120), metal furniture manufacturing (2130), plastic furniture manufacturing (2140), and other furniture manufacturing (2190). This level of aggregation of tariff measures, 71-sector level, is sufficiently broad to diffuse potential concerns that tariffs depend endogeneously on the behavior of disaggregated firms. Nevertheless, we estimate the impact of tariffs on TFP using both an OLS and an IV approach.

2.2 Measuring Productivity and Tariffs

Total Factor Productivity (TFP). We measure TFP for each firm and year using a standard two-stage procedure developed by Olley and Pakes (1996). However, in various parts of the paper we test for the robustness of our results to the use of alternative methods. We present results using OLS and firm fixed effects to derive TFP as well as the more recent innovations proposed by Ackerberg et al. (2015). For the Olley-Pakes (OP) estimation, in the first stage we estimate a three-input gross-output production function. We use the estimated factor output elasticities for labor, capital, and materials to construct measures of total factor productivity for each firm in each year it appears in our 1998-2007 sample. In the second stage, we regress the dependent variable, lnTFP, on our three tariff measures and an extensive set of controls.

The first-stage production function is:

$$\ln Y_{ijt} = \alpha_0 + \alpha_L \ln L_{ijt} + \alpha_M \ln M_{ijt} + \alpha_K \ln K_{ijt} + \mu_{ijt}$$
(1)

where α_0 , α_L , α_K and α_M are parameters to be estimated, subscript *i* refers to an individual firm in sector *j* and in year *t*. Variable *Y* is deflated output, *L* is number of employees, *K* is capital, *M* is material inputs, detailed below. The purpose of the first-stage is to get unbiased estimates of the factor-output elasticities.

All output and input variables are deflated by their corresponding price indices. Output value (quantities*prices) is deflated by the 29 individual sector ex-factory price indices of industrial products. To deflate material inputs, these 29 sector price indices are assigned with as much consistency as possible to the output data for the 71 sector aggregates. Capital is defined as the net value of fixed assets, which is deflated by a uniform fixed assets investment index, and labor is a physical measure of the total number of employees. Intermediate inputs used for production are deflated by the intermediate-input price index. While these inflation measures are useful to take out some spurious variations across sec-

tors, they do not fully capture changes in prices when products are differentiated within sectors. So, measured TFP still picks up markups.

In the second-stage, we regress firm-level TFP on a series of firm-level and sector-level controls:

$$\ln TFP_{ijt} = \beta_1 \ln \text{Output}_{\text{Tariff}_{jt}} + \beta_2 \ln \text{Upstream}_{\text{Tariff}_{jt}} + \beta_3 \ln \text{Downstream}_{\text{Tariff}_{jt}} + S_{jt} + \Sigma \alpha_i + \Sigma \alpha_t + \varepsilon$$
(2)

where $\ln TFP_{ijt}$ is the predicted value of $\ln Y_{ijt} - \hat{\alpha}_L \ln L_{ijt} - \hat{\alpha}_M \ln M_{ijt} - \hat{\alpha}_k \ln K_{ijt}$ from equation (1) above. In equation (2) α_i are firm fixed effects, α_t are time fixed effects, and S_{jt} are firm- and time-varying control variables described below.

Tariffs. We construct three tariff measures for each firm and year. Consider a firm in sector j. First, a decrease in sector-j tariffs increases import competition for the firm. We refer to these own-sector tariffs as output tariffs. Second, the tariffs on the sectors that provide inputs to sector j affect the firm's costs. We refer to these tariffs as upstream tariffs. The literature often refers to them as input tariffs, and we change the nomenclature to make it symmetric to the novel concept of downstream tariffs. Third, if sector j provides inputs to a sector whose tariffs are cut, the firm may be impacted. We refer to these tariffs as downstream tariffs. The first two types of tariffs—output and upstream tariffs—have been extensively analyzed in the trade literature, while the effect of downstream tariffs has, to our knowledge, only been documented in the context of foreign direct investment (e.g., Javorcik (2004)).

To fix ideas on these three tariff measures, consider the example of a firm that produces car engines. It may be impacted by Chinese entry into the WTO if the tariffs on the pistons that go into engines decrease (upstream tariff), if the tariffs on car engines decrease (output tariff) increasing import competition, or if tariffs on cars decrease (downstream tariffs) and change the type of car Chinese producers make.

While we use Brandt et al. (2017)'s measures of final and upstream tariffs, we construct our own downstream tariffs. Our time series of tariffs is collected from the World Integrated Trading Solution (WITS), maintained by the World Bank. We created a concordance between the tariff data, China's Input-Output table and the Chinese survey data at the most disaggregated level possible, given that sectoral classifications differ across data sources. We end up with 71 sectors that comprise a wide range of economic activities, such as ship-building, electronic computers, tobacco products, motor vehicles, and parts and accessories for motor vehicles. The aggregation of tariffs to this 71-sectoral classification uses the output in 2003 as weights.

To construct upstream tariffs, Brandt et al. (2017) use China's Input-Output table (2002) and follow the procedures suggested by Amiti and Konings (2007). The upstream tariffs are a weighted average of the output tariffs, where the weights are based on the Input-Output table. For instance, if a chocolate producer uses 60 percent sugar and 40 percent cocoa powder, the upstream tariff for that chocolate industry is equal to 60 percent of the sugar tariff plus 40 percent of the cocoa tariff.

More specifically, the upstream tariff in Amiti and Konings (2007) and Brandt et al. (2017) is calculated as:

upstream_tariff_{jt} =
$$\sum_{m \neq j} \delta_{jm}$$
 output_tariff_{mt}

where δ_{jm} is the share of sector *m* provided as an input to sector *j*. Our downstream tariff measure is calculated as:

downstream_tariff_{jt} =
$$\sum_{k \neq j} \alpha_{jk}$$
 output_tariff_{kt}

where α_{jk} is the share of sector j's production supplied to downstream sector k. The values of α_{jk} and δ_{jm} are both taken from the 2002 input-output table. Downstream tariffs will be highest in those sectors j where the downstream users in sector k face high tariffs and demand a large share of sector j's output. This concept of a "downstream tariff" is a new one and showing that tariff changes had a major impact via this channel is a primary contribution of this paper.

Instruments for tariffs The high level of aggregation at which tariffs are measured, 71 sectors, partly diffuses the concern that individual firms endogenously influence the level of tariffs through lobbying. Still, we use an instrumental variable to further address the potential endogeneity of tariffs. Similar to other trade liberalizations, China reduced both the levels and the heterogeneity in tariffs. Between 1998 to 2007, tariff reductions were higher in sectors where tariff levels were high at the beginning of the sample period, in 1998. This correlation is illustrated in figure 1 taken from Du et al. (2012).

Following the literature, we use initial tariffs as instruments.³ Output tariffs, upstream tariffs, and downstream tariffs are instrumented using the initial period value for these

³For example, Goldberg and Pavcnik (2007) use this instrument for India and Attanasio et al. (2004) use it for Colombia. Brandt et al. (2017) follow a similar approach for instrumenting Chinese tariffs. They instrument for tariffs using rates from the accession agreement, which were mostly fixed by 1999.



Figure 1: Tariff changes and initial levels

tariffs at the establishment level interacted with a dummy variable equal to one after China entered into the WTO. Since our regressions have firm fixed effects, we cannot include the initial levels of tariffs alone. If the firm did not exist in 1998, we use instead the initial mean tariff in the firm's sector.

Additional control variables. Control variables capture exposure to foreign investment at the sector level, other policies, and ownership variables. Following Javorcik (2004), we define three sector-level FDI variables. Horizontal_{it} captures foreign presence in sector j at time t and is defined as foreign equity participation averaged over all firms in the sector, weighted by each firm's share in sectoral output. Downstream_FDI_{it} captures foreign presence in the sectors that are supplied by sector j. That is, Downstream_FDI_{it} is a measure for foreign participation in the downstream industries of sector j. Upstream_FDI_{it} is a weighted share of output in upstream industries of sector j produced by firms with foreign ownership. The reader is referred to Javorcik (2004) for more details on the construction of these FDI variables. Industrial policy is captured through zeroone dummy variables indicating whether the firm received subsidies (index_subsidies), whether the firm received a tax holiday (index_tax), and whether the firm paid below median interest rates on loans (index_interest). Finally, we control for the share of state ownership in the sector of the firm. Compared to other studies, our control variables are very detailed, but level of aggregation is high—Amiti and Konings (2007), for instance, use 4-digit measures of protection for Indonesia, while we can only use 3-digit measures for tariffs and FDI.

2.3 Results on TFP and Trade

Our baseline results are reported in Table 1. The sample includes all establishments without foreign ownership or significant public ownership (although the results are not qualitatively affected by the inclusion of this additional set of enterprises as we shall see in Table 2). The first two columns report the OLS results using either the OP approach or OLS with firm fixed effects in the first stage. All specifications allow for both firm fixed effects and year effects. While all results reported here use the log of tariffs as a measure of tariffs, the results are similar if we instead use actual tariffs or their lagged levels.

Our key results are in the first three rows of Table 1, which report coefficients on output tariffs, downstream tariffs, and upstream tariffs. For our OLS results in the first two columns of Table 1, all three tariff measures are negative. The instrumental variable (IV) estimates are reported in columns (3) and (4) of Table 1. The coefficient on the WTO dummy interacted with initial tariff levels in the first stage is highly significant and negative, indicating that China's entry into the WTO led to significant tariff declines across all manufacturing sectors. For the IV estimates, the coefficient on output tariffs in the OLS and OP specifications are both significant and negative. For output tariffs, the coefficient estimates of -0.0312 and -0.0478 indicate that a ten percent reduction in tariffs would raise TFP by .3 to .5 percent. The coefficient on downstream tariffs is also significant and negative, and its magnitude is about four times greater. The point estimates suggest that a ten percent reduction in tariffs on downstream users would lead productivity of their suppliers to increase by nearly 2 percent. The results in the first four columns of Table 1 indicate that both output tariffs and downstream tariffs have a negative and significant impact on our different productivity measures. However, the coefficient on the downstream tariff has much greater magnitude.

The coefficients on the control variables are plausible and reassuring. The results suggest that subsidies and tax holidays are associated with higher TFP at the firm level, while subsidized interest rates are associated with lower TFP. The impact of vertical linkages from foreign ownership is generally positive and significant, while horizontal linkages are insignificant in the OLS specifications but positive and significant in the IV specifications.

Columns (5) and (6) repeat the estimation but exclude exporting enterprises. Although the signs of the coefficients of interest are the same, the magnitudes change. The coefficient on downstream tariffs more than doubles while the coefficient on output tariffs remains consistent with the first four columns. When firms do not export, the positive impact of a reduction in tariffs for downstream users of a firm's products are even greater. For firms that do not export, the magnitudes for downstream tariffs are ten times more important than the negative estimates for output tariffs. The point estimates indicate

Dependent variable: TFP measured à la Olley-Pakes (OP) or OLS with fixed effects (FE)							
All Enterprises Excluding SOEs and Multinationals Only Non-Exporters							
	OP	FE	OP	\mathbf{FE}	OP	\mathbf{FE}	
	OLS	OLS	IV	IV	IV	IV	
	(1)	(2)	(3)	(4)	(5)	(6)	
$output_tariff$	-0.0312***	-0.0331***	-0.0478^{***}	-0.0459^{***}	-0.0592^{***}	-0.0566***	
	(0.0082)	(0.0087)	(0.0109)	(0.0112)	(0.0110)	(0.0112)	
$downstream_tariff$	-0.0154	-0.0168	-0.173***	-0.169^{***}	-0.426^{***}	-0.451***	
	(0.0308)	(0.0366)	(0.0372)	(0.0373)	(0.0474)	(0.0476)	
$upstream_tariff$	-0.130***	-0.140**	-0.350***	-0.461***	-0.217^{***}	-0.308***	
	(0.0445)	(0.0528)	(0.0610)	(0.0620)	(0.0638)	(0.0647)	
index_subsidy	0.0108^{***}	0.0130^{***}	0.0103^{***}	0.0123^{***}	0.00747^{***}	0.00879^{***}	
	(0.0018)	(0.0017)	(0.0011)	(0.0011)	(0.0014)	(0.0014)	
index_tax	0.0216^{***}	0.0220^{***}	0.0214^{***}	0.0217^{***}	0.0211^{***}	0.0216^{***}	
	(0.0009)	(0.0009)	(0.0007)	(0.0007)	(0.0008)	(0.0008)	
index_interest	-0.0121***	-0.0133***	-0.0120***	-0.0132***	-0.0134***	-0.0146^{***}	
	(0.0012)	(0.0011)	(0.0008)	(0.0008)	(0.0009)	(0.0009)	
$exportshare_sector$	0.12	0.166	0.388^{***}	0.479^{***}	0.479^{***}	0.581^{***}	
	(0.142)	(0.145)	(0.030)	(0.031)	(0.038)	(0.039)	
State_share	-0.00154	-0.000965	-0.00194	-0.00148	-0.000568	0.000428	
	(0.0037)	(0.0037)	(0.0039)	(0.0039)	(0.0044)	(0.0044)	
Horizontal FDI	0.151	0.212	0.144^{***}	0.198^{***}	0.236^{***}	0.299^{***}	
	(0.180)	(0.200)	(0.022)	(0.022)	(0.027)	(0.028)	
Downstream FDI	1.074	0.982	1.635^{***}	1.559^{***}	2.266^{***}	2.237^{***}	
	(0.783)	(0.904)	(0.148)	(0.149)	(0.187)	(0.189)	
Upstream FDI	0.085	0.0911	0.150^{***}	0.176^{***}	0.036	0.0637	
	(0.404)	(0.409)	(0.036)	(0.037)	(0.043)	(0.043)	
Observations	982,142	982,142	982,142	982,142	777,739	777,739	

 Table 1: Basic Regressions of Productivity on Tariffs

Standard errors are clustered. Tariffs and TFP are in logs. All specifications include fixed effects for the firm, time, and two-digit sector. All specifications also include a dummy variable equal to 1 if the firm changes a four digit sector as well. IV estimates use initial 1998 tariffs and initial tariffs interacted with a WTO dummy as instruments. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

Table 2: Regressions including public-sector enterprises and firms with minority foreign ownership and lagged tariffs

Bependent varia			oney i anes				
All Enterprises Only Non-Exporters							
	OP	FE	OP	\mathbf{FE}	OP	OP	
	OLS	OLS	IV	IV	OLS	IV	
	(1)	(2)	(3)	(4)	(5)	(6)	
$output_tariff$	-0.0285***	-0.0297***	-0.0421***	-0.0372***	-0.0329***	-0.0520***	
	(0.0067)	(0.0070)	(0.0108)	(0.0111)	(0.0078)	(0.0114)	
$downstream_tariff$	-0.0245^{*}	-0.0254*	-0.117**	-0.123**	-0.0319**	-0.573***	
	(0.0135)	(0.0146)	(0.0515)	(0.0520)	(0.0151)	(0.0739)	
$upstream_tariff$	-0.0195	-0.019	-0.737***	-0.814***	-0.00961	-0.413***	
	(0.0175)	(0.0188)	(0.0690)	(0.0702)	(0.0181)	(0.0710)	
Observations	821,970	821,970	821,970	821,970	619,448	619,448	

Dependent variable: TFP measured à la Ollev-Pakes (OP) or OLS with fixed effects (FE)

Specifications are the same as table 1, except that this table uses lagged tariffs and includes public-sector enterprises and firms with minority foreign ownership. The number of observations decreases with the use of lagged tariffs and increases due to the larger set of firms. We report here only the coefficients on the variables of interest. The Appendix reports the coefficients on all control variables. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

that a 10 percent reduction in tariffs would result in a 4.3 to 4.5 percent increase in productivity. Documenting the negative impact of these downstream tariffs on productivity and the consequent productivity gains when tariffs are reduced are a primary empirical contribution of this paper.

For comparative purposes, we report the results using the lagged log of tariffs and a sample that includes both public sector enterprises and foreign firms in Table 2. The complete set of coefficients appear in Appendix Table A.1. Lagged tariffs are consistent with the specifications employed by Loren Brandt, Johannes Van Biesebroeck, Luhang Wang, and Yifan Zhang (2017), in their paper "WTO Accession and Performance of Chinese Manufacturing Firms". Table 2 shows that the use of lagged instead of current period tariffs leads to very similar results. Also similar to Brandt et al. (2017), Tables 1 and 2 include 2-digit sector dummies to diffuse the concern that TFP measures may not be comparable across sectors. Appendix Table A.2 shows that our results are robust to removing 2-digit sector dummies. In sum, while the main innovation of our paper is the focus on downstream tariffs, it is reassuring that our results on output tariffs are comparable in magnitudes to Brandt et al. (2017).

Tables 1 and 2 show that the largest impact of the unilateral tariff reductions was the

impact on suppliers to sectors with falling protection. This effect has not been identified previously in the trade literature. It is at a first sight puzzling because non-exporting input suppliers should be impacted by import competition downstream only to the extent that downstream firms themselves change their behavior. Yet, increases in the TFP of upstream suppliers are larger in magnitude (downstream tariffs) than increases in the TFP of import-competing firms (output tariffs). The model below provides the following explanation: While trade reforms lead both import-competing firms and their suppliers to invest in product differentiation, only import-competing firms significantly reduce their markups. These markup reductions exert opposite effects on observed TFP and can lead researchers to underestimate the positive impact of trade reform on firms.

3 Theory

We study the effect of import competition on firms' investment in product differentiation and markups. The investment is modeled as a fixed cost to decrease the elasticity of demand that the firm faces. It is intended to capture the resources—e.g., R&D spending and managerial time—that firms allocate to the creation of new market niches where the firm can enjoy greater monopoly power. Section 3.1 presents a model with only final-goods firms to focus on the effect of tariffs on firms directly competing with imports. Section 3.3 adds input suppliers to the model. All proofs are in the Appendix.

3.1 A Model with Only Final-Goods Production

There is monopolistic competition between a fixed and finite set of firms. Firms have heterogeneous productivities. Each firm has a unique variety. Firms may exit or pay a fixed cost to produce. If the firm produces, it chooses between two levels of differentiation. Less-differentiated varieties face a higher price elasticity of demand, but they require a lower fixed cost to produce relative to the more differentiated varieties. To avoid cumbersome language, we refer to the less-differentiated varieties as "non-differentiated" and to the more-differentiated as "differentiated" although all varieties are differentiated in the sense of facing a finite elasticity of demand. Given our empirical focus on import competition, domestic firms do not export.

3.1.1 Demand

Total spending is inelastic and normalized to one. A continuum of varieties is classified into nests. Spending on a variety with price p in nest n follows a nested CES structure:

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$$x(p) = P^{\eta-1} P_n^{\sigma-\eta} p^{1-\sigma}$$
(3)
where $P_n = \left[\sum_{i \in n} p_i^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$
$$P = \left[\int P_n^{1-\eta} dn\right]^{\frac{1}{1-\eta}},$$

 P_n is the price index of nest n and P is the overall price index. Assume that the elasticity of substitution within nests is larger than across nests: $\sigma > \eta > 1$.

There are two types of nests. Nest \mathcal{O} contains all non-differentiated varieties and we denote its variables with a zero. When a firm has a differentiated variety, it is the single producer in its own nest. Then, $P_n = p$ and demand reduces to $x = (p/P)^{1-\eta}$. For simplicity, there is a continuum of nests and we take the overall price index P as exogenous. Under the interpretation that nests are sectors, differentiated products compete more directly with firms in other sectors, and the assumption that P is exogenous is justified by our empirical analysis, which exploits cross-sectoral variation. The price of individual nests P_0 and P_n for the finite set of firms modeled is endogenous.

3.1.2 Technology

In addition to pricing, each firm decides between three discrete choices. If it exits, its profit is zero. If it produces, it chooses whether to invest in product differentiation or not. The fixed cost of production is f_0 if the firm does not invest, and it is $f_D > f_0$ if the firm invests. Firm *i*'s marginal cost is c_n/ϕ_i , where ϕ_i is firm-specific productivity. Input cost $c_n = c_0$ if the product is not differentiated and $c_n = c_D$ otherwise. The assumption that c_n is common to all firms implies that any productivity gain or loss associated with the investment is common to all firms. As in Melitz (2003), c_n/ϕ_i is cost adjusted for quality. Thus the model has no predictions for prices only for markups.

3.1.3 Equilibrium

The set of potentially active firms is exogenous. One can interpret this assumption as allowing for free entry and for firms to know their productivity prior to entry. Alternatively, the Appendix endogenizes the set of firms by introducing free entry, dynamics and sunk costs.⁴ The price of foreign varieties and the productivity of each domestic firm are exogenous and known. Timing is as follows. In order of productivity, firms make their exit and investment decisions. Once these discrete choices are made, firms simultaneously set prices. We consider subgame perfect equilibria.

The timing of firms' discrete choices according to productivity is an equilibrium selection mechanism. It is well known (and easy to see) that multiple equilibria may arise when a finite set of large firms play simultaneously. But the timing here is such that, when more productive firms make their discrete choices, they fully anticipate the actions of their competitors. And so they are effectively selecting among subgame equilibria. Since uniqueness holds in each stage of each subgame, the subgame perfect equilibrium is unique by backward induction.⁵

3.1.4 Markups, Competition and Product Differentiation

To characterize the equilibrium, we focus on a firm's problem and omit the firm's subscript i. A firm in nest n chooses price p to maximizes profits

$$\pi = \max_{p} P^{\eta-1} P_n^{\sigma-\eta} p^{-\sigma} (p - c_n/\phi).$$

$$\tag{4}$$

Following Atkeson and Burstein (2008), the firm's markup over marginal cost is $\epsilon/(\epsilon-1)$, where

$$\epsilon = \sigma(1-s) + \eta s \tag{5}$$

 ϵ is the endogenous elasticity of demand with respect to price and s is the market share of the firm within its nest $s = (p/P_n)^{1-\sigma}$. The elasticity of demand is a weighted average between the elasticity within the nest σ and the elasticity across nests η . If the firm invests, $P_n = p$, s = 1 and the elasticity of its demand is η . Otherwise, $P_n = P_0$.

⁴The assumption that the set of firms is exogenous implies that import competition decreases the domestic price index. Normally, in static models with free entry and without export expansion, foreign competition induces the exit of domestic plants and has no effect on the price index. Then, import competition has no effect on the behavior of surviving firms. With sunk entry costs, firms do not immediately exit with import competition and the price index temporarily decreases as in Alessandria et al. (2014).

⁵More precisely, equilibrium is unique up to a perturbation of the parameters since multiple equilibria arise if a firm is indifferent between two subgame perfect equilibria.

The firm's operating profit with and without product differentiation is, respectively,

$$\pi_D = \frac{P^{\eta-1}}{\eta} \left(\frac{\eta c_D}{(\eta-1)\phi}\right)^{1-\eta}.$$

$$\pi_0 = P^{\eta-1} \frac{P_0^{\sigma-\eta}}{\epsilon} \left(\frac{\epsilon c_0}{(\epsilon-1)\phi}\right)^{1-\sigma},$$
 (6)

The firm chooses $\max\{0, \pi_0 - f_0, \pi_D - f_D\}$. By backward induction, we can solve for each firm's discrete choice in all subgames, starting with the least productive firms. Throughout, we ignore the uninteresting decisions at indifference points.

Proposition 1 *Exit.* There exists a unique $\tilde{\phi} > 0$ such that firms produce if and only if $\phi \geq \tilde{\phi}$. Cutoff $\tilde{\phi}$ is decreasing in P, and increasing in costs c_D and c_0 .

Although the decision to exit seems standard, the proof hinges on the assumption that more productive firms make their discrete choices first. Otherwise, the entry of a less productive firm could drive down the price index sufficiently to prevent the entry of a more productive firm.

The decision to invest, in contrast, is not monotonic in productivity. We characterize it as a function of the level of competition the firm faces, summarized by $(\phi, P_{-i0}, P, c_0, c_D)$ where P_{-i0} is the price index that firm *i* would face if it did not invest in differentiation considering all other firms' responses to firm *i*'s decision not to invest:

$$P_{-i0} = \left(\sum_{i' \neq i, i' \in \mathcal{O}(i)} p_{i'}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}.$$
(7)

where $\mathcal{O}(i)$ is the set of firms that do not invest when firm *i* does not invest.

Proposition 2 Investment. For any given (P_{-i0}, P, c_0, c_D) , there exist cutoffs $\phi > 0$ and $\overline{\phi} \ge \phi$ such that the firm does not invest if $\phi < \phi$ or $\phi > \overline{\phi}$. The upper limit $\overline{\phi}$ satisfies

- (i) $\overline{\phi} = \infty$ if $c_D < c_0$
- (*ii*) $\overline{\phi} < \infty$ if $c_D \ge c_0$

For any (P_{-i0}, P, c_0, c_D) , the set of investing firms is

- (iii) increasing in P and c_0
- (iv) decreasing in P_{-i0} and c_D

Parts (iii) and (iv) are straightforward applications of the envelope theorem to the profit function (4). For parts (i) and (ii), the Appendix shows that the set of firms investing is not necessarily convex in productivity ϕ in a given equilibrium, and it finds sufficient conditions for convexity for a given level of competition P_{-i0} .⁶

Assuming convexity and for a given (P_{-i0}, P, c_0, c_D) , figure 2A plots the net gain from investing, $(\pi_D - f_D) - (\pi_0 - f_0)$ as a function of productivity ϕ , when (a) $c_D > c_0$, (b) $c_D = c_0$ and (c) $c_D < c_0$. There are two potential gains from investing in differentiation. First, there is a productivity gain if $c_D < c_0$. As $\phi \to \infty$, this gain becomes proportional to productivity. Then, all firms with sufficiently large ϕ invest. Secondly, the investment decreases the elasticity of demand. As $\phi \to \infty$, this gain goes to zero because the firm becomes a monopolist in the non-differentiated nest \mathcal{O} and its markup converges to the differentiated firms' markup $\frac{\eta}{\eta-1}$ (elasticity $\epsilon \to \eta$ when $s \to 1$ in equation (5)). Then, very productive firms will not invest if the first gain is not present—i.e., if $c_D \ge c_0$, as stated in part (ii), and illustrated in figures 2(a) and (b). In Figure 2B, the markup is $\frac{\eta}{\eta-1}$ if the firm does not invest.

Patterns in figure 2 have close parallels in the literature. The productivity gain from investing when $c_D < c_0$ appears in Lileeva and Trefler (2010) and Bustos (2011), where there is a fixed cost to invest, and the gain is proportional to productivity. Then, there is a unique productivity threshold above which firms invest. Despite the similarities in the cross-section, if productivity were the only gain from investing, then competition would always decrease investment. So, the mechanism in Lileeva and Trefler (2010) and Bustos (2011) cannot explain the empirical regularities in section 2 above that show increases in import competition are linked to increases in firm productivity.

The novel gain is the decrease in the elasticity of demand. It is best illustrated in figures (a) and (b) where the productivity gain is not present, $c_D \leq c_0$. If the firm is sufficiently unproductive (ϕ is too small) or the market is sufficiently tight (P is too small), then the firm does not invest because sales are too small to pay for the investment. If, on the other extreme, the firm is much more productive than its competitors—relative to P_{-i0} —it faces a low elasticity of demand in nest \mathcal{O} and does not have an incentive to pay a fixed cost to further differentiate its product. In other words, a firm that is close to being a monopolist charges high markups for inferior products. This finding is supported by case studies and anecdotal evidence, surveyed in Holmes and Schmitz (2010).

⁶Sufficient conditions are (i) that all firms' market share in the non-differentiated nest is less than 0.5, or (ii) differentiated goods are sufficiently costly to produce $(c_0/c_D)^{\eta-1} < 0.5$. Arguably, the case where where firms' market shares are less than 0.5 is the empirically relevant one.



Figure 2: Gains from investing and markups

Figure 2A can also be reinterpreted to capture the effects of competition. Proposition 2 (iii) and (iv) implies that competition, broadly construed as a change in both price indices P_{-i0} and P, has an ambiguous effect on investment: P_{-i0} increases investment while P decreases it. But fixing the ratio P_{-i0}/P , competition is relaxed if either P or ϕ increases—i.e., if the firm becomes more productive relative to its competitors. The change in ϕ is precisely the exercise in figure 2. When competition is too lax and existing firms are near monopolies, they do not invest. When competition is too tight, firms do not invest because operating profits are too small to compensate for the fixed investment. This non-monotonic effect of competition on investment in R&D is reminiscent of Aghion et al. (2005) and Aghion and Griffith (2008). Our model brings these results closer to quantitative models of international trade with CES preferences.⁷

In sum, competition broadly construed has an ambiguous effect on investment. We derive sharper predictions on the effect of *import competition* by upholding Assumption 1:

Assumption 1 Tariffs are an increase in the price of non-differentiated foreign firms.

⁷Aghion et al. (2005) and Aghion and Griffith (2008) are difficult to interpret with data because its equilibrium has only one active firm per sector. Other firms affect the equilibrium through their threat of entry, but they are never observed.

There are at least four justifications for Assumption 1. First, under the interpretation that differentiated goods compete more directly with other sectors, the effect of the tariff on P is smaller than the direct effect in the non-differentiated nest \mathcal{O} . Second, Holmes and Stevens (2014) argue that differentiated goods are less tradable because they require face-to-face interactions or they are more tailored to domestic tastes. A decrease in tariffs then disproportionately affects more standardized goods. Third, the elasticity of trade with respect to trade costs is higher for varieties that are more substitutable, $\sigma > \eta$. The fourth reason is didactic. Our data and previous empirical work associate trade liberalizations to improvements in firms' productivity and demand for skills—suggesting an increase in investment and product differentiation.⁸ Assumption 1 is sufficient for large tariff reductions to always increase investment in the model:

Proposition 3 Import competition. A sufficiently large decrease in import tariffs increases exit. Among surviving firms, it increases investment in differentiation. The markup increases for firms that invest in differentiation, and it decreases for other firms.

A small decrease in non-differentiated foreign prices does not necessarily decrease P_{-i0} for all domestic firms *i* because it may lead some of firm *i*'s domestic competitors to leave nest \mathcal{O} by investing or not producing. But trivially, if P_{0F} decreases to less than the original P_{-i0} , it decreases P_{-i0} . Although the proposition holds only for "a sufficiently large decrease in import tariffs", we do not view this condition as restrictive since it merely requires competition to tighten for all domestic firms. It is easily met in our empirical application given the massive increase in imports following China's accession to the WTO.⁹

Figure 3 illustrates the effect of the tariff on the gains from investing and markups in proposition 3. We focus on the case $c_D > c_0$ but the conclusions also hold when $c_D \leq c_0$. The solid black curves are the same as in figure 2(a) with the axes flipped. The dashed red line indicates the effects of the tariff reduction. Under assumption 1, it decreases profit π_0 and has no effect on π_D . So, it unambiguously increases the net profit from investing.

In Figure 3(b), the markup increases to $\eta/(\eta - 1)$ for newly investing firms, and it decreases for firms that remain non-differentiated. This pro-competitive effect on non-

⁸See Tybout (2003), Goldberg and Pavcnik (2004) and Goldberg and Pavcnik (2007) for surveys.

⁹To see why the statement of the proposition breaks down for small decreases in P_{0F} , consider an example with two firms. Before the liberalization, the more productive firm invests because it cannot deter the entry of the second firm into nest \mathcal{O} if it invests. As foreign price P_{0F} decreases with the trade liberalization, the first firm may choose not to invest because it deters the entry of the second firm into nest \mathcal{O} . Then, firm 1 divests with the trade liberalization. In this example, however, the decrease in P_{0F} is not sufficiently large. Price index $P_{-1,0}$ increases firm 2 leaves nest \mathcal{O} , either by not producing or investing. This example highlights that strategic interactions between large firms may lead to unexpected, often counterintuitive results—as in oligopoly games in Tirole (1988).



Figure 3: Effect of a reduction in tariffs on investment and markups

differentiated firms implies that measured productivity is not a good proxy for the model's investment in differentiation. These measures of productivity are derived under the assumptions of homogeneous goods within sectors and Hicks neutrality, assumptions which are both violated by our model.¹⁰ When these assumptions fail, measured productivity generally increases in markups, and so pro-competitive effects biases downward (in absolute value) the coefficient on output tariffs on table 1. Next, we add intermediate inputs to the model to interpret the coefficient on the downstream tariff and compare it to output tariffs.

3.2 Welfare

The analysis above treats the exogenous set of firms in question as having zero measure, and so the consumer utility is a function of two exogenous parameters—his income divided by price index P. Nevertheless, we can conduct welfare analysis by assuming either that (i) the firms above are not zero measure but they are small enough to take the price index P as exogenous or (ii) the sectors not modeled arise from a continuum of sets of firms symmetric to the ones described above. In both interpretations, the positive predictions of firm behavior above remain unchanged, and yet the analysis of the welfare effect of labor allocations is a meaningful exercise. In particular, section 3.2.1 analyzes the allocation of labor across firms given the discrete choices to exit, produce a non-differentiated variety or produce a differentiated variety. Section 3.2.2 analyzes the discrete choices. Throughout,

¹⁰See De Loecker and Warzynski (2012), Ackerberg et al. (2015), DeLoecker and Pavcnik (2016), Gandhi et al. (2011). The assumption of Hicks neutrality is violated in the model with intermediate inputs and with assumption 3 on skill intensity, both below.

we study systematic deviations of the market equilibrium from the planner's optimal solution to the problem of maximizing welfare for a given total quantity of labor.

3.2.1 Productivity and Labor Allocation

A limited planner Following Edmond et al. (2015), we show that markup dispersion leads to productivity distortions. Let \mathcal{O} be the set of non-differentiated varieties (as before) and \mathcal{D} be the set of differentiated varieties. Let's start with a planner who cannot change sets \mathcal{O} and \mathcal{D} . But after firms make their discrete choices, he can unexpectedly change labor allocations. His problem is to choose quantities q_i for all $i \in \mathcal{O} \bigcup \mathcal{D}$ to solve:

$$\max U = \left[Q_0^{\frac{\eta-1}{\eta}} + \sum_{i \in \mathcal{D}} q_i^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

subject to $Q_0 = \left(\sum_{i \in \mathcal{O}} q_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$
 $L = \int_{i \in \mathcal{O}} \left(\frac{c_0}{\phi} q_i \right) + \int_{i \in \mathcal{D}} \left(\frac{c_D}{\phi} q_i \right).$ (8)

We denote utility here with U rather than Q because U is only the contribution to overall utility of the firms modeled, not including exogenous nests. The first order conditions with respect to quantities imply that a firm with productivity ϕ has quantities

$$q_0^W = \lambda^{-\sigma} \left(\frac{c_0}{\phi}\right)^{-\sigma} Q^{\sigma/\eta} Q_0^{(\eta-\sigma)/\eta} \tag{9}$$

$$q_D^W = \lambda^{-\eta} \left(\frac{c_D}{\phi}\right)^{-\eta} Q \tag{10}$$

where λ is the Lagrange multiplier for constraint (8) and we denote the firm's quantities with q_0 if its variety is not differentiated and q_D if it is differentiated.

Substituting q_0 in the definition of Q_0 and multiplying quantities by labor requirements, we get that the planner's allocation of labor for the production of non-differentiated and differentiated inputs is respectively

$$L_0^W = \lambda^{-\eta} Q C_0^{1-\eta} \tag{11}$$

$$L_D^W = \lambda^{-\eta} Q C_D^{1-\eta}$$

(12)

where price indices C_0 and C_D are

$$C_0 = c_0 \left(\int_{i \in \mathcal{O}} \phi_i^{\sigma - 1} \right)^{\frac{1}{1 - \sigma}}.$$

$$C_D = c_D \left(\int_{i \in \mathcal{D}} \phi_i^{\eta - 1} \right)^{\frac{1}{1 - \eta}}.$$
(13)

Market. Using market demand equation (3), aggregate labor demand for the production of non-differentiated and differentiated goods is

$$L_{0} = \sum_{i \in \mathcal{O}} q_{0i} \frac{c_{0}}{\phi_{i}} = Q P^{\eta} P_{0}^{\sigma-\eta} \sum_{i \in \mathcal{O}} (\mu_{0i})^{-\sigma} (c_{0}/\phi_{i})^{1-\sigma}$$

$$L_{D} = \sum_{i \in \mathcal{O}} q_{Di} \frac{c_{D}}{\phi_{i}} = Q P^{\eta} \mu_{D}^{-\eta} \sum_{i \in \mathcal{O}} (c_{D}/\phi_{i})^{1-\eta} = Q P^{\eta} \mu_{D}^{-\eta} C_{D}^{1-\eta}$$
(14)

where $\mu_{i0} = \epsilon_i/(\epsilon_i - 1)$ is the markup of non-differentiated firm *i*, and $\mu_D = \eta/(\eta - 1)$ is the markup of differentiated firms. We summarize the comparison between the planner's and the market's allocation in a lemma.

Lemma 4 Consider a planner who cannot choose sets \mathcal{O} and \mathcal{D} . After firms have made their discrete choices, the planner can reallocate labor to maximize welfare. Between any two firms in set \mathcal{O} , the planner allocates relatively more labor to the more productive firm compared to the market. The planner also allocates more labor to set \mathcal{D} relative to \mathcal{O} .

Sketch of proof. Denote with l_{0i}^W and $l_{0i'}^W$ the planner's allocation of labor for production and l_{0i} and $l_{0i'}$ the market's allocation. From demand function (3) and planner's quantities (9) and (10), the ratio of labor market allocations is

$$\frac{l_{0i}}{l_{0i'}} = \left(\frac{\mu_{0i}}{\mu_{0i'}}\right)^{-\sigma} \left(\frac{\phi_i}{\phi_{i'}}\right)^{\sigma-1} = \left(\frac{\mu_{0i}}{\mu_{0i'}}\right)^{-\sigma} \frac{l_{0i}^W}{l_{0i'}^W} < \frac{l_{0i}^W}{l_{0i'}^W}$$

where the last equality follows because $\mu_{0i} > \mu_{0i'}$ whenever $\phi_i > \phi'_i$.

As for aggregate labor allocations, L_0^W and L_D^W the appendix shows that because $\mu_D > \mu_{0i}$ for all *i*, the following inequality

$$L_0 > Q P^{\eta} \mu_D^{-\eta} C_0^{1-\eta}$$

Taking the ratios of labor allocations in equations (11) and (14), we then have:

$$\frac{L_0}{L_D} > \left(\frac{C_0}{C_D}\right)^{1-\eta} = \frac{L_0^W}{L_D^W}$$

Given the same sets \mathcal{O} and \mathcal{D} , the market allocates relatively more labor to the lowrelative to high-productivity varieties within \mathcal{O} and it allocates more labor in the nondifferentiated nest. The intuition for this result in lemma 4 is that, compared to the planner, the market allocates relatively more labor to varieties with lower markups.

3.2.2 Welfare, Exit and Product Differentiation

We now turn to the discrete choices: exit, produce, and invest. To analyze planner's optimal discrete choices, we must put some structure into the gains from allocating labor for the fixed costs to sectors not modeled. Denote with C the aggregate marginal cost of labor in the economy. For example, if marginal cost is constant in other sectors, then C = L/Q where L is the labor allocated for production and Q is aggregate utility. Define the average markup in the economy as $\overline{\mu} = P/C$, price over marginal cost. We uphold the following assumption:

Assumption 2 The market equilibrium satisfies $\overline{\mu} < \mu_D$ and $\overline{\mu} \ge \mu_{0i}$ for all *i* in the non-differentiated nest \mathcal{O} .

The equilibrium of the market satisfies $\mu_D > \mu_{0i}$ as long as there is more than one non-differentiated firm. If all sectors are modeled symmetrically to the one above, then the assumption will be satisfied when there is a sufficient number of differentiated firms so that $\overline{\mu}$ is close to μ_D , and market shares in the non-differentiated nest are sufficiently spread across firms so that no firm holds an almost monopoly and has markups close to μ_D .

We again start the analysis with a limited planner. Suppose the planner can choose sets \mathcal{O} and \mathcal{D} , but once these sets are chosen, firms are free to choose prices and quantities clear the market. Denote with $v(\mathbf{p}, w)$ the indirect utility of the consumer when the vector of prices is \mathbf{p} and consumer income is w. Denote with (\mathbf{p}_{-i}, p') the vector of prices where the i^{th} element is changed to p' and all other elements are maintained at their original \mathbf{p} prices. Then, the utility of variety i to the planner is

$$u_i = v(\mathbf{p}, 1) - v((\mathbf{p}_{-i}, \infty), 1) - f_i/C$$

where **p** is the equilibrium prices and income is set to one because it is the numeraire. That is, the utility of variety *i* is the change in indirect utility to the consumer when the price of *i* is raised from infinity to its equilibrium level and the fixed cost is reallocated from the production of other goods to variety *i* where $f_i = f_0$ if the firm is non-differentiated and $f_i = f_D$ if it is differentiated. By Roy's identity,

$$q_i(\mathbf{p}, w) = -\frac{v_i(\mathbf{p}, 1)}{v_w(\mathbf{p}, 1)}$$

where $q_i = x_i/p_i$ is demand function, v_i is the partial derivative of v with respect to p_i and v_w is the partial derivative with respect to consumer income. Using $v_w(\mathbf{p}, w) = P^{-1}$ and rearranging

$$u_i = \int_{p_i}^{\infty} v_i((\mathbf{p}_{-i}, p'), 1) dp - f/C = -P^{-1} \int_{p_i}^{\infty} q_i((\mathbf{p}_{-i}, p'), 1) dp' - f/C$$
(15)

Since differentiated firms have constant elasticity of demand, we can write the demand function as

$$q_i((\mathbf{p}_{-i}, p'), 1) = A_i(p')^{-\eta}$$
(16)

where the constant A_i is set by the terminal condition

$$q_{iD}(\mathbf{p},1) = QP^{\eta}(p_i)^{-\eta}$$

where Q = 1/P is the consumer's total utility and $p_i = \mu_D c_D / \phi_i$ is the equilibrium price of non-differentiated variety *i*. Substituting (16) into u_i in equation (), we have

$$u_{i} = C^{-1} \left[\left(\frac{\mu_{D}}{\overline{\mu}} \right) \frac{QP^{\eta}}{\eta} (p_{i})^{1-\eta} - f \right]$$

> $C^{-1} \left[\frac{QP^{\eta}}{\eta} (p_{i})^{1-\eta} - f \right] = C^{-1} \pi_{D}$ (17)

where the first line follows from derivations in the Appendix, the inequality in the last line comes from Assumption 2 and firm's profit π_D in the square brackets is in equation (6).

For non-differentiated varieties, demand at equilibrium prices is

$$q_{i0}(\mathbf{p},1) = QP^{\eta}P_0^{\sigma-\eta}(p_i)^{-\sigma}$$

where the equilibrium price for non-differentiated varieties is $p_i = \epsilon_i c_0/(\phi_i(\epsilon_i - 1))$, and ϵ_i is the elasticity of demand for variety *i* at **p**. By Assumption 2, non-differentiated varieties do not have a monopoly of nets \mathcal{O} . Then the elasticity of demand is strictly increasing in the interval $p' \in [p_i, \infty)$, and the following inequality holds:

$$u_{i} = -P^{-1} \int_{p_{i}}^{\infty} q_{i}((\mathbf{p}_{-i}, p'), 1)dp' - f/C$$

$$< P^{-1} \frac{1}{\epsilon_{i} - 1} q_{i}(\mathbf{p}, 1)p_{i} - f/C$$

$$= C^{-1} \left[\frac{QP^{\eta}P_{0}^{\sigma - \eta}}{\epsilon_{i} - 1} (p_{i})^{1 - \sigma} - f \right]$$

$$= C^{-1} \left[\left(\frac{\mu_{0i}}{\overline{\mu}} \right) \frac{QP^{\eta}P_{0}^{\sigma - \eta}}{\epsilon_{i}} (p_{i})^{1 - \sigma} - f \right]$$

$$< C^{-1} \left[\frac{QP^{\eta}}{\epsilon_{i}} (p_{i})^{1 - \eta} - f \right] = C^{-1} \pi_{0}$$
(18)

where the last line comes from Assumption 2 and firm's profit π_0 is again in equation (6). Compared to the market, the planner's valuation is multiplied by C^{-1} simply to convert units from money to labor. More relevant is that inequalities (17) and (17) imply the following lemma:

Lemma 5 Consider a planner who chooses sets \mathcal{O} and \mathcal{D} but cannot choose prices and labor allocations given these sets. Relative to this planner, the market features too much entry of unproductive, non-differentiated varieties in \mathcal{O} and too little investment in non-differentiation \mathcal{D} .

Recall that from Lemma 4, given sets \mathcal{O} and \mathcal{D} , the planner reallocates production from less productive to more productive firms within \mathcal{O} , and from set \mathcal{O} to set \mathcal{D} . So, the results in Lemma 5 hold for an unconstrained planner.

Proposition 6 Consider a planner who chooses sets \mathcal{O} and \mathcal{D} as well as labor allocations. Relative to this planner, the market features too much entry of unproductive, non-differentiated varieties in \mathcal{O} and too little investment in non-differentiation \mathcal{D} .

Proposition 3 states that import competition leads to the exit of the least productive firms and to an increase in investment in product differentiation among surviving firms. Assuming that firms close to the exit threshold are non-differentiated, Lemma 5 assures us that these trade-induced changes in discrete choices are welfare enhancing. That is, that the investment in differentiation is indeed a new gain from trade:

Corollary 7 Compared to a scenario where firms are forced not to change their discrete choices, the exit of the least productive firms from nest \mathcal{O} and the increase in investment induced by import competition is always welfare enhancing.

3.3 Extension: Upstream sector

We add an upstream sector to the model to study the effect of import competition downstream on investments and markups upstream. Accordingly, we assume that input suppliers do not export. Whenever it is important to distinguish upstream from downstream variables, we use subscript M (for "materials"). The Appendix shows that all results above hold in the extended model.

Upstream firms are modeled symmetrically to downstream firms above. There is an exogenous and finite set of input suppliers. Each firm has monopoly rights over a unique input variety. It chooses to exit, produce a non-differentiated variety, or produce a differentiated variety. The fixed cost of production is f_{0M} if the firm does not invest in differentiation, and $f_{DM} > f_{0M}$ if it invests. Non-differentiated upstream firms service only non-differentiated downstream firms, and they face a higher elasticity of demand.

Upstream firms are sufficiently large to internalize the effect of their prices on sales downstream. Although this feature of the model complicates the expression for markups upstream, it is important not to rule out a priori a pro-competitive effect of import competition downstream on upstream firms' markups.

3.3.1 Non-differentiated upstream firms

The input cost of non-differentiated final goods is

$$c_{0} = \left[(P_{0M})^{1-\eta_{M}} + (P_{M})^{1-\eta_{M}} \right]^{\frac{1}{1-\eta_{M}}}$$
(19)
where $P_{0M} = \left[\sum_{i \in \mathcal{O}_{M}} (p_{i})^{1-\sigma_{M}} \right]^{\frac{1}{1-\sigma_{M}}},$

 \mathcal{O}_M is the set of non-differentiated upstream varieties, p_i is the price of variety i, P_{0M} is the price index of non-differentiated inputs, and P_M is the price index of all other inputs—potentially including labor, capital and materials from other upstream sectors. As in the downstream sector, we take P_M to be exogenous, while price index P_{0M} and set \mathcal{O}_M are endogenous. Assume $\sigma_M < \eta_M$.

Normalize to one the input cost of non-differentiated upstream firms so that an upstream firm with productivity ϕ_M has marginal cost $1/\phi_M$. Combining equation (19) with the downstream firms' demand for inputs given c_0 , the Appendix derives the profit of this upstream firm:

$$\pi_0^M = \max_p E P_0^{\sigma - \eta} c_0^{\eta_M - \sigma} P_{0M}^{\sigma_M - \eta_M} p^{-\sigma_M} (p - 1/\phi_M)$$
(20)

where p is the price. With a finite set of varieties \mathcal{O}_M , the firm internalizes its effect on

price indices P_{0M} , c_0 and P_0 . The term

$$E = P^{\eta - 1} \sum_{i \in \mathcal{O}_H} \left(\frac{\epsilon_i - 1}{\epsilon_i} \right)^{\sigma} \phi_i^{\sigma - 1}$$

is a market size effect. Given the equilibrium timing below, the firm takes as exogenous the markups of downstream firms—it best responds to them. Price index P_0 enters the upstream firm's problem because input cost c_0 affects the sales of downstream domestic firms through competition with foreigners within nest \mathcal{O} and through competition across nests. In particular,

$$P_0 = \left[P_{0H}^{1-\sigma} + P_{0F}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

where $P_{0H} = c_0 \sum_{i \in \mathcal{O}_H} \left(\frac{\epsilon_i}{(\epsilon_i - 1)\phi_i} \right)^{1-\sigma}$

and P_{0F} are the exogenous foreign price index and \mathcal{O}_H is the set of non-differentiated downstream domestic firms. Taking first order conditions on profit (20), the optimal markup of the upstream firm is $\epsilon_M/(\epsilon_M - 1)$ where ϵ_M is the endogenous elasticity of demand:

$$\epsilon_M = \sigma_M (1 - s_M) + \eta_M s_M (1 - S_{0M}) + s_M S_{0M} \left[\sigma (1 - S_{0H}) + \eta S_{0H} \right]$$
(21)

where $s_M = (p/P_{0M})^{1-\sigma}$ is the market share of the firm in nest \mathcal{O}_M , $S_{0M} = (P_{0M}/c_0)^{1-\rho}$ is the share of nest \mathcal{O}_M in the cost of non-differentiated downstream firms, and $S_{0H} = (P_{0H}/P_0)^{1-\sigma}$ is the domestic market share in non-differentiated downstream sales.

The firm's endogenous elasticity of demand ϵ_M is a weighted average of four elasticities: σ_M, η_M, σ , and η . The first two terms capture competition between inputs. If nest \mathcal{O}_M had measure zero, then $S_{0M} = 0$ and the expression would reduce to the analogous equation (5) for downstream. The last term captures competition downstream. The share of the upstream firm in the total cost of all non-differentiated domestic downstream firms is $s_M S_{0M}$. If this share is large, the firm internalizes the effect of its prices on the sales of downstream domestic firms, firms which compete with foreigners with an elasticity σ and with other nests with elasticity η .

3.3.2 Differentiated upstream firms

As in the downstream sector, we simplify the problem of differentiated firms by assuming that there is a continuum and exogenous set of differentiated varieties. The input cost to produce differentiated final goods c_D is exogenous. An upstream differentiated firm with productivity ϕ_M charges markup $\frac{\eta_M}{\eta_M - 1}$ over marginal cost and gets profits

$$\pi_{DM} = (\phi_M)^{\eta_M - 1} X_{DM}.$$
(22)

Parameter X_{DM} captures the size of the market and its tightness, input costs, and potential productivity changes from the investment in differentiation. If $\eta_M \leq \eta$ the elasticity of demand of differentiated firms is always smaller than the endogenous elasticity ϵ_M for non-differentiated firms in equation (21).

3.3.3 Equilibrium with intermediate inputs

Price P_{0F} and productivity of all firms, upstream and downstream, are exogenous and known. Timing is as follows. (i) In order of productivity, all upstream firms make their discrete choices. (ii) In order of productivity, all downstream firms make their discrete choices. (iii) All firms, upstream and downstream, simultaneously set prices.

As before, the equilibrium is unique because uniqueness holds in all subgames (up to a perturbation of parameters). The first-mover advantage of more productive firms implies that there exist exit cutoffs, $\tilde{\phi}$ and $\tilde{\phi}_M$ for upstream and downstream firms—as per proposition 1. The assumption that discrete choices are made before prices implies that firms cannot commit on prices to manipulate discrete choices, and markup equations (5) and (21) hold. The assumption that firms simultaneously set prices implies that firms best respond to each other's markups, consistent with the set up of the problem of firms above. The assumption that upstream firms make discrete choices before downstream firms is not important.

3.3.4 Import Competition Downstream and Upstream Firms

Proposition 8 Assumption 1 holds. A sufficiently large decrease in import tariffs increases the exit of upstream firms. Among surviving upstream firms, it increases investment in differentiation. If $\eta_M \leq \eta$, the markup increases for firms that invest in differentiation.

Proposition 8 is analogous to proposition 3 for downstream firms. The direction of exit and investment is the same, and all firms that invest increase their markups. A precise quantitative comparison between up and downstream firms is infeasible because these sectors may differ in various respects—e.g., elasticities of substitution, fixed costs, distributions of technologies. Still, to get a sense of magnitude, we apply the Envelope Theorem to profits in equations (6) and (20). The elasticity of profits in the non-differentiated nest with respect to P_{0F} is the same for upstream and downstream firms:

$$\frac{P_{0F}}{\pi_0} \frac{d\pi_0}{dP_{0F}} = \frac{P_{0F}}{\pi_0^M} \frac{d\pi_0^M}{dP_{0F}} = \sigma - \eta.$$
(23)

These derivatives ignore general equilibrium effects that, with large firms, may lead to discrete jumps in profits π_0 and π_0^M . But *ceteris paribus* they suggest that incentives to invest in differentiation are not smaller for upstream firms than for downstream firms. The key assumption is that non-differentiated upstream firms sell only to non-differentiated downstream firms. Then, import competition decreases sales in the same proportion for non-differentiated upstream firms.

Pricing, in contrast, is the key difference between the up and downstream sectors. Among non-differentiated firms, tariff cuts decrease the markup of downstream firms and have an ambiguous effect on upstream firms. For easier reference, we repeat here equations (5) and (21) with the elasticity of demand of downstream and upstream firms, respectively,

$$\epsilon = \sigma(1-s) + \eta s, \tag{24}$$

$$\epsilon_M = \sigma_M (1 - s_M) + \eta_M s_M (1 - S_{0M}) + s_M S_{0M} \left[\sigma (1 - S_{0H}) + \eta S_{0H} \right].$$
(25)

Taking the partial derivative of these equations with respect to P_{0F} , we have

$$\frac{\partial \epsilon}{\partial P_{0F}} = \frac{s}{S_{0H}} (\sigma - \eta) \left(-\frac{\partial S_{0H}}{\partial P_{0F}} \right),$$
$$\frac{\partial \epsilon_M}{\partial P_{0F}} = s_M S_{0M} (\sigma - \eta) \left(-\frac{\partial S_{0H}}{\partial P_{0F}} \right).$$

Rearranging and taking the average over all non-differentiated firms, we have

$$\overline{\frac{\partial \epsilon_M}{\partial P_{0F}}} = S_{0M} \left(\frac{|\mathcal{O}_H|}{|\mathcal{O}_M|} \right) \overline{\frac{\partial \epsilon}{\partial P_{0F}}}$$
(26)

where the over line indicates the average and $|\mathcal{O}|$ indicates the number of firms in set \mathcal{O} . The sign of $\partial \epsilon_M / \partial P_{0F}$ and $\partial \epsilon / \partial P_{0F}$ is the same: Tariff reductions decreases the markup of downstream firms directly competing with imports, as well as the markups of their large input suppliers that internalize these pro-competitive effects. But the magnitude of this direct effect is much smaller for upstream firms since $S_{0M} \in (0, 1)$ is a market share.

Moreover, this small negative effect of import competition on upstream firms' markups

may be overturned by general equilibrium effects. To the extent that the decrease in tariffs leads some upstream firms to exit or invest—as the data in sections 2 and 4 suggest—the market share s_M and markup of upstream firms both increase. Equation (25) reduces to (24) in the special case where $S_{0M} = 0$. Then, sufficiently large tariffs unambiguously increase the markup of upstream firms through an increase in s_M . So, the added complication of the general case $S_{0M} \ge 0$ strengthens our result in the sense that we give the best shot to the possibility that large input suppliers decrease their markups in response to pro-competitive effects downstream, and yet we find that this effect is an order of magnitude smaller than the effect on downstream firms and that it may be overturned by general equilibrium effects on investment and exit.

To summarize, by Assumption 1, import competition downstream decreases the market for domestic non-differentiated firms. This market size effect increases exit and investment, and it has the same magnitude for downstream firms competing with foreigners and for input suppliers that do not sell to differentiated firms. Markups, in turn, are mostly determined by a firms' market share within its nest. While import competition decreases the market share of downstream firms, it does not directly change the market share of upstream firms (s_M) . If anything, exit and investment by some upstream firms increase the market share of input suppliers that remain non-differentiated.

Recall from section 2 that, in the data, a reduction in tariffs downstream increased the measured productivity of both downstream (coefficient on output tariff) and upstream sectors (coefficient on downstream tariff). Puzzlingly, the effect on upstream was persistently larger than the effect downstream. If measured productivity increases in markups, the model explains this puzzle. It predicts that the coefficient on output tariffs is biased downward (in absolute value), and the coefficient on downstream tariffs is either not biased or biased upward (in absolute value). Through the lenses of the model, the negative coefficient on output tariffs is strong evidence for differentiation and the coefficient on downstream tariffs is only suggestive.

More broadly, measured productivity is a faulty statistic to evaluate the effect of the tariff on investment in differentiation. We are not the first to observe that international trade affects firms' markups and production methods. The standard solution is to propose methods to disentangle markups from productivity. Existing methods, however, rely on the assumptions that goods are homogeneous within sectors and/or of Hicks neutrality—assumptions which are violated by the model.¹¹ Our solution is not to search for a perfect statistic, but to propose other measures to supplement section 2.

¹¹Hicks neutrality is violated with the assumption that differentiated firms use different material inputs and they are more skill intensive (below).

3.4 Other Proxies for Investment

Assumption 3 Investment in differentiation is associated with:

- (i) the introduction of new goods,
- (ii) a higher probability of switching sectors,
- (iii) an increase in skill intensity.

Parts (i) and (ii) are almost tautological. Mechanically in the model, investment in differentiation changes the variety the firm produces, and differentiated varieties compete more directly with other sectors. In the data, investment in product differentiation may be changes in the physical features of products, as well as changes in product appeal through advertising or added customer service. Among these variables, we observe in the data the introduction of new products and firms' switching sector. Part (iii) holds if differentiated goods have on average higher quality since there is ample evidence that higher-quality goods are skill intensive.¹² It may also hold if new products induce restructuring of the firm's management or production processes, and implementing these changes requires skilled labor. Corollary 9 below summarizes propositions 3 and 8 highlighting the links to the data that we'll test in section 4.

Corollary 9 A sufficiently large decrease in tariffs has the following effects on downstream firms

- (i) it increases exit
- (ii) it increases the probability of switching sectors
- (iii) it increases the introduction of new goods
- (iv) it increases skill intensity
- (v) it decreases sales of non-differentiated firms
- (vi) it decreases the profit margin of non-differentiated firms

Effects (i) through (v) hold also for upstream firms.

 $^{^{12}}$ See Bernard et al. (2007), Verhoogen (2008), Fieler et al. (2017).

4 Additional Empirical Results

Section 4.1 uses accounting margins to check if profit margins disproportionately fall for import-competing firms, prediction (vi) of corollary 9. Section 4.2 searches for evidence associating tariff reductions with the introduction of new goods, sector switching and skill intensity—predictions (ii), (iii) and (iv) of corollary 9. We do not observe skill intensity for each firm and year. But using data from 2004, the only year where firms' skill intensities are available, we construct measures of sectoral skill intensities. Section 4.2 shows that firms that switch sectors in response to tariff cuts generally switch to more skill-intensive sectors. The predictions that tariff reductions (i) increases exit and (v) decrease sales are standard in heterogeneous-firm models. So, we relegate these results to the Appendix and discuss them briefly in section 5 below.

4.1 Profit Margins

We estimate the determinants of accounting profits, which we define as the establishment level reported gross profits in Chinese currency as a share of establishment revenues.¹³ The survey form indicates that gross profits are defined as revenues less cost of goods sold. The results are reported in Table 3. The first three columns report the results for all enterprises, while the next four columns separate the results into non-exporters (columns (4) and (5)) and exporters (columns (6) and (7)). Since the model was developed for firms targeting the domestic market, we expect the results to apply most strongly to the sample of enterprises that primarily sell domestically.

The results in Table 3 confirm the predictions of the model. In most specifications, only output tariffs positively and significantly affect accounting profits. Downstream tariffs generally have no significant impact on supplier firms. As predicted, these results are strongest and only significant for non-exporters. These markup results are consistent with results in Tables 1 and 2 indicating that positive TFP effects of tariffs in the final-goods sector may be observationally difficult to identify due to declining revenue from falling markups.

The coefficient on log final-goods tariffs ranges from 0.254 in column (1) to 1.710 in column (4). For firms that do not export, this implies that a two standard deviation reduction in tariffs would lead to a reduction in ROS of between .25 to 1.7 percentage points. Since the average ROS in the sample is five percentage points, this is a significant

¹³An alternative is to follow De Loecker and Warzynski (2012). The issue with their measure is that it requires goods to be homogeneous within sectors, like Olley-Pakes. Loecker and Warzynski explicit admit that their results on measured productivity could be driven by quality upgrading (see page 2441).

Dependent variable: Reported Gross Profit Margin as a Share of Sales						
	All Ent Excludi and Mult	erprises ng SOEs inationals	Only Non-	-Exporters	Only E	xporters
	OLS (1)	IV (2)	$OLS \\ (3)$	IV (4)	OLS (5)	IV (6)
$\log output_tariff$	0.254^{**} (0.1160)	1.596^{***} (0.3030)	0.324^{**} (0.1450)	1.710^{***} (0.3040)	$0.093 \\ (0.1260)$	-0.529 (2.6830)
log downstream_tariff	-0.202 (0.1470)	$0.66 \\ (0.6980)$	-0.223 (0.1740)	1.177 (0.8830)	-0.201 (0.1590)	$1.068 \\ (2.7910)$
log upstream_tariff	$\begin{array}{c} 0.0186 \ (0.3050) \end{array}$	2.049^{*} (1.0460)	-0.176 (0.3930)	1.577 (1.1210)	$0.37 \\ (0.2750)$	$1.322 \\ (5.2250)$
index_subsidy	$\begin{array}{c} 0.792^{***} \\ (0.0571) \end{array}$	0.793^{***} (0.0356)	$\begin{array}{c} 0.944^{***} \\ (0.0663) \end{array}$	$\begin{array}{c} 0.941^{***} \\ (0.0468) \end{array}$	$\begin{array}{c} 0.429^{***} \\ (0.0629) \end{array}$	$\begin{array}{c} 0.420^{***} \\ (0.0510) \end{array}$
$index_tax$	$2.931^{***} \\ (0.1410)$	$\begin{array}{c} 2.929^{***} \\ (0.0209) \end{array}$	3.018^{***} (0.1590)	3.017^{***} (0.0244)	$2.482^{***} \\ (0.1170)$	$2.481^{***} \\ (0.0433)$
index_interest	$0.036 \\ (0.0304)$	$0.0329 \\ (0.0215)$	$0.0397 \\ (0.0327)$	0.0381 (0.0254)	0.0257 (0.0605)	$0.0291 \\ (0.0414)$
State_share	-0.281^{**} (0.1220)	-0.249^{*} (0.1330)	-0.366^{***} (0.1330)	-0.331^{**} (0.1520)	-0.115 (0.2610)	-0.104 (0.3060)
Horizontal FDI	-1.061 (0.694)	-3.399^{***} (0.473)	-1.273 (0.902)	-3.898^{***} (0.572)	-1.047^{*} (0.578)	-2.534 (1.825)
Downstream FDI	-0.121 (1.755)	-3.840^{**} (1.765)	1.047 (2.387)	-3.677^{*} (2.190)	$0.0225 \\ (1.624)$	-3.36 (10.810)
Upstream FDI	$0.155 \\ (0.372)$	$\begin{array}{c} 2.477^{***} \\ (0.509) \end{array}$	$0.407 \\ (0.508)$	$2.952^{***} \\ (0.608)$	0.247 (0.270)	0.0176 (3.217)
Observations	981,001	981,001	776,775	776,775	204,226	204,226

Table 3: Accounting Margins and Tariffs

Standard errors are clustered. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

but not implausibly large effect. In contrast, tariffs have no impact on markups for firms oriented towards export markets, as indicated by the results in columns (5) and (6).

4.2 Switching products

The model predicts that firms invest in differentiation to escape import competition caused by falling tariffs. Under assumption 3, this investment is associated with an increase in skill intensity. Although we do not observe firms' skill intensity in every year in our data, the 2004 survey asked firms for details on the composition of their work force. We use this 2004 cross-section to measure sectoral skill intensity and then verify whether tariff cuts prompted firms to switch to more skill-intensive sectors.

In particular, we define skilled workers as those who have completed a three- or fouryear college degree, senior high, mid- and high-level technicians, and mid- and high-level engineers.¹⁴ We calculate the share of skilled workers in each firms' labor force in 2004 and then aggregate this firm level information to the sector level to construct a ranking of sectors in increasing order of skill intensity. There are 450 sectors in the data. The least skill intensive sector was the production of packaging and bags, while the most skill intensive sector was a subsector in aircraft manufacturing.

We then merge these sectoral ranks with our panel of firms, from 1998 to 2007. Table 4 regresses sectoral rank (with highest indicating most skill-intensive) on the three measures of tariffs and a number of control variables. For example, the fourth row suggests that a typical firm receiving subsidies moves to a more skill intensive sector by half a sector to a full sector. Since all specifications include firm fixed effects, the identification stems from changes in sectoral affiliation within the firm.

Many of the coefficients reported in Table 4, while not the focus of this paper, are of interest in themselves and seem plausible. For example, the large and negative coefficient on sectoral export share indicates that a sector which moved from no exports to 100 percent exports would move down the sectoral ranking by almost 200 steps. The results also suggest that additional foreign investment in the same sector is associated with an improvement in the ranking of 25 to 56 steps, while an increase in foreign investment downstream is associated with a large increase in the quality of suppliers.

For this paper, the coefficients of interest are the tariff variables. The first two columns report coefficients for all firms. The middle two columns report OLS and IV results for non-exporters, while the last two columns report the same specifications for

¹⁴We could have chosen to use only a subset of these designations to define sectors as highly skilled intensive, but since all alternative measures are highly correlated with each other, the choice of which occupations to include is not critical.

Dependent variable: Ranking of sector according to skill intensity						
	All Ent Excludit and Mult	erprises ng SOEs inationals	Only Non-Exporters Only Exporter			xporters
	OLS (1)	IV (2)	$OLS \\ (3)$	IV (4)	OLS (5)	IV(6)
Output Tariff	-19.38^{***} (4.58)	-26.32^{***} (0.84)	-20.36^{***} (4.12)	-19.64^{***} (0.84)	-14.85^{**} (6.56)	-146.2^{***} (12.58)
Downstream Tariff	9.437^{*} (5.12)	-27.92^{***} (2.05)	$8.102 \\ (5.52)$	-26.40^{***} (2.48)	9.727^{*} (5.06)	-120.7^{***} (11.80)
Upstream Tariff	25.92^{**} (10.65)	104.7^{***} (3.04)	28.02^{***} (10.44)	89.58^{***} (3.24)	20.33 (12.22)	278.6^{***} (21.69)
$\mathrm{index}_{-} \operatorname{subsidy}$	0.562^{**} (0.22)	$\begin{array}{c} 0.648^{***} \\ (0.12) \end{array}$	0.743^{**} (0.31)	$\begin{array}{c} 0.788^{***} \\ (0.14) \end{array}$	$0.362 \\ (0.26)$	$0.449 \\ (0.36)$
$index_tax$	$0.104 \\ (0.11)$	0.124^{*} (0.07)	$\begin{array}{c} 0.163 \\ (0.11) \end{array}$	$0.12 \\ (0.08)$	-0.262 (0.17)	$0.248 \\ (0.27)$
index_interest	-0.379^{**} (0.143)	-0.339^{***} (0.083)	-0.442^{***} (0.146)	-0.453^{***} (0.095)	-0.294 (0.193)	-0.233 (0.296)
Export Share (Sector Level)	-189.1^{***} (24.55)	-185.3^{***} (1.58)	-200.1^{***} (27.76)	-198.1^{***} (1.95)	-173.2^{***} (22.97)	-107.5^{***} (7.73)
State Share	-0.155 (0.509)	$\begin{array}{c} 0.0461 \\ (0.341) \end{array}$	-0.334 (0.593)	-0.0648 (0.382)	$0.354 \\ (0.797)$	$\begin{array}{c} 0.325 \ (1.306) \end{array}$
Horizontal FDI	50.76^{*} (30.11)	25.41^{***} (1.54)	52.72^{*} (30.35)	32.64^{***} (1.71)	55.77^{*} (30.98)	-80.68^{***} (12.10)
Downstream FDI	478.3^{***} (103.80)	525.2^{***} (5.40)	$491.2^{***} \\ (114.60)$	528.3^{***} (6.43)	$\begin{array}{c} 438.0^{***} \\ (91.09) \end{array}$	940.5^{***} (44.62)
Upstream FDI	-57.24^{**} (24.66)	-67.61^{***} (1.35)	-67.36^{**} (27.44)	-71.95^{***} (1.61)	-32.88 (21.62)	-169.2^{***} (13.77)
Observations	982,143	982,143	777,740	777,740	204,403	204,403

Table 4: Movements to Sectors with Higher Skilled Worker Share Based on 2004 survey

Sectors with a higher rank (number) are more skill intensive. Robust standard error in parenthesis. All regressions include firm fixed effects. Results with sector fixed effects appear in Appendix.

establishments with positive export sales.

The coefficient on the log of tariffs is consistently negative and significant, with point estimates ranging from -15 to -146. The results indicate that a decline in output tariffs is associated with an increase in movement to more skill intensive sectors, as proxied by the sophistication and education of the labor force. The point estimates indicate that a one standard deviation reduction in log tariffs (around .5) would be associated with a movement up the rank of between 7 and 125 sectors. The coefficient on upstream tariffs, on the other hand, is positive. The positive coefficient on upstream tariffs suggests that a reduction in tariffs on inputs would be associated with a movement down the rank towards less skill-intensity for imported inputs.

The coefficient on downstream tariffs in all IV specifications is also negative and significant. Consistent with the model, a tariff reduction in the downstream sector is accompanied by an increase in the skill intensity of local suppliers. The magnitudes are very close to those for output tariffs. The evidence on sector shifts is consistent with the model, with firms investing in innovation in order to escape competition brought on by lower tariffs. In the case of sectoral shifts, we see that the fraction of firms that do change sectors move to more skilled intensive products as output and downstream tariffs fall. In the sample, approximately 15 percent of establishments change sectoral affiliation over the 1998 through 2007 period.

Another way to measure innovation in this data is through the introduction of new products. We measure this introduction of new products in two ways. First is the share of new products in total sales, as reported at the establishment level. Second, we use a dummy variable equal to one if the establishment introduces a new product in a particular year. If a reduction in protection is associated with innovation or escaping competition, we would expect that tariff reductions would be associated with an increase in either the share of new products or the introduction of a new product. Our results are reported in Table 5.

The coefficients of interest are primarily the first three rows of Table 5. Focusing on the IV specifications, column (2) indicates that a one standard deviation reduction in log output tariffs (around .5) would be associated with an increase in new products of 0.8 percentage points in total sales (multiplied by -0.0164). The coefficient on downstream tariffs is also significant and negative but is twice as large. One standard deviation reduction in downstream tariffs is associated with an increase in the share of new products in revenues of 1.5 percentage points.

Columns (3) and (4) of Table 5 repeat the estimation but instead use a zero-one dummy as an indicator of whether the enterprise introduced a new product. The results indicate

	All Enterp	rises excludi	ng SOE's and r	nultinationals	Only Non-Expor	rting Enterprises
dependent variable \rightarrow	new	new	0-1 dummy for	0-1 dummy for	0-1 dummy for	new
	product	product	introducing	introducing	introducing	product
	share	share	a new	a new	a new	share
			product	product	product	
	OLS	IV	OLS	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(9)
log output_tariff	-0.000475	-0.0164^{***}	-0.000554	-0.0413^{***}	-0.0309^{***}	-0.0107^{***}
	(0.0021)	(0.0044)	(0.0047)	(0.0091)	(0.0077)	(0.0038)
log downstream_tariff	-0.00369	-0.0302^{***}	0.00824	-0.0606***	-0.0547^{***}	-0.0359^{***}
	(0.0033)	(0.0106)	(0.0105)	(0.0209)	(0.0212)	(0.0110)
log upstream_tariff	0.0032	0.0349^{**}	-0.000129	0.110^{***}	0.100^{***}	0.0419^{***}
	(0.0045)	(0.0161)	(0.0110)	(0.0325)	(0.0286)	(0.0146)
index_subsidy	0.00653^{***}	0.00657^{***}	0.0175^{***}	0.0177^{***}	0.0118^{***}	0.00455^{***}
	(0.0012)	(0.0007)	(0.0025)	(0.0013)	(0.0013)	(0.007)
index_tax	-0.000638*	-0.000606*	-0.00206^{***}	-0.00197^{***}	-0.00136^{**}	-0.000427
	(0.0003)	(0.0003)	(0.0008)	(0.0006)	(0.0006)	(0.0003)
index_interest	-0.00189^{***}	-0.00183^{***}	-0.00635^{***}	-0.00619^{***}	-0.00356^{***}	-0.000957^{**}
	(0.0005)	(0.0004)	(0.0014)	(0.0008)	(0.0007)	(0.0004)
exportshare_sector	-0.0123	0.00743	0.000489	0.0405^{**}	-0.00905	0.00128
	(0.012)	(0.008)	(0.028)	(0.016)	(0.017)	(0.00)
$State_share$	0.000572	0.000457	0.00578	0.0056	0.00177	-0.000349
	(0.0021)	(0.0020)	(0.0036)	(0.0039)	(0.0038)	(0.0021)
Horizontal FDI	0.0315^{**}	0.0227^{***}	0.0201	-0.0128	0.0176	0.0215^{**}
	(0.014)	(0.00)	(0.035)	(0.017)	(0.016)	(0.008)
Downstream FDI	-0.0127	0.0327	-0.0577	0.0434	0.041	0.0563^{*}
	(0.030)	(0.030)	(0.070)	(0.057)	(0.057)	(0.031)
Upstream FDI	-0.00734	-0.0301^{***}	-0.0156	-0.0713^{***}	-0.0588***	-0.0294^{***}
	(0.008)	(0.008)	(0.016)	(0.016)	(0.016)	(0.009)
Observations	982, 142	982, 142	982, 142	982, 142	777,739	777,739

Table 5: Introduction of New Goods, Instrumental Variable Estimates

Robust standard errors in parentheses. Dependent variable is either a dummy variable equal to 1 if a new product is introduced by the enterprise in that year or the share of new products in revenues. All specifications include firm fixed effects and time effects. Instruments in the IV specifications for log of output tariff, downstream tariff, and upstream tariff include the WTO dummy interacted with the initial tariff. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1. that a reduction on both output and downstream tariffs are associated with a significant increase in the introduction of new products. The results are robust to restricting the sample only to non-exporting enterprises, as reported in the last four columns of Table 5. In all, Table 5 provides evidence that import-competing firms and their input suppliers innovate in response to tariff reductions. Perhaps even more surprisingly, they shift their economic activity toward more skill-intensive sectors, China's comparative disadvantage sectors.

5 Extensions and Robustness Tests

In this section, we explore further implications of our theory and additional robustness tests. We begin by exploring whether the significant sector switching that occurs among firms is systematically related to tariff changes. We then explore whether firms are more likely to exit, as predicted by our model, when tariffs decline. A number of robustness tests are reported as well. We explore whether selection could be driving our results, as firms are more likely to exit as reduced tariffs induce greater competition. Finally, we explore the robustness of our results to alternative measures of total factor productivity and to inclusion or exclusion of certain key sectors like textiles and apparel and the computer industry.

Our results in previous sections suggest a systematic relationship between tariff reductions and sector switching to more skill intensive sectors. If this is the case, then we would expect that tariff changes would affect the likelihood of sector switching. We explore this possibility in Table 6. The dependent variable is a dummy variable equal to 1 if the enterprise switches from one two-digit sector to another. Recall that we have 71 of these two digit sectors that have been normalized to take into account classification changes over the sample period. We estimate a probit regression and report the results for all enterprises, non-exporters, and exporters. The results indicate that enterprises are more likely to switch sectors if tariffs fall, although the effects are less strong for output tariffs. For downstream tariffs, the results suggest that a one standard deviation reduction in downstream tariffs would increase the probability of sector switching by 8 to 9 percentage points. These results are consistent with our earlier results suggesting movement towards more skilled sectors as a result of tariff declines.

The other results in Table 6 are also of interest. The positive coefficient on subsidies indicates that firms receiving subsidies are more likely to switch sectors. Conversely, firms receiving tax breaks or low interest loans are less likely to switch sectors. Firms in sectors with a high share of export activity are more likely to switch sectors unless

	All enterprises (1)	Non-Exporters (2)	Exporters (3)
log output_tariff	-0.0117*	-0.00131	-0.0720***
.0 I	(0.0070)	(0.0080)	(0.0143)
log downstream_tariff	-0.161***	-0.179***	-0.00749
0	(0.0111)	(0.0127)	(0.0243)
log upstream_tariff	-0.155***	-0.205***	-0.0401
0	(0.0140)	(0.0157)	(0.0307)
index_subsidy	0.133***	0.138***	0.0800***
U	(0.0090)	(0.0109)	(0.0165)
index_tax	-0.0169***	-0.0144**	-0.0135
	(0.0063)	(0.0072)	(0.0134)
index_interest	-0.0449***	-0.0346***	-0.0635***
	(0.0067)	(0.0077)	(0.0136)
exportshare_sector	0.167***	0.312***	-0.468***
-	(0.031)	(0.039)	(0.058)
State_share	-0.177***	-0.136***	-0.376***
	(0.0279)	(0.0316)	(0.0602)
Horizontal FDI	-0.212***	-0.167***	-0.437***
	(0.053)	(0.061)	(0.107)
Downstream FDI	2.291***	2.370^{***}	2.121***
	(0.114)	(0.133)	(0.225)
Upstream FDI	0.287^{***}	0.294^{***}	0.233***
	(0.030)	(0.035)	(0.057)
Observations	931,429	736,941	194,488

Table 6: Probit Regression of Whether or Not Establishment Switched Sector

Dependent variable is is a zero-one dummy variable for whether or not the enterprise changed sector. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1. they are exporters; if they export, then firms in export-intensive sectors are less likely to switch. Firms in sectors with a high share of foreign investment are less likely to switch sectors. However, firms supplying to foreign firms or firms in sectors with a high share of foreign suppliers are more likely to switch sectors.

Our model indicates that import competition increases the probability of exit. We test this theoretical prediction in Appendix Table A.3. While the probit estimates in the first three columns of the table are reported for illustrative interest, we focus on the linear probability model in the last three columns where we instrument tariffs with initial tariffs interacted with the WTO dummy. The coefficients on output tariffs and downstream tariffs are negative, indicating that a reduction in tariffs raises the probability of exit. In contrast, the coefficient on upstream tariffs is positive and significant, indicating that a reduction in tariffs on inputs reduces the probability of exit. If we focus on the last column, which reports the results for non-exporters who do not change sector, the magnitudes are highest for downstream and upstream tariffs. The coefficients indicate that a one standard deviation reduction in tariffs would increase the probability of exit by 4.2 percent for output tariffs, and by nearly 20 percent for downstream tariffs. For upstream tariffs, a one standard deviation reduction in tariffs would reduce exit by nearly 15 percent.

Appendix Table A.4 explores the robustness of our results to alternative specifications. In particular, we test whether the results are affected by multicollinearity. We explore whether the coefficients change if we only put in tariffs one at a time. This extension is important in case the multicollinearity between final goods and downstream tariffs (their correlation is around .5) drive the lower coefficient on final goods tariffs. Multicollinearity does not seem to be a problem, as the coefficient magnitudes are generally unaffected by entering tariffs into the equation one at a time.

The next sets of tables explore the importance of selection and whether or not it affects our results. Following Wooldridge (2002), we test for survivorship bias by including a lead of the selection indicator $s_{i,t+1}$ in our estimating equations, where $s_{i,t+1}$ is equal to 0 for firms that do not exit the sample and switches from 0 to 1 in the period just before attrition. The coefficient on the lead of the selection indicator was negative and significant in our TFP regressions. When results suggest that such a "pre-exit" dummy is significant and negative, this suggests that firms that are likely to exit the sample are less productive. These results are not surprising and are consistent with a number of studies.

To test whether selection affected our core results, we performed two tests. The first test is to retain all enterprises that were present in all years in the sample. By creating this so-called balanced panel, we eliminated ninety percent of the sample, and only retain 65,239 observations because the vast majority of enterprises do not have a complete time series. With this much smaller sample, we repeated the main specification from Table 1 and report the results in Appendix Table A.5. The results are remarkably consistent with our first set of results. Output and downstream tariffs negatively affect productivity, with magnitudes almost ten times larger for downstream tariffs than output tariffs.

For our second test, we follow Wooldridge (2010) and construct a Heckman-type correction in the context of a panel dataset with firm fixed effects. In the context of panel data with an unobserved firm fixed effect and attrition, Wooldridge proposes as a solution a variant of a two-stage Heckman correction. In each period, Wooldridge proposes estimating a selection equation using a probit approach and calculating lambda, the inverse Mills ratio, for each parent *i*. Once a series of lambdas has been estimated for each year and parent, the estimating equations are augmented by these lambdas. This approach is successful only if we can identify determinants of the binary selection variable set before the firm exits the sample (in period t-1) that do not belong in the estimating equation. We identify candidate variables using the insights from models where heterogeneity in productivity is a significant determinant of whether firms enter into international trade or foreign investment (see Melitz (2003)). In these models, only the most profitable firms survive. Since we already control for output and factor price shocks using a variety of input and output price deflators, we use the establishment's profitability in the previous period as the determinant of survival that does not appear in the estimating equation.

Appendix Table A.6 reports the second-stage estimates using this two-step approach. The first four columns include all observations, while the last two columns include only non-exporters. The sample size decreases, since implementing the selection correction eliminates the first time-series observation for each firm. The coefficients on the inverse Mills ratios are statistically significant across all specifications, indicating that selection could have biased the results. Nonetheless, adding the inverse Mills ratio to control for selection does not change the sign and barely changes the point estimates of the coefficients of interest.

The last table Appendix Table A.7 has three components. We first explore the robustness of the results to dropping some key sectors. Since there were major liberalizations in textiles and apparel during this period, one concern is that the results only reflect these sectors. The Multi-fibre Agreement (MFA) was phased out during this time and could have played a major role in driving the results. Consequently, columns (1) and (2) drop those sectors and show that our main results are unaffected. Columns (3) and (4) repeat this exercise but instead drop the computer and computer peripherals sector. These sectors experienced large growth due to offshoring. The last two columns explore the robustness of the results to including tariffs in the first stage of the TFP estimation using Olley and Pakes. The first stage of the OP approach has been critiqued on the grounds that excluding policy variables may lead to biased estimates of the key factor share parameters on labor, capital, and materials. One simple solution is to add policy variables in the first stage to ensure that coefficients on key inputs are properly measured and there is no omitted variable bias. Our results in the last two columns of Appendix Table A.7 indicate that adding policy variables to the OP first stage does not significantly affect the TFP results.

The last robustness test, with results reported in Appendix Table A.7, uses an alternative TFP estimation strategy to OP. In particular, we implement Caves, Fraser, and Ackerberg (ACF) and test the robustness of the TFP results to this alternative strategy. ACF argue that there are some key shortcomings to OP, particularly in terms of identification of parameters of the production function. Using their approach, we show that our results are robust to alternative measurement strategies for TFP.

6 Concluding Comments

This paper proposes a new gain from trade: Firms invest to differentiate their products when import competition tightens. We provide evidence that this gain accrues both to import-competing firms and to their suppliers. In particular, final goods and downstream tariff reductions are associated with productivity gains for both of these sets of firms, and the gains are generally larger for suppliers facing a cut in downstream tariffs than for firms directly competing with imports. We argue, however, that productivity measures capture both the investment in differentiation and changes in markups. Since these two effects go in opposite directions for import-competing firms, measured TFP is biased downward (in absolute value) and hence a faulty statistic to assess the effects of import competition on firms. This means that an additional benefit of focusing on the linkages between downstream tariffs and upstream behavior is to disentangle markups from productivity, as our results suggest that downstream tariffs are not typically associated with higher markups for upstream firms.

Alternatively, we also search for evidence of investment in differentiation using other firm outcomes. Tariff reductions increase the probability that both import-competing firms and their input suppliers switch sectors and that they switch to more skill-intensive sectors. These firms also introduce new products. These results together are inconsistent with previous models of international trade—the classic models of factor proportions as well as more recent models of heterogeneous firms with multiple products. So, together, these results provide suggestive evidence for our mechanism: Firms escape import competition by differentiating their products and creating new market niches. As firms differentiate, they push their suppliers to also invest in differentiation—introduce new products and switch to skill-intensive sectors.

The link between investments upstream and downstream appears in previous work on foreign investment, but has not been examined either theoretically or empirically to study the effects of import penetration. For the Chinese experience, we show that the biggest gains in productivity occurred through a reduction in downstream tariffs. Downstream tariffs induced upstream suppliers to differentiate products, switch to higher skilled sectors, and increase productivity. These effects are much larger than the impact of tariff reductions in the same sector. While previous work on unilateral trade reforms has measured the impact of final goods tariffs and input (upstream) tariffs on firm performance, to our knowledge this is the first paper to measure the impact of downstream tariffs on firm performance.

The introduction of new products and skill intensity have been used to analyze the effects of imported inputs on firms, and skills have been used to analyze the effects of import competition. By putting these elements together and focusing on import-competing firms and their input suppliers, this paper brings us closer to a more complete picture of the effects of international trade on firms.

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Escaping import competition and Downstream Tariffs

Appendix

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Contents

Α	Add	litional Empirical Results	1
в	App	pendix to Theory	10
	B.1	Downstream Firms	10
	B.2	Welfare in model with only final goods	14
		B.2.1 Productivity and labor allocation	14
		B.2.2 Welfare and Discrete Choices	16
	B.3	Upstream firms	19
	B.4	Equilibrium with free entry and intermediate inputs	20

A Additional Empirical Results

This Appendix presents additional empirical results. Table A.1 reports the coefficients on all control variables of Table 2 in the main text. Industrial policy is captured through zero-one dummy variables indicating whether the firm received subsidies ("index_subsidy"), whether the firm received a tax holiday ("index_tax"), and whether the firm paid below median interest rates on loans ("index_interest"). These policies are self-reported by the firm in the survey. The results suggest that subsidies and tax holidays are associated with higher TFP at the firm level, while subsidized interest rates are associated with lower TFP. The impact of vertical linkages from foreign investment is generally positive and significant, while horizontal linkages are insignificant in the OLS specifications but positive and significant in the IV specifications. We refer the reader to the main text for explanations on the remaining tables.

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1					<u> </u>	D (
	ÔÐ	All Ente	erprises	F F	Only Non-	-Exporters
	OP	FE	OP	FE	OP	OP
	OLS	OLS	IV	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
$output_tariff$	-0.0285***	-0.0297***	-0.0421***	-0.0372***	-0.0329***	-0.0520***
	(0.0067)	(0.0070)	(0.0108)	(0.0111)	(0.0078)	(0.0114)
$downstream_tariff$	-0.0245*	-0.0254*	-0.117**	-0.123**	-0.0319^{**}	-0.573***
	(0.0135)	(0.0146)	(0.0515)	(0.0520)	(0.0151)	(0.0739)
$upstream_tariff$	-0.0195	-0.019	-0.737***	-0.814^{***}	-0.00961	-0.413***
	(0.0175)	(0.0188)	(0.0690)	(0.0702)	(0.0181)	(0.0710)
index_subsidy	0.00783^{***}	0.00972^{***}	0.00633^{***}	0.00806^{***}	0.00644^{***}	0.00480^{***}
	(0.0015)	(0.0015)	(0.0012)	(0.0012)	(0.0021)	(0.0016)
index_tax	0.0239^{***}	0.0245^{***}	0.0243^{***}	0.0250^{***}	0.0234^{***}	0.0238^{***}
	(0.0011)	(0.0011)	(0.0008)	(0.0008)	(0.0011)	(0.0010)
index_interest	-0.00596***	-0.00711***	-0.00497***	-0.00605***	-0.00794^{***}	-0.00694^{***}
	(0.0013)	(0.0013)	(0.0009)	(0.0009)	(0.0012)	(0.0011)
$exportshare_sector$	0.128	0.151	0.521***	0.577***	0.148	0.641***
	(0.154)	(0.160)	(0.038)	(0.039)	(0.184)	(0.052)
State_share	-0.0195***	-0.0184***	-0.0240***	-0.0233***	-0.0185***	-0.0218***
	(0.0032)	(0.0036)	(0.0030)	(0.0030)	(0.0038)	(0.0035)
Horizontal FDI	0.0109	0.0193^{*}	0.00657	0.0144	0.00176	-0.00234
	(0.010)	(0.010)	(0.010)	(0.011)	(0.017)	(0.017)
Downstream FDI	0.15	0.2	-0.0265	0.00927	0.232	0.0767^{**}
	(0.197)	(0.213)	(0.026)	(0.027)	(0.228)	(0.033)
Upstream FDI	1.394	1.294	2.223***	2.227***	1.211	1.572***
	(0.851)	(0.914)	(0.141)	(0.145)	(0.881)	(0.167)
Change in four-digit sector	0.218	0.205	0.330***	0.343***	-0.0353	0.209***
	(0.4070)	(0.4040)	(0.0475)	(0.0482)	(0.4920)	(0.0606)
Observations	821,970	821,970	821,970	821,970	619,448	619,448

Table A.1: Basic regressions including SOE's and Firms with Minority Foreign Ownership and lagged tariffs

Dependent variable:	TFP measured	l à la Olley-Pakes ((OP) or OLS	with fixed effects	(FE)
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Standard errors are clustered. All specifications include fixed effects for the firm, time, and two-digit sector. All specifications also include a dummy variable equal to 1 if the firm changes a four digit sector as well. IV estimates use initial 1998 tariffs and initial tariffs interacted with a WTO dummy as instruments. Tariffs are lagged and regressions include state-owned enterprises, and firms with minority foreign ownership. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

Dependent variable	: TFP measu	ıred à la Olle	y-Pakes (OP)) or OLS wit	th fixed effe	cts (FE)
	All Enterpri	ses Excluding S	SOEs and Mult	inationals	Only Non-	Exporters
	OP	\mathbf{FE}	OP	\mathbf{FE}	OP	\mathbf{FE}
	OLS	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)
$Output_tariff$	0.0269	-0.00214	-0.00601	-0.00709	-0.0467***	-0.0296***
	(0.0218)	(0.0184)	(0.0115)	(0.0113)	(0.0116)	(0.0114)
Downstream_tariff	-0.0721	-0.108**	-0.0163	-0.101^{***}	-0.239***	-0.285^{***}
	(0.0524)	(0.0506)	(0.0268)	(0.0252)	(0.0327)	(0.0315)
Upstream_tariff	-0.117	0.0916	-0.533***	-0.382***	-0.366***	-0.289***
	(0.0754)	(0.0613)	(0.0431)	(0.0422)	(0.0470)	(0.0457)
Index_subsidy	0.00895^{***}	0.0126^{***}	0.00838^{***}	0.0118^{***}	0.00658^{***}	0.00925^{***}
	(0.0018)	(0.0016)	(0.0013)	(0.0012)	(0.0016)	(0.0015)
Index_tax	0.0213***	0.0219***	0.0213***	0.0217***	0.0211***	0.0218***
	(0.0009)	(0.0009)	(0.0008)	(0.0008)	(0.0009)	(0.0009)
Index_interest	-0.0134***	-0.0150***	-0.0134***	-0.0151***	-0.0153***	-0.0168***
	(0.0016)	(0.0014)	(0.0009)	(0.0009)	(0.0010)	(0.0010)
Export_share_sector	0.688***	0.368**	0.828***	0.550***	1.131***	0.807***
	(0.191)	(0.152)	(0.024)	(0.023)	(0.032)	(0.030)
State_share	-0.00118	-0.000976	-0.00327	-0.00287	-0.000755	0.0000239
	(0.0039)	(0.0039)	(0.0042)	(0.0041)	(0.0047)	(0.0046)
Horizontal FDI	0.199	0.298*	0.345***	0.466^{***}	0.334***	0.483***
	(0.173)	(0.172)	(0.026)	(0.024)	(0.030)	(0.028)
Downstream FDI	1.05	2.131***	1.149***	2.396^{***}	1.296^{***}	2.621***
	(0.737)	(0.578)	(0.092)	(0.085)	(0.112)	(0.108)
Upstream FDI	0.542**	0.500***	0.478***	0.450^{***}	0.364^{***}	0.341^{***}
-	(0.211)	(0.112)	(0.023)	(0.021)	(0.029)	(0.026)
Observations	982,142	982,142	982,142	982,142	777,739	777,739

Table A.2: Basic Regres	ssions of Productiv	ity on Tariffs with	out Sector Fixed Effect
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Standard errors are clustered. Tariffs and TFP are in logs. Different from Table 1 in the text, the table does not have sector fixed effect or a dummy for whether the firm changes its four-digit sector. IV estimates use initial 1998 tariffs and initial tariffs interacted with a WTO dummy as instruments. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

	All enterprises (1)	Non-Exporters (2)	Exporters (3)
output_tariff	-0.0597***	-0.0541***	-0.0885***
1	(0.0137)	(0.0137)	(0.0140)
downstream_tariff	-0.284***	-0.307***	-0.372***
	(0.0359)	(0.0399)	(0.0454)
upstream_tariff	0.249***	0.266***	0.292***
-	(0.0522)	(0.0580)	(0.0578)
index_subsidy	-0.0303***	-0.0303***	-0.0282***
	(0.0016)	(0.0016)	(0.0020)
index_tax	-0.00529***	-0.00552***	-0.00693***
	(0.0010)	(0.0011)	(0.0012)
$index_interest$	0.0142^{***}	0.0135^{***}	0.0138^{***}
	(0.0012)	(0.0012)	(0.0014)
$exportshare_sector$	0.192^{***}	0.225^{***}	0.266^{***}
	(0.024)	(0.027)	(0.032)
State_share	0.0024	0.0013	-0.002
	(0.0052)	(0.0052)	(0.0060)
Horizontal FDI	-0.146^{***}	-0.136^{***}	-0.160***
	(0.025)	(0.025)	(0.029)
Downstream FDI	0.581^{***}	0.506^{***}	0.602^{***}
	(0.085)	(0.094)	(0.105)
Upstream FDI	-0.133***	-0.154^{***}	-0.210***
	(0.022)	(0.023)	(0.028)
Observations	807,820	777,512	634,245

Table A.3: Determinants of Exit

Liner probability model with IV. Dependent variable is is a zero-one dummy variable for whether or not the enterprise exits in the next period. All specifications include firm and time effects. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

1		v	()	
	(1)	(2)	(3)	(4)
$output_tariff$	-0.015	-0.0197^{*}		
	(0.0105)	(0.0107)		
$downstream_tariff$			-0.177^{***}	-0.115^{***}
			(0.0289)	(0.0349)
upstream_tariff	-0.551^{***}	-0.624^{***}	-0.483***	-0.586^{***}
	(0.0410)	(0.0570)	(0.0337)	(0.0508)
index_subsidy	0.00664^{***}	0.0108^{***}	0.00607^{***}	0.0105^{***}
	(0.0016)	(0.0012)	(0.0016)	(0.0012)
$index_tax$	0.0214^{***}	0.0211^{***}	0.0212^{***}	0.0209^{***}
	(0.0009)	(0.0008)	(0.0009)	(0.0008)
index_interest	-0.0153^{***}	-0.0129^{***}	-0.0156^{***}	-0.0129***
	(0.0010)	(0.0009)	(0.0010)	(0.0009)
$exportshare_sector$	1.000^{***}	0.567^{***}	1.101^{***}	0.635^{***}
	(0.026)	(0.033)	(0.030)	(0.035)
State_share	-0.00117	-0.00259	-0.000365	-0.00222
	(0.0047)	(0.0042)	(0.0047)	(0.0042)
Horizontal FDI	0.374^{***}	0.177^{***}	0.355^{***}	0.184^{***}
	(0.030)	(0.027)	(0.028)	(0.026)
Downstream FDI	0.866^{***}	1.269^{***}	1.017^{***}	1.390^{***}
	(0.093)	(0.123)	(0.104)	(0.145)
Upstream FDI	0.463^{***}	0.369^{***}	0.407^{***}	0.394^{***}
	(0.025)	(0.031)	(0.023)	(0.026)
Observations	777,739	863,363	785,458	872,225
Exclude exporters?	yes	no	yes	no
Keep only enterprises	no	yes	no	yes
that do not switch sectors?				

Table A.4: Testing for Multicollinearity Dependent variable: TFP measured à la Olley-Pakes (OP)

Standard errors are clustered. All specifications include fixed effects for the firm and time. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

	All Enterpri	ses Excluding S	Only Non-Exporters			
	OP FE OP FE		FE	OP	OP	
	OLS	OLS	IV	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
output_tariff	-0.0535***	-0.0560***	-0.0345**	-0.0340*	-0.0608***	-0.0628***
	(0.0131)	(0.0143)	(0.0172)	(0.0181)	(0.0148)	(0.0184)
$downstream_tariff$	-0.0616	-0.0674	-0.303***	-0.285^{***}	-0.0707	-0.633***
	(0.0487)	(0.0560)	(0.0794)	(0.0804)	(0.0536)	(0.1140)
upstream_tariff	-0.105	-0.126	-0.326***	-0.454^{***}	-0.0789	-0.137
	(0.0677)	(0.0771)	(0.0953)	(0.0974)	(0.0764)	(0.1070)
index_subsidy	0.0116^{***}	0.0144^{***}	0.00927^{***}	0.0116^{***}	0.00931^{***}	0.00556
	(0.0033)	(0.0034)	(0.0027)	(0.0028)	(0.0032)	(0.0037)
index_tax	0.0162***	0.0160***	0.0161^{***}	0.0161***	0.0158^{***}	0.0146***
	(0.0030)	(0.0030)	(0.0021)	(0.0022)	(0.0040)	(0.0027)
index_interest	-0.00192	-0.00335	-0.0024	-0.00383*	-0.00365	-0.00438
	(0.0031)	(0.0030)	(0.0023)	(0.0023)	(0.0033)	(0.0030)
exportshare_sector	0.394**	0.442**	0.695^{***}	0.772***	0.491**	0.905***
1	(0.165)	(0.175)	(0.065)	(0.067)	(0.230)	(0.091)
State_share	0.0169	0.017	0.0189	0.0189	0.0289^{**}	0.0326^{**}
	(0.0129)	(0.0130)	(0.0129)	(0.0129)	(0.0130)	(0.0143)
Horizontal FDI	0.135	0.193	0.134**	0.183***	0.181	0.178**
	(0.247)	(0.269)	(0.053)	(0.055)	(0.285)	(0.071)
Downstream FDI	1.564	1.669	2.528***	2.660***	1.345	2.961***
	(1.033)	(1.189)	(0.303)	(0.320)	(1.091)	(0.409)
Upstream FDI	0.131	0.151	0.312***	0.340***	0.00118	0.229**
o potroani i Di	(0.434)	(0.442)	(0.084)	(0.086)	(0.524)	(0.113)
	(0.101)	(0.112)	(0.001)	(0.000)	(0.021)	(0.110)
Observations	$65,\!239$	65,239	65,239	65,239	46,655	$46,\!655$

Table A.5: Regressions keeping only a balanced panel of firms Dependent variable: TFP measured à la Olley-Pakes (OP) or OLS with fixed effects (FE)

Notes: Robust standard errors in parentheses. Dependent variable is log TFP. Only retains observations where establishments are present in all years. All specifications include time effects and 2-digit Sector Dummies. Instruments in the IV specifications for lnTariff, ln downstream Tariff, and ln upstream tariff include the WTO dummy interacted with the initial tariff. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

Dependent variable. 111 measured a la Oney-Taxes (OF) of OLD with fixed cheets (TD)						
	All Enterpri	ises Excluding S	Only Non-Exporters			
	OP	FE	OP	${ m FE}$	OP	OP
	OLS	OLS	IV	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
$output_tariff$	-0.0336***	-0.0355***	-0.0218**	-0.0203*	-0.0381^{***}	-0.0252**
	(0.0074)	(0.0080)	(0.0104)	(0.0106)	(0.0085)	(0.0106)
$downstream_tariff$	-0.128*	-0.132*	-0.163^{***}	-0.168^{***}	-0.155^{**}	-0.498^{***}
	(0.0660)	(0.0754)	(0.0532)	(0.0533)	(0.0726)	(0.0675)
upstream_tariff	-0.0575	-0.0652	-0.345***	-0.449***	-0.0395	-0.173**
	(0.0416)	(0.0496)	(0.0756)	(0.0765)	(0.0425)	(0.0740)
index_subsidy	-0.0227***	-0.0215***	-0.0234***	-0.0224***	-0.0241***	-0.0244***
	(0.0024)	(0.0024)	(0.0014)	(0.0014)	(0.0028)	(0.0017)
index_tax	0.0324***	0.0330***	0.0322***	0.0327***	0.0326***	0.0320***
	(0.0011)	(0.0011)	(0.0008)	(0.0008)	(0.0010)	(0.0010)
index_interest	0.00478***	0.00442**	0.00516***	0.00493***	0.00338^{**}	0.00339***
	(0.0017)	(0.0017)	(0.0010)	(0.0010)	(0.0016)	(0.0011)
exportshare_sector	0.167	0.205	0.311***	0.391***	0.198	0.404***
1	(0.130)	(0.137)	(0.027)	(0.028)	(0.162)	(0.036)
State_share	0.0288***	0.0304***	0.0285***	0.0300^{***}	0.0302***	0.0298***
	(0.0047)	(0.0046)	(0.0039)	(0.0039)	(0.0056)	(0.0044)
Horizontal FDI	0.187	0.225	0.168***	0.200***	0.224	0.212***
	(0.186)	(0.203)	(0.022)	(0.023)	(0.205)	(0.027)
Downstream FDI	1.18	1.177	1.316***	1.353***	1.052	1.147***
	(0.864)	(1.002)	(0.108)	(0.109)	(0.897)	(0.128)
Upstream FDI	0.107	0.115	0.176***	0 203***	-0.00984	0.137***
o potrotani i Di	(0.380)	(0.388)	(0.038)	(0.038)	(0.411)	(0.046)
Mills	-0.367***	-0.355***	-0 744***	-0 784***	-0 392***	-0.693***
IVIIII5	(0.042)	(0.042)	(0.022)	(0.022)	(0.044)	(0.025)
Mills00	(0.042) 0.014	0.014	0.390***	(0.022) 0.440***	0.023	0.329***
111115555	(0.014)	(0.014)	(0.027)	(0.027)	(0.025)	(0.020)
Mills00	(0.045)	0.030	0.021)	0.442***	0.049	0.354***
WIIII500	(0.045)	(0.030)	(0.403)	(0.027)	(0.049)	(0.034)
Mille01	(0.047) 0.117***	0.122***	(0.027)	(0.027)	(0.055)	(0.031)
WIIIIS01	-0.117	-0.132	(0.234)	(0.269)	-0.0839	(0.237)
M:11-09	(0.038)	(0.040)	(0.020)	(0.020)	(0.043)	(0.031)
MIIIS02	(0.008) (0.042)	(0.028) (0.042)	(0.025)	(0.025)	(0.028)	(0.030)
M:11-02	(0.042)	(0.043)	(0.025)	(0.025)	(0.043)	(0.029)
MIIIS05	(0.042)	(0.020)	(0.024)	(0.439)	(0.0703)	(0.091)
M:11 04	(0.042)	(0.042)	(0.024)	(0.024)	(0.044)	(0.027)
MillS04	(0.053)	-0.0888*	0.299^{-10}	0.307^{44}	(0.045)	$(0.236^{-0.01})$
	(0.049)	(0.052)	(0.024)	(0.024)	(0.046)	(0.029)
Mills05	-0.296***	-0.340***	0.0843***	0.0932***	-0.256***	0.0530**
	(0.054)	(0.059)	(0.021)	(0.021)	(0.059)	(0.024)
Mills06	-0.382***	-0.436***			-0.333***	
	(0.063)	(0.068)			(0.067)	
Observations	806.766	806.766	806.766	806.766	633,360	633,360
	,		,	,·	,	,

Table A.6: Controlling for Selection by Including the Inverse Mills Ratio Dependent variable: TFP measured à la Olley-Pakes (OP) or OLS with fixed effects (FE)

Notes: Specification is the same as Table 1, with added controls for the inverse Mills ratio. *** indicates p < 0.01, ** p < 0.05, and * indicates p < 0.1.

	Dropping Textiles and Apparel		Dropping Computers		Including Policy Variables	
			and Peripherals		the First Stage of OP Estimates	
	OP	$\rm FE$	OP	$\rm FE$	OP	$\rm FE$
	(1)	(2)	(3)	(4)	(5)	(6)
output_tariff	-0.0699***	-0.0715^{***}	-0.0477^{***}	-0.0458^{***}	-0.0469^{***}	-0.0456^{***}
	(0.0119)	(0.0122)	(0.0109)	(0.0112)	(0.0111)	(0.0112)
$downstream_tariff$	-0.504***	-0.562^{***}	-0.174^{***}	-0.170***	-0.142***	-0.171^{***}
	(0.0485)	(0.0489)	(0.0371)	(0.0372)	(0.0377)	(0.0373)
upstream_tariff	-0.241***	-0.321***	-0.350***	-0.461^{***}	-0.414***	-0.458***
	(0.0503)	(0.0511)	(0.0609)	(0.0619)	(0.0619)	(0.0620)
index_subsidy	0.00921^{***}	0.0112^{***}	0.0102^{***}	0.0122^{***}	0.0126^{***}	0.0123^{***}
	(0.0013)	(0.0013)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
index_tax	0.0218^{***}	0.0221***	0.0213^{***}	0.0217^{***}	0.0220***	0.0216^{***}
	(0.0008)	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
$index_interest$	-0.0123***	-0.0137***	-0.0121***	-0.0133***	-0.0139***	-0.0132***
	(0.0009)	(0.0009)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
$exportshare_sector$	0.333^{***}	0.391^{***}	0.384^{***}	0.474^{***}	0.395^{***}	0.479^{***}
	(0.025)	(0.025)	(0.030)	(0.030)	(0.030)	(0.031)
State_share	0.0000315	0.000568	-0.0018	-0.00133	-0.00027	-0.00144
	(0.0042)	(0.0042)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
Horizontal FDI	0.152^{***}	0.223***	0.156^{***}	0.212***	0.134^{***}	0.198^{***}
	(0.024)	(0.025)	(0.022)	(0.022)	(0.022)	(0.022)
Downstream FDI	2.466^{***}	2.492***	1.704***	1.638^{***}	1.632***	1.560***
	(0.167)	(0.171)	(0.148)	(0.149)	(0.150)	(0.149)
Upstream FDI	0.126^{***}	0.136***	0.144***	0.169^{***}	0.141***	0.178^{***}
	(0.036)	(0.036)	(0.036)	(0.037)	(0.037)	(0.037)
Observations	800,420	800,420	981,733	981,733	982,142	982,142

Table A.7: Other Robustness Checks Dependent variable: TFP measured à la Olley-Pakes (OP) or OLS with fixed effects (FE)

Notes: Robustness checks on table 1. All specifications use IV and include all enterprises, excluding SOE's and multinationals. All specifications estimated with firm fixed effects and clustered standard errors. All specifications include 2 digit sector dummies and time dummies. All specifications also include a dummy variable equal to 1 if the firm changes a four digit sector as well. Instrumental variables are initial 1998 tariffs and initial tariffs interacted with a WTO dummy as instruments.

	All Enterprises Excluding		Only Non-Exporters		
	SOEs and Mul	ltinationals			
	OLS	IV	OLS	IV	
	(1)	(2)	(3)	(4)	
$output_tariff$	-0.0634^{***}	-0.135***	-0.0694^{***}	-0.185^{***}	
	(0.0209)	(0.0279)	(0.0239)	(0.0282)	
$downstream_tariff$	-0.0419	-0.598***	-0.0403	-1.297^{***}	
	(0.1700)	(0.0711)	(0.1770)	(0.0874)	
upstream_tariff	-0.375*	-0.935***	-0.400*	-0.537***	
	(0.1940)	(0.1270)	(0.2120)	(0.1360)	
index_subsidy	0.0100^{***}	0.00837^{***}	0.00773^{**}	0.00459^{*}	
	(0.0037)	(0.0021)	(0.0037)	(0.0027)	
index_tax	0.0278^{***}	0.0271^{***}	0.0287^{***}	0.0266^{***}	
	(0.0046)	(0.0013)	(0.0051)	(0.0016)	
index_interest	-0.0154^{***}	-0.0150***	-0.0165***	-0.0159***	
	(0.0049)	(0.0015)	(0.0061)	(0.0018)	
$exportshare_sector$	0.554^{*}	1.400***	0.692^{*}	1.778^{***}	
	(0.309)	(0.059)	(0.387)	(0.079)	
State_share	-0.00152	-0.00271	0.0027	0.00359	
	(0.0068)	(0.0070)	(0.0078)	(0.0080)	
Horizontal FDI	1.226^{*}	1.213^{***}	1.455^{*}	1.552^{***}	
	(0.664)	(0.049)	(0.736)	(0.064)	
Downstream FDI	-2.342	-0.442	-2.828	0.955^{**}	
	(2.249)	(0.299)	(2.314)	(0.377)	
Upstream FDI	-0.503	-0.329***	-0.848	-0.610***	
	(0.849)	(0.073)	(0.931)	(0.079)	
Observations	980,963	980,963	776,922	776,922	

Table A.8: Productivity Measure of Ackerberg, Caves, Frazer (2015) Dependent variable: TFP measured following Ackerberg, Caves, Frazer (2015)

Notes: All specifications estimated with firm fixed effects and clustered standard errors. All specifications include 2 digit sector dummies and time dummies. All specifications also include a dummy variable equal to 1 if the firm changes a four digit sector as well. IV estimates use initial 1998 tariffs and initial tariffs interacted with a WTO dummy as instruments.

B Appendix to Theory

B.1 Downstream Firms

Proposition 1: Exit. There exists a unique $\tilde{\phi} > 0$ such that firms produce if and only if $\phi \geq \tilde{\phi}$. Cutoff $\tilde{\phi}$ is decreasing in P, and increasing in costs c_D and c_0 .

Claim 1. Cutoff $\tilde{\phi} > 0$ is unique for all firms Suppose by contradiction that *i* firm with productivity ϕ_i enters and a firm *j* with $\phi_j > \phi_i$ does not enter. If firm *i* invests in differentiation, then trivially, firm *j* would make positive profits from entering and investing. Let firm *j* be the lowest productivity firm that does not enter and that has some firms with productivity lower than it enter. Consider the subgame perfect equilibrium where firm *j* enters and does not invest. If any of the subsequent firms remain in the market, then firm *j* must make positive profits in this subgame, since other firms have productivity lower than *j*. So, the entry of firm *j* must induce exit from all subsequent firms to exit. This is a contradiction because firm *j*'s profits in this subgame equilibrium must be strictly higher than $\pi_i \geq 0$.

For the **properties of** $\tilde{\phi}$, it is sufficient to prove the properties of the cutoff $\tilde{\phi}$ for a given (P_{-i0}, P, c_0, c_D) . Profits π_0 and π_D are both strictly increasing in ϕ with limits $\lim_{\phi\to 0} \max\{\pi_D, \pi_0\} = 0$ and $\lim_{\phi\to\infty} \min\{\pi_D, \pi_0\} = \infty$. Then, $\tilde{\phi} \in \mathbb{R}_{++}$. The relationship between the cutoff and exogenous variables are an application of the Envelope Theorem to profits. Profits π_D and π_0 both increase in price index P. If the lowest-productivity firm invests at threshold $\tilde{\phi}$, then its profit π_D is strictly decreasing in c_D .

Proposition 2 Investment. A. For all (P_{-i0}, P, c_0, c_D) , there exist cutoffs $\phi > 0$ and $\overline{\phi} \ge \phi$ such that the firm does not invest if $\phi < \phi$ or $\phi > \overline{\phi}$). The upper limit $\overline{\phi}$ satisfies

- (i) $\overline{\phi} = \infty$ if $c_D < c_0$
- (ii) $\overline{\phi} < \infty$ if $c_D \ge c_0$
 - B. The set of investing firms is
- (iii) increasing in P and c_0
- (iv) decreasing in P_{-i0} and c_D

Part B is a straightforward application of the envelope theorem to profits and hence we do not prove it. To prove part A, we take the limits of the gain from investing when ϕ tends to 0 or infinity.

Claim 1. There exists $\phi > 0$ such that firms do not invest if $\phi < \phi$.

Proof. Profits π_0 and π_D go to zero as $\phi \to 0$, and so the gain from investing $\pi_D - \pi_0$ must also go to zero. Then, there exists a sufficiently small $\tilde{\phi}$ such that $(\pi_D - \pi_0) < f_D - f_0$ and hence no firm invests if $\phi < \tilde{\phi}$. Since at least some firm invests in the statement of the proposition, take ϕ to be the infimum ϕ such that the firm invests and does not exit: $(\pi_D - \pi_0) \ge f_D - f_0$ and $\pi_D \ge f_D$.

Claim 2 The following limit holds

$$\lim_{\phi \to \infty} (\pi_D - \pi_0) = \begin{cases} \infty & \text{if } c_D < c_0 \\ 0 & \text{if } c_D = c_0 \\ -\infty & \text{if } c_D > c_0. \end{cases}$$

For a non-differentiated firm, $\lim_{\phi\to\infty} s = 1$, $\lim_{\phi\to\infty} \epsilon = \eta$ and $\lim_{\phi\to\infty} P_0 = \frac{\eta c_0}{(\eta-1)\phi}$. We use these limits below,

$$\lim_{\phi \to \infty} (\pi_D - \pi_0) = \lim_{\phi \to \infty} P^{\eta - 1} \left[\frac{1}{\eta} \left(\frac{\eta c_D}{(\eta - 1)\phi} \right)^{1 - \eta} - \frac{P_0^{\sigma - \eta}}{\epsilon_0} \left(\frac{\epsilon_0 c_0}{(\epsilon_0 - 1)\phi} \right)^{1 - \sigma} \right]$$
$$= P^{\eta - 1} \left[\frac{1}{\eta} \left(\frac{\eta c_D}{(\eta - 1)\phi} \right)^{1 - \eta} - \frac{1}{\eta} \left(\frac{\eta c_0}{(\eta - 1)\phi} \right)^{1 - \eta} \right]$$
$$= P^{\eta - 1} \frac{1}{\eta} \left(\frac{\eta}{(\eta - 1)\phi} \right)^{1 - \eta} \left[c_D^{1 - \eta} - c_0^{1 - \eta} \right]$$

The term outside the brackets tends to infinity. The term in the square brackets is independent of ϕ and satisfies

$$\begin{bmatrix} c_D^{1-\eta} - c_0^{1-\eta} \end{bmatrix} < 0 \quad \text{if } c_D > c_0 \\ \begin{bmatrix} c_D^{1-\eta} - c_0^{1-\eta} \end{bmatrix} = 0 \quad \text{if } c_D = c_0 \\ \begin{bmatrix} c_D^{1-\eta} - c_0^{1-\eta} \end{bmatrix} > 0 \quad \text{if } c_D < c_0 \end{bmatrix}$$

Convexity I. We find sufficient conditions for the set of investing firms to be convex for a given vector (P_{-i0}, P, c_0, c_D) .

Step 1. Get $\frac{d\pi}{d\phi}$. The profit of a downstream firm is

$$\pi = \max_{p} P^{\eta-1} P_n^{\sigma-\eta} p^{-\sigma} (p - c_n/\phi)$$

Applying the Envelope Theorem, at the optimal price, $\frac{d\pi}{d\phi}=\frac{\partial\pi}{\partial\phi}$

$$\frac{\partial \pi}{\partial \phi} = P^{\eta - 1} P_n^{\sigma - \eta} p^{-\sigma} \frac{c_n}{\phi^2}
= \frac{\pi}{\phi} \left(\frac{c_n / \phi}{p - c_n / \phi} \right)
= (\epsilon - 1) \frac{\pi}{\phi}$$
(B.1)

where the last line uses $p = \left(\frac{\epsilon}{\epsilon-1}\right) \frac{c_n}{\phi}$. For differentiated firms, $\epsilon = \eta$.

Step 2. Get $\frac{d\epsilon}{d\phi}$. The elasticity of demand is implicitly defined through equation

$$\Psi \equiv (\sigma - \eta)s - \sigma + \epsilon = 0 \tag{B.2}$$

where
$$s = \frac{\left(\frac{\epsilon}{(\epsilon-1)\phi}\right)^{1-\sigma}}{P_{-i0}^{1-\sigma} + \left(\frac{\epsilon}{(\epsilon-1)\phi}\right)^{1-\sigma}}$$
 (B.3)

Taking derivatives,

$$\phi \Psi_{\phi} = (\sigma - \eta)(\sigma - 1)(1 - s)s$$

$$\epsilon \Psi_{\epsilon} = \epsilon + (\sigma - \eta)(\sigma - 1)(1 - s)s/(\epsilon - 1)$$

where we use the standard notation $\Psi_x = \partial \Psi/(\partial x)$ for any variable x. By the Implicit Function Theorem,

$$\frac{\phi d\epsilon}{\epsilon d\phi} = -\frac{\phi \Psi_{\phi}}{\epsilon \Psi_{\epsilon}} = -\frac{(\sigma - \eta)(\sigma - 1)(1 - s)s}{\epsilon + (\sigma - \eta)(\sigma - 1)(1 - s)s/(\epsilon - 1)}$$
(B.4)

Step 3 Define the net gain from investing as $G(\phi) = (\pi_D(\phi) - \pi_0(\phi))$. We show that G has a unique maximum.¹ That is, for all ϕ satisfying the first order conditions, the second order conditions hold strictly. Using the derivatives in (B.1),

$$G'(\phi) = \frac{1}{\phi} \left[(\eta - 1)\pi_D - (\epsilon - 1)\pi_0 \right]$$

$$G''(\phi) = -\frac{1}{\phi^2} \left[(\eta - 1)\pi_D - (\epsilon - 1)\pi_0 \right] + \frac{1}{\phi^2} \left[(\eta - 1)^2 \pi_D - (\epsilon - 1)^2 \pi_0 \right] - \frac{\pi_0}{\phi} \frac{d\epsilon}{d\phi}$$

Evaluating $G''(\phi)$ where $G'(\phi^*) = 0$ and using equation (B.4), we have

$$\begin{aligned} G''(\phi^*) &= \frac{1}{\phi^2} \left[(\eta - 1)^2 \pi_D - (\epsilon - 1)^2 \pi_0 \right] - \frac{1}{\phi} \pi_0 \frac{d\epsilon}{d\phi} \\ &= \frac{\pi_0}{\phi^2} \left[(\eta - 1)(\epsilon - 1) - (\epsilon - 1)^2 \right] + \frac{\pi_0}{\phi^2} \left(\frac{\epsilon(\sigma - \eta)(\sigma - 1)(1 - s)s}{\epsilon + (\sigma - \eta)(\sigma - 1)(1 - s)s/(\epsilon - 1)} \right) \\ &= \frac{\pi_0}{\phi^2} (\sigma - \eta)(1 - s) \left[-(\epsilon - 1) + \frac{\epsilon(\sigma - 1)s}{\epsilon + (\epsilon - \eta)(\sigma - 1)s/(\epsilon - 1)} \right] \end{aligned}$$

where the second line uses equation (B.4) and the third line uses $(\epsilon - \eta) = (\sigma - \eta)(1 - s)$ from rearranging equation (B.2). Since the term out of the brackets is positive, to prove G'' < 0, we must

¹It suffices to prove that there does not exist a local minimum for the gain from investing G. If there existed $\phi' < \phi'' < \phi'''$ such that the firm invested at ϕ' and ϕ''' but not at ϕ'' then $G(\phi'') \leq \min\{G(\phi'), G(\phi''')\}$ and there would be a local minimum in $[\phi', \phi''']$.

show

$$\epsilon - 1 > \frac{\epsilon(\sigma - 1)s}{\epsilon + (\epsilon - \eta)(\sigma - 1)s/(\epsilon - 1)}$$

$$\Leftrightarrow \quad (\epsilon - \eta)(\sigma - 1)s + \epsilon(\epsilon - 1) - \epsilon(\sigma - 1)s > 0$$

$$\Leftrightarrow \epsilon(\epsilon - 1) - \eta(\sigma - 1)s > 0$$

$$\Leftrightarrow \frac{\epsilon(\epsilon - 1)}{\sigma - \epsilon} > \frac{\eta(\sigma - 1)}{\sigma - \eta}$$
(B.5)

The inequality does not hold everywhere since it does not hold when s = 1 and $\epsilon = \eta$. But the right-hand-side is increasing in ϵ and decreasing in s. So, if we show that the inequality holds for s = 1/2, then it holds for all $s \le 1/2$. When s = 1/2, $\epsilon = (\sigma + \eta)/2$ and equation (B.5) becomes

$$\begin{aligned} &\frac{(\sigma+\eta)(\sigma+\eta-2)}{2(\sigma-\eta)} > \frac{\eta(\sigma-1)}{\sigma-\eta} \\ \Leftrightarrow & (\sigma+\eta)^2 - 2\sigma - 2\eta > 2\eta\sigma - 2\eta \\ \Leftrightarrow & \sigma^2 + \eta^2 + 2\eta\sigma - 2\sigma > 2\eta\sigma \\ \Leftrightarrow & (\sigma-\eta)^2 + 2\eta\sigma - 2\sigma > 0 \\ \Leftrightarrow & (\sigma-\eta)^2 + 2\sigma(\eta-1) > 0 \end{aligned}$$

which always holds since $\eta > 1$.

Let's see if the first order conditions hold when s > 1/2. Using the expressions for profits, we can rewrite these conditions as:

$$(\eta - 1)\pi_D = (\epsilon - 1)\pi_0$$

$$\frac{\eta - 1}{\eta} \left(\frac{\eta c_D}{(\eta - 1)\phi}\right)^{1 - \eta} = \frac{\epsilon - 1}{\epsilon} P_0^{\sigma - \eta} \left(\frac{\eta c_0}{(\eta - 1)\phi}\right)^{1 - \sigma}.$$

$$\equiv s = \left(\frac{\epsilon(\eta - 1)}{(\epsilon - 1)\eta}\right) \left(\frac{\eta c_D}{(\eta - 1)\phi}\right) P_0^{\eta - 1}.$$

The first term is always smaller than zero. The second term is the ratio of sales of the firm if it becomes differentiated to the sales of all non-differentiated firms if the firm is does not invest. So, a sufficient condition for the set of investing firms to be convex is for this ratio of sales to always be less than 1/2. Alternatively, we can use $P_0 < \epsilon c_0/[(1 - \epsilon)\phi]$. Then,

$$s < \left(\frac{\epsilon(\eta-1)}{(\epsilon-1)\eta}\right)^{\eta} \left(\frac{c_0}{c_D}\right)^{\eta-1} < \left(\frac{c_0}{c_D}\right)^{\eta-1}$$

So that a sufficient condition on the problem's exogenous parameters is for the marginal cost of the differentiated good to be sufficiently high: $(c_0/c_D)^{\eta-1} < 1/2$.

Convexity II. We show that the set of firms investing is not necessarily convex in a given equilibrium because firms face different levels of competition in the non-differentiated nest P_{-i0} .

Figure B.1: Set of productivities ϕ where investment is profitable, given $P_{-10} = P_{-20} > P_{-30}$



The conditions above are sufficient for the set of firms investing to be convex in ϕ for a given (P_{-i0}, P, c_0, c_D) . While (P, c_0, c_D) is common for all firms, P_{-i0} is not. We sketch an example where the equilibrium set of investing firms is not necessarily convex. Consider an economy with Foreign competition and three domestic firms with productivity parameters $\phi_1 > \phi_2 > \phi_3$. Let $c_D = c_0$ so that the set of investing firms is a bounded interval $(\phi, \overline{\phi})$ for any given P_{-i0} . We claim that for some parameter values, it is possible to construct an equilibrium with strategies {invest, not invest, invest}. Suppose that in the subgame where firm 1 does not invest, then the two other firms invest. Then, the level of competition faced by the three firms in the non-differentiated nest is $P_{-10} = P_{-20} > P_{-30}$.² Then, the set of productivity ϕ that makes the investment profitable is illustrated in Figure B.1 in bold. The set is larger for firm 3 because $P_{-10} = P_{-20} > P_{-30}$, and so it is possible to judiciously pick productivity levels in the regions indicated with an oval such that the proposed equilibrium holds.

B.2 Welfare in model with only final goods

B.2.1 Productivity and labor allocation

Planner. Let's start with a planner who cannot change sets \mathcal{O} and \mathcal{D} . But after firms make their discrete choices, he can unexpectedly change labor allocations. His problem is to choose quantities q_i maximize

$$\max U = \left[Q_0^{\frac{\eta-1}{\eta}} + \sum_{i \in \mathcal{D}} q_i^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

subject to $Q_0 = \left(\sum_{i \in \mathcal{O}} q_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$
 $L = \int_{i \in \mathcal{O}} \left(\frac{c_0}{\phi} q_i \right) + \int_{i \in \mathcal{D}} \left(\frac{c_D}{\phi} q_i \right).$ (B.6)

We denote utility here with U rather than Q because U is only the contribution to overall utility of the firms modeled, not including exogenous nests. The first order conditions with respect

²In this example, $P_{0F} = P_{-10} = P_{-20}$.

to quantities imply that a firm with productivity ϕ has quantities

$$\begin{split} q_0^W &= \lambda^{-\sigma} \left(\frac{c_0}{\phi}\right)^{-\sigma} Q^{\sigma/\eta} Q_0^{(\eta-\sigma)/\eta} \\ q_D^W &= \lambda^{-\eta} \left(\frac{c_D}{\phi}\right)^{-\eta} Q \end{split}$$

where λ is the Lagrange multiplier for constraint (B.6) and we denote the firm's quantities with q_0 if its variety is not differentiated and q_D if it is differentiated. Substituting q_0 in the definition of Q_0 and rearranging, we get

$$Q_0^W = (\lambda C_0)^{-\eta} Q$$

where $C_0 = c_0 \left(\int_{i \in \mathcal{O}} \phi_i^{\sigma - 1} \right)^{\frac{1}{1 - \sigma}}$. (B.7)

Substituting it back into quantities of varieties,

$$q_0^W = \lambda^{-\eta} Q C_0^{\sigma - \eta} \left(\frac{c_0}{\phi}\right)^{-\sigma}$$

Similarly to C_0 , we define the aggregate cost of the differentiated goods \mathcal{D} :

$$C_D = c_D \left(\int_{i \in \mathcal{D}} \phi_i^{\eta - 1} \right)^{\frac{1}{1 - \eta}}.$$

The planner's allocation of labor for production is then

$$\begin{split} L_0^W &= \lambda^{-\eta} Q C_0^{1-\eta} \\ L_D^W &= \lambda^{-\eta} Q C_D^{1-\eta} \end{split}$$

Market. Market quantities of individual varieties are:

$$q_0 = Q P^{\eta} P_0^{\sigma-\eta} (\mu_{0i} c_0 / \phi)^{-\sigma}$$
$$q_D = Q P^{\eta} (\mu_D c_D / \phi)^{-\eta}$$

Aggregating over varieties we get the labor used for production of the non-differentiated varieties L_0 and of differentiated varieties L_D :

$$L_{0} = \sum_{i \in \mathcal{O}} q_{0i} \frac{c_{0}}{\phi_{i}} = Q P^{\eta} P_{0}^{\sigma - \eta} \sum_{i \in \mathcal{O}} (\mu_{0i})^{-\sigma} (c_{0}/\phi_{i})^{1 - \sigma}$$
$$L_{D} = \sum_{i \in \mathcal{O}} q_{Di} \frac{c_{D}}{\phi_{i}} = Q P^{\eta} \mu_{D}^{-\eta} \sum_{i \in \mathcal{O}} (c_{D}/\phi_{i})^{1 - \eta} = Q P^{\eta} \mu_{D}^{-\eta} C_{D}^{1 - \eta}$$

To compare it to the planner's allocations, L_0^W and L_D^W , note that since $\mu_D > \mu_{0i}$ for all *i*, the following inequalities hold

$$\begin{split} L_{0} &= Q P^{\eta} P_{0}^{\sigma-\eta} \left(\sum_{i \in \mathcal{O}} (\mu_{0i})^{-\sigma} (c_{0}/\phi_{i})^{1-\sigma} \right) \\ &= Q P^{\eta} \mu_{D}^{-\eta} \left[\sum_{i \in \mathcal{O}} \frac{\mu_{0i}}{\mu_{D}} \left(\frac{\mu_{0i}}{\mu_{D}} \right)^{-\sigma} (c_{0}/\phi_{i})^{1-\sigma} \right]^{\frac{\sigma-\eta}{1-\sigma}} \left[\sum_{i \in \mathcal{O}} \left(\frac{\mu_{0i}}{\mu_{D}} \right)^{-\sigma} (c_{0}/\phi_{i})^{1-\sigma} \right] \\ &> Q P^{\eta} \mu_{D}^{-\eta} \left[\sum_{i \in \mathcal{O}} \left(\frac{\mu_{0i}}{\mu_{D}} \right)^{-\sigma} (c_{0}/\phi_{i})^{1-\sigma} \right]^{\frac{1-\eta}{1-\sigma}} \\ &> Q P^{\eta} \mu_{D}^{-\eta} C_{0}^{1-\eta} \end{split}$$

So, the ratio of labor allocations in the non-differentiated relative to the differentiated nests satisfy:

$$\frac{L_0}{L_D} > \frac{L_0^W}{L_D^W}$$

Given the same sets \mathcal{O} and \mathcal{D} , the market allocates relatively more labor to the non-differentiated nest compared to the planner. The intuition for this result is the same as the allocation of labor across varieties within the non-differentiated nest. Compared to the planner, the market allocates relatively more labor to the nest with lower markups.

B.2.2 Welfare and Discrete Choices

We now turn to the discrete choices: To exit, produce, and invest. The analyze planner's optimal discrete choices, we must put some structure into the gains from allocating labor for the fixed costs to sectors not modeled. Denote with C the aggregate marginal cost of labor in the economy. For example, if marginal cost is constant in other sectors, then C = L/Q where L is the labor allocated for production and Q is aggregate utility. Define the average markup in the economy as $\overline{\mu} = P/C$, price over marginal cost. We uphold the following assumption:

A2. Assumption The market equilibrium satisfies $\overline{\mu} < \mu_D$ and $\overline{\mu} \ge \mu_{0i}$ for all *i* in the nondifferentiated nest \mathcal{O} .

The equilibrium of the market satisfies $\mu_D > \mu_{0i}$ as long as there is more than one nondifferentiated firm. If all sectors are modeled symmetrically to the one above, then the assumption will be satisfied there is a sufficient number of differentiated firms so that $\overline{\mu}$ is close to μ_D , and market shares in the non-differentiated nest are sufficiently spread across firms so that no firm holds an almost monopoly and has markups close to μ_D .

We again start the analysis with a limited planner. Suppose the planner can choose sets \mathcal{O} and \mathcal{D} , but once these sets are chosen, firms are free to choose prices and quantities clear the market. Denote with $v(\mathbf{p}, w)$ the indirect utility of the consumer when the vector of prices is \mathbf{p} and consumer income is w. Denote with (\mathbf{p}_{-i}, p') the vector of prices where the i^{th} element is changed to p' and all other elements are maintained at their original \mathbf{p} prices. Then, the utility of variety i to the planner is

$$u_i = v(\mathbf{p}, 1) - v((\mathbf{p}_{-i}, \infty), 1) - f_i/C$$

where **p** is the equilibrium prices and income is set to one because it is the numeraire. That is, the utility of variety *i* is the change in indirect utility to the consumer when the price of *i* is raised from infinity to its equilibrium level and the fixed cost is reallocated from the production of other goods to variety *i* where $f_i = f_0$ if the firm is non-differentiated and $f_i = f_D$ if it is differentiated.

By Roy's identity,

$$q_i(\mathbf{p}, w) = -\frac{v_i(\mathbf{p}, 1)}{v_w(\mathbf{p}, 1)}$$

where $q_i = x_i/p_i$ is demand function, v_i is the partial derivative of v with respect to p_i and v_w is the partial derivative with respect to consumer income. Using $v_w(\mathbf{p}, w) = P^{-1}$ and rearranging

$$u_{i} = -P^{-1} \int_{p_{i}}^{\infty} v_{i}((\mathbf{p}_{-i}, p'), 1)dp - f/C = P^{-1} \int_{p_{i}}^{\infty} q_{i}((\mathbf{p}_{-i}, p'), 1)dp' - f/C$$
(B.8)

Since differentiated firms have constant elasticity of demand, we can write the demand function as

$$q_i((\mathbf{p}_{-i}, p'), 1) = A_i(p')^{-\eta}$$
(B.9)

where the constant A_i is set by the terminal condition

$$q_{iD}(\mathbf{p},1) = QP^{\eta}(p_i)^{-\eta}$$

where Q = 1/P is the consumer's total utility and $p_i = \mu_D c_D/\phi_i$ is the equilibrium price of

differentiated variety *i*. Substituting (B.9) into u_i , we have:

$$u_{i} = P^{-1} \int_{p_{i}}^{\infty} q_{i}((\mathbf{p}_{-i}, p'), 1)dp' - f/C$$

$$= P^{-1}A_{i}\frac{1}{\eta - 1}(p')^{1-\eta}|_{p'=p_{i}}^{\infty} - f/C$$

$$= \frac{P^{-1}}{\eta - 1}QP^{\eta}(p_{i})^{1-\eta} - f/C$$

$$= C^{-1}\left[\left(\frac{\mu_{D}}{\overline{\mu}}\right)\frac{QP^{\eta}}{\eta}(p_{i})^{1-\eta} - f\right]$$

$$> C^{-1}\left[\frac{QP^{\eta}}{\eta}(p_{i})^{1-\eta} - f\right] = C^{-1}\pi_{D}$$
(B.10)

where the last line comes from Assumption A2.

For non-differentiated varieties, demand at equilibrium prices is

$$q_{i0}(\mathbf{p},1) = QP^{\eta}P_0^{\sigma-\eta}(p_i)^{-\sigma}$$

where the equilibrium price for non-differentiated varieties is $p_i = \epsilon_i c_0 / (\phi_i(\epsilon_i - 1))$, and ϵ_i is the elasticity of demand for variety *i* at **p**. By Assumption A2, non-differentiated varieties do not have a monopoly of nets \mathcal{O} . Then the elasticity of demand is strictly increasing in the interval $p' \in [p_i, \infty)$, and the following inequality holds:

$$u_{i} = P^{-1} \int_{p_{i}}^{\infty} q_{i}((\mathbf{p}_{-i}, p'), 1)dp' - f/C$$

$$< P^{-1} \frac{1}{\epsilon_{i} - 1} q_{i}(\mathbf{p}, 1)p_{i} - f/C$$

$$= C^{-1} \left[\frac{QP^{\eta}P_{0}^{\sigma - \eta}}{\epsilon_{i} - 1} (p_{i})^{1 - \sigma} - f \right]$$

$$= C^{-1} \left[\left(\frac{\mu_{0i}}{\overline{\mu}} \right) \frac{QP^{\eta}P_{0}^{\sigma - \eta}}{\epsilon_{i}} (p_{i})^{1 - \sigma} - f \right]$$

$$< C^{-1} \left[\frac{QP^{\eta}}{\epsilon_{i}} (p_{i})^{1 - \eta} - f \right] = C^{-1} \pi_{0}$$
(B.11)

where the last line comes from Assumption A2. Compared to the market, the planner's valuation is multiplied by C^{-1} simply to convert units from money to labor. More relevant is that inequalities (B.10) and (B.10) implies that compared to the limited planner, the market features too much entry of unproductive, non-differentiated varieties in \mathcal{O} and too little investment in non-differentiation \mathcal{D} . Recall that given sets \mathcal{O} and \mathcal{D} , the planner reallocates production from less productive to more productive firms within \mathcal{O} , and from set \mathcal{O} to set \mathcal{D} . So, the discrete choice results that the market features too much entry of unproductive, non-differentiated varieties in \mathcal{O} and too little investment in non-differentiation \mathcal{D} holds also for an unconstrained planner who can choose sets \mathcal{O} and \mathcal{D} as well as labor allocations. A corollary to these results is that investment induced by international trade is welfare enhancing. That is, compared to a scenario where firms are forced not to change their discrete choices, the exit of the least productive firms from nest \mathcal{O} and the increase in investment is always welfare enhancing.

B.3 Upstream firms

This Appendix derives results for the model with upstream firms.

Profit and markup of a downstream firm. We derive the profit of an upstream firm:

$$\pi_0^M = \max_p E P_0^{\sigma - \eta} c_0^{\eta_M - \sigma} P_{0M}^{\sigma_M - \eta_M} p^{-\sigma_M} (p - 1/\phi_M)$$
(B.12)

The cost of final goods' input is

$$c_{0} = \left[(P_{0M})^{1-\eta_{M}} + (P_{M})^{1-\eta_{M}} \right]^{\frac{1}{1-\eta_{M}}}$$
(B.13)
where $P_{0M} = \left[\sum_{i \in \mathcal{O}_{M}} (p_{i})^{1-\sigma_{M}} \right]^{\frac{1}{1-\sigma_{M}}},$

 \mathcal{O}_M is the set of non-differentiated upstream varieties, p_i is the price of variety i, P_{0M} is the endogenous price index of non-differentiated inputs, and P_M is the exogenous price index of all other inputs—potentially including labor, capital and materials from other upstream sectors. The elasticity of substitution between non-differentiated upstream varieties and other inputs is $\rho < \sigma$.

From equation (B.13), spending on a non-differentiated upstream variety with price p is

$$x_M(p) = p^{1-\sigma} (P_{0M})^{\sigma-\rho} c_0^{\rho-1} X_{0M}$$
(B.14)

where X_0^M is total spending on non-differentiated inputs:

$$X_{0M} = P^{\eta-1} P_0^{\sigma-\eta} c_0^{1-\sigma} \sum_{i \in \mathcal{O}_H} \left(\frac{\epsilon_i}{(\epsilon_i - 1)}\right)^{-\sigma} \phi_i^{\sigma-1}$$

where \mathcal{O}_H is the set of non-differentiated domestic final goods. Normalize to one the input cost of non-differentiated upstream firms. A firm with productivity ϕ_M has marginal cost $1/\phi_M$. Substituting X_{0M} into equation (B.14), its profit is given by equation (B.12).

$$\pi_{0M} = \max_{p} E(P_{0M})^{\sigma - \eta} c_0^{\rho - \sigma} P_0^{\sigma - \eta}(p)^{-\sigma} (p - 1/\phi^M)$$
(B.15)

where $E = P^{\eta-1} \sum_{i \in \mathcal{O}_H} \left(\frac{\epsilon_i - 1}{\epsilon_i}\right)^{\sigma} \phi_i^{\sigma-1}$ is a market-size effect that the firm takes as exogenous. Taking first order conditions, the optimal price is $p = \frac{\epsilon^M}{\epsilon^M - 1} \frac{1}{\phi^M}$ where ϵ^M is the endogenous elasticity of demand:

$$\epsilon_M = \sigma_M (1 - s_M) + \eta_M s_M (1 - S_{0M}) + s_M S_{0M} \left[\sigma (1 - S_{0H}) + \eta S_{0H} \right]$$
(B.16)

where $s_M = (p/P_{0M})^{1-\sigma}$ is the market share of the firm in nest \mathcal{O}_M , $S_{0M} = (P_{0M}/c_0)^{1-\rho}$ is the share of nest \mathcal{O}_M in the cost of non-differentiated downstream firms, and $S_{0H} = (P_{0H}/P_0)^{1-\sigma}$ is the domestic market share in non-differentiated downstream sales.

Pricing upstream and markups downstream. As stated in the main text, the derivations above assume that upstream firms take the markups of downstream firms as given. That is, it takes $E = P^{\eta-1} \sum_{i \in \mathcal{O}_H} \left(\frac{\epsilon_i - 1}{\epsilon_i}\right)^{\sigma} \phi_i^{\sigma-1}$ as exogenous. To get a sense of magnitude, we derive dE/dp_M applying the implicit function theorem to equation (B.2), where the price upstream affects markups downstream through its effect on c_0 . After some algebra, we get

$$\frac{p_M}{E} \frac{dE}{dp_M} = (\sigma - 1)(\sigma - \eta)(1 - S_{0H})S_{0H}S_{0M}s_M \left[\frac{P^{\eta - 1}}{E} \frac{\sum_{i \in \mathcal{O}_H} ((\epsilon_i - 1)/\epsilon_i)^{\sigma} \phi_i^{1 - \sigma}}{\epsilon_i(\epsilon_i - 1) + (\epsilon_i - \eta)(\sigma - 1)s_i}\right]$$
$$\geq \frac{(\sigma - 1)(\sigma - \eta)(1 - S_{0H})S_{0H}S_{0M}s_M}{\min_i\{\eta_i(\eta_i - 1)\}}$$

The denominator is bounded away from zero as long as no downstream firm faces an inelastic demand, i.e., $\epsilon_i \geq \eta > 1$. The denominator, in turn, has the product of four market shares: The share of Foreign varieties in non-differentiated downstream sales $(1 - S_{0H})$, the share of domestic firms in these downstream sales S_{0H} , the share of all non-differentiated inputs in downstream costs S_{0M} and the market share of the upstream firm in its nest s_M . So, the effect ignored is likely to be very small.

B.4 Equilibrium with free entry and intermediate inputs

We introduce free entry, dynamics and sunk costs to the model. We use the model with intermediate inputs for generality. Our empirical results refer to an increase in a sector's import competition. In standard partial-equilibrium models of trade with free entry, import competition has no effect on the price index because the entry of foreign firms is offset by the exit of domestic firms in order for the price index and expected profits to remain unchanged. To allow import competition to decrease the price index, we propose the simplest dynamic model with sunk costs. The key insight, from ?, is that firms that have incurred sunk costs do not immediately exit when import competition increases. Following a decrease in trade barriers, there is a temporary overshooting of varieties and decrease in price index.

Time is discrete. In the beginning of each period t, there is a finite set of upstream and downstream firms from the previous period. A period is divided into stages. An equilibrium is a set of strategies by firms, in each period and each stage, where all firms maximize profits given its information set at the time and other firms' strategies. The stages are:

- Stage 1. Upstream and downstream firms surviving from period t-1 exit with probability δ . Foreign firms set prices.
- Stage 2. A large mass of entrepreneurs decides to enter the upstream market or not. To enter, they pay a fixed entry cost f_E and exclusive variety. Subsequently, entrepreneurs decide whether to enter the downstream market. Entrepreneurs enter sequentially so that all entering entrepreneurs have expected profits greater than or equal to f_E . Firms surviving from stage 1 do not pay this cost.
- Stage 3. All firms—new and old, upstream and downstream—draw a productivity ϕ from a common distribution. All firms' productivity is common knowledge.
- Stage 4. In order of productivity φ, upstream firms make their discrete choices: (i) not to produce in the period, (ii) to pay a fixed cost f₀ and produce a non-differentiated variety, (iii) to pay a fixed cost f_D and produce a differentiated variety.
- Stage 5. In order of productivity ϕ , downstream firms make their discrete choices (i), (ii) or (iii) above.
- Stage 6. Upstream firms simultaneously set prices.
- Stage 7. Downstream firms simultaneously set prices.
- Stage 8. Profits are realized. All firms, upstream and downstream survive to stage 1 of period t + 1.

The rationale for the stages above is as follows. First, dynamics and the sunk cost f_E implies that a sufficiently large increase in the set of foreign firms or decrease in foreign prices induces a temporary overshooting of varieties. Price index P_0 may temporarily fall pushing expected profits below f_E so that no firm enters in stage 2. Second, for simplicity and as in ?, all firms decisions are static because firms do not inherit productivity from previous periods. Third, the sequential decisions of stage 4 and 5 are an equilibrium selection. For any set of discrete choices in stages 4 and 5, stage 6 delivers a unique equilibrium. With perfect foresight, more productive firms maximize their profits over all possible scenarios of stages 4 and 5 given its discrete choices and other firms' best responses. In stage 2, profits in the non-differentiated upstream and downstream nests decrease monotonically to zero if the number of firms go to infinity. The optimal number of entering firms is also unique under the assumption that the exogenous expected profit of always choosing (i) not to produce or (iii) to produce a differentiated product is less than f_E for both upstream and downstream firms. By backward induction, since uniqueness holds in all stages, it holds in the game as a whole. More specifically, if for a given set of parameters a firm is indifferent between discrete decisions in stages 3 or 4, a small perturbation of parameters breaks the indifference.

The movement of upstream firms before downstream firms explain the set up of the firms' problems. Downstream firms take input cost c_n as exogenous, because conditional on choosing to

produce a non-differentiated variety in stage 4, the firm can fully anticipate other firms' choices, including prices of inputs. Prices are set after discrete choices so that firms cannot commit on prices—otherwise, a non-differentiated upstream firm might commit to a lower price to induce more downstream firms to remain non-differentiated, or a downstream firm might commit to lower prices to increase its sales and induce more entry upstream. Because upstream firms set prices first, they internalize the effect of their prices on the cost and sales of downstream firms. The only simplification, as stated above, is that they disregard the effect of their prices on the markups of downstream firms. Finally, assuming that downstream firms move after upstream firms allows us to more clearly analyze the effect of import competition on investment in differentiation—without complicating the problem of downstream firms with strategic interactions with their input suppliers.

Finally, the results in the main text may be interpreted as the short-run effects of the trade liberalization. A decrease in foreign prices together with a sufficiently large number of survivors, implies that no firm enters in stage 2. So, effectively, the game played in the period is one where the set of firms is exogenous. The long run effect of a permanent decrease in foreign prices P_{0F} is an increase in c_0 and in P_0 . Cost c_0 increases with investment and exit upstream. As a result of the increase in cost, the overall level of competition downstream P_0 has to increase for domestic firms to break even. In other words, the consumer looses from import competition in a comparative disadvantage industry because increasing returns to scale implies that domestic production becomes less efficient.