# Escaping Import Competition in China

Ana Cecília Fieler, Ann Harrison*

June 2019

*Preliminary Draft*

**Abstract**

We use establishment data from China spanning its WTO accession in 2001. Tariff cuts are associated with increases in revenue productivity, the introduction of new goods, switches to skill-intensive sectors. We propose a model in which firms differentiate their products to escape import competition. Facing a nested CES demand, heterogeneous firms choose between producing a variety in a nest with competitors or incurring a higher cost to be a monopolist in a new nest. The profit from differentiation is an inverted U-shaped function of firm productivity, and it increases with import competition. Differentiation explains product innovation in the data, and markups explain why the increase in revenue productivity is larger for small firms. A firm's profit from differentiation is smaller than the social welfare gain. So, differentiation may constitute a new source of gain from trade.

*Fieler: Department of Economics at Yale University and NBER. Harrison: Haas School of Business at the University of California Berkeley and NBER. We are especially grateful to Jonathan Eaton for his readings of previous drafts. We thank Matilde Bombardini, Beata Javorcik, Teresa Fort, Elisa Giannone, Amit Khandelwal, Andrés Rodriguez-Clare, Esteban Rossi-Hansberg, Eric Verhoogen, and Shang-Jin Wei for their suggestions. The research for this paper was conducted in part while Fieler was visiting the Economics Department at Princeton University. We thank them for their hospitality.

# 1 Introduction

Policy makers and trade economists generally agree that trade reforms improve the performance of domestic competitors, even though the theoretical and empirical underpinnings for this view remain elusive. Evidence on the effect of tariff or quota reductions on firm productivity is mixed, and if forced to explain a mechanism, a number of economists might vaguely resort to "x-inefficiency" or "dynamic gains from trade."[1] This paper aims to, at least in part, narrow the gap between policy makers' perceptions and the academic literature.

We study the effects of import competition on Chinese manufacturing firms using panel data from 1998 to 2007, spanning the year of China's accession to the WTO in 2001. Within firms, tariff cuts are associated with increases in revenue productivity, the introduction of new goods, and switches to more skill-intensive sectors. We find some evidence that increases in revenue productivity is larger among small firms.[2] These findings are at odds with standard models of international trade, where import competition decreases sales and markups. It leads firms to divest in cost-reducing technologies, drop their least productive varieties, and switch to unskill-intensive sectors in an unskill-abundant country. (See references in Section 2.3.)

We propose that domestic firms respond to import competition by seeking market niches that are insulated from foreign competition. They cater to domestic tastes, offer greater customization, and bundle products with non-tradable services. For example, the cell phone company Xiaomi prevented the expansion of Apple in China by offering Chinese language options and a superior integration of its software with local apps. Chery

[1] See Holmes and Schmitz (2010) for theories and case studies based on x-inefficiencies. Tybout (2003) surveys of studies on the trade liberalizations in developing countries in the 1980s and 1990s. Mixed evidence appears in more recent papers, e.g., Amiti and Konings (2007), Eslava et al. (2013), DeLoecker et al. (2016) and Chen and Steinwender (2019). Our empirical findings do not preclude the presence of x-inefficiencies, but our mechanism has more specific predictions that are born out by the data.

[2] To mitigate the problem of endogeneity, we follow the literature in using initial tariffs as instruments for tariff changes. See Goldberg et al. (2009), Amiti and Konings (2007), Attanasio et al. (2004). We cannot observe changes in skill intensity because we only observe skill intensity in one year. The effect of competition on productivity is also larger for small firms in Chen and Steinwender (2019).

Automobiles introduced several new, small car models with many optional features, and it made replacement parts readily available. These changes insulate Chery from import competition, not only because small and fuel-efficient cars appeal to Chinese consumers, but also because it is difficult for firms producing cars abroad to offer customized accoutrements and a wide range of replacement parts.[3] To implement this strategy, Chery invested in research and development, and in skill-intensive technologies such as modern machinery amenable to production in small batches, and integrated computer systems that enable just-in-time inventory controls.

In line with the empirical findings, this sort of reaction to foreign competition involves the introduction of new goods. While many of the switches to skill-intensive tasks occur within sectors, some may imply a switch in the firm's four-digit sectoral classification. Common sector switches in the data include from cotton and chemical fibers to textile and garment manufacturing, and from steel rolling processing to metal structures. They suggest upgrading to higher value-added sectors with a greater the scope for differentiation. Since revenue productivity is a measure of the ratio of revenue to cost, markup responses may explain changes in revenue productivity and why these changes are larger for small firms. Import competition decreases the markup of firms that remain in direct competition with foreigners, but may increase the markup of firms that escape competition. Large firms generally have a greater scope to reduce markups if they remain in direct competition with foreigners than small firms whose prices are closer to cost.[4] Also because of initially high markups, large firms have a more limited scope to further increase markups through differentiation than small firms.

We formalize these points in a model with heterogeneous firms and a demand system with nested constant elasticity of substitution (CES). In decreasing order of productivity,

[3]See Farhoomand and Schuetz (2007), Boyd et al. (2008), Teagarden and Fifi (2015), Feng and Wei (2015) for case studies. In interviews with Foreign Affairs (Rose (2015)), American entrepreneurs emphasize their search for market niches where they can enjoy monopoly power.

[4]Pro-competitive effects on markups are larger for large firms also in Amiti et al. (2014) and Edmond et al. (2015).

each firm chooses whether (1) to exit, (2) to produce a variety in a nest with other competitors, or (3) to incur a higher (fixed or variable) cost and produce in a new nest where it is a monopolist. After these discrete choices are made, all firms simultaneously set prices. The choice of product differentiation, between (2) and (3), is our only departure from Atkeson and Burstein (2008).

A firm that differentiates its product faces a lower elasticity of demand and sells more for a given price. The incremental profit from differentiation is a non-monotonic function of the firm's productivity, given the productivity of other firms in the common nest. If the firm is very unproductive, its profit is small in any nest. If the firm is much more productive than its competitors, then it will hold near monopoly power and charge a high markup even in the common nest. The benefit from further differentiation is small.

We study how the subgame perfect equilibrium changes with a shock to foreign competition in a single sector. We assume that a large reduction in foreign costs disproportionately tightens competition in the common nest. It then increases the profit from product differentiation (escaping to a new nest) for domestic firms. The markup increases for firms that escape competition and decreases for firms that remain in the common nest. When firms of all sizes respond to the shock similarly in terms of product differentiation, the markup of small firms increases relative to large firms.

The increased differentiation among domestic firms is consistent with the link between tariff cuts and the introduction of new products and switches to skill intensive sectors. This link is of similar magnitude for small and large firms in the data, suggesting through the lenses of the model that large and small firms differentiate their products to a similar extent when import competition tightens. The model then predicts that the markup of small firms increases relative to large firms, consistent with the heterogeneous findings on revenue productivity in the data. Although revenue productivity is the standard measure of firm performance in the empirical literature, it is not a good proxy for differentiation in the model. It confounds the positive effect of product differentiation with the negative

effects of import competition on the markups of firms in the common nest.[5]

We find conditions for a uniform reduction in foreign costs that affects all sectors to increase differentiation. In the model, the private profit from product differentiation is smaller than the social benefit. Allowing firms to differentiate their products increases the welfare gain from the trade shock relative to a model where firms cannot change their variety, as in standard settings. A back-of-the-envelope calculation in Section 5 shows that such gain may be sizable.

Holmes and Stevens (2014) also observe that firms offering customized products are more insulated from foreign competition. We extend their model to account for endogenous product differentiation and markups (their focus is firm size). Consistent with our findings, Brandt and Thun (2010) and Brandt and Thun (2016) describe the increased market segmentation in China during the period of our analysis. In Aghion et al. (2005) and Aghion et al. (2015), competition may increase innovation, and the profit from innovation is non-monotonic in productivity. In these models, goods are homogeneous within sectors, and only the most productive firm produces. We bring their results closer to recent quantitative models of international trade with co-existing differentiated varieties. Our welfare analysis complements Spence (1976a), Spence (1976b), Dixit and Stiglitz (1977) and Dhingra and Morrow (2018). Our approach differs from the latter two papers, whose methods apply to monopolistic competition.

The empirical analysis is in Section 2. To highlight the main mechanisms, we present the model of a closed economy in Section 3 and the model of a small open economy in Section 4. The welfare analysis is in Section 5. Section 6 presents extensions and robustness of the empirical results. Section 7 concludes.

[5]See Section 4.3 for references and further discussion on measured productivity.

# 2 Data and Evidence

We describe the data in Section 2.1, the empirical specification in Section 2.2, and the results in Section 2.3.

## 2.1 Data Sources

We use an annual survey of industrial establishments collected by the Chinese National Bureau of Statistics. The survey comprises all state-owned enterprises (SOEs), regardless of size, and private enterprises with annual sales of more than 5 million yuan. We use a ten-year unbalanced panel from 1998 to 2007. The data contain information on output, fixed assets, total workforce, total wages, intermediate input costs, foreign investment, revenue from domestic and export sales. Output price indices by sector are reported annually in the official publication. For further details on the survey, see Du et al. (2012), Aghion et al. (2015), and Brandt et al. (2017).

The original dataset has 2,226,104 firm-year observations. We keep only firms in manufacturing, the more tradable sector. We drop three sectors with missing price indices, and we delete observations with missing data on output, number of employees, capital, or material inputs. Our main results restrict the sample to firms with zero foreign ownership and with zero or a minority state ownership. Section 6 presents the results with multinationals and SOE's. The final sample has 1,037,738 observations. Our time series of tariffs is the World Integrated Trading Solution (WITS), maintained by the World Bank. We use the Chinese Input-Output Table (2002) to construct some control variables.

## 2.2 Empirical Specification

Our main regression specification is:

$$y_{it} = \beta \ln \text{Tariff}_{j(i,t)t} + \gamma_1 X_{j(i,t)t} + \gamma_2 X_{i,t} + \alpha_i + \alpha_t + \varepsilon \tag{1}$$

where the subscripts refer to firm $i$, year $t$, and the sector $j(i,t)$ of firm $i$ at time $t$, $\alpha_i$ are firm fixed effects, and $\alpha_t$ are time fixed effects. Sector-time control variables $X_{jt}$ include the weighted average of tariffs in sectors upstream and downstream from the firm's own sector $j$, state ownership in sector $j$, and foreign ownership in sector $j$ and in sectors upstream and downstream from $j$.[6] Firm-time controls $X_{it}$ are zero-one dummy variables indicating whether firm $i$ in year $t$ received subsidies, whether it received a tax holiday, and whether it paid below median interest rates on loans. The procedure to measure these control variables and their coefficient estimates are in Appendix A.1. We cluster standard errors by firm and by the firm's initial sector.

The independent variable of interest is the tariff that China imposes on its imports of sector $j$ at time $t$. We use instrumental variables to mitigate the concern that firms endogenously influence tariffs through lobbying. Similar to other trade liberalizations, China reduced both the level and the heterogeneity in tariffs. Between 1998 to 2007, tariff reductions were larger in sectors with initial high tariffs. Following the literature, we instrument for tariffs using the value of tariffs for the firm in 1998 interacted with a dummy variable equal to one after China entered the WTO.[7]

The dependent variables $y_{it}$ are firm outcomes often associated with innovation or quality upgrading in the literature: Revenue total factor productivity (TFP), introduction of new goods, and skill intensity.

For TFP, we estimate separately for each 2-digit sector the production function

$$\log X_{it} = \alpha_{0j(i,t)} + \alpha_{Lj(i,t)} \log L_{it} + \alpha_{Mj(i,t)} \log M_{it} + \alpha_{Kj(i,t)} \log K_{it} + \mu_{it} \qquad (2)$$

[6] We follow Javorcik (2004) to construct foreign ownership variables. For tariffs upstream from $j$, we follow Amiti and Konings (2007) and Brandt et al. (2017), and we use an analogous procedure to measure tariffs downstream from $j$.

[7] We use the corresponding instrument for other tariff measures in $X_{jt}$ (Appendix A). Similar instruments appear in Goldberg et al. (2009) for India, Amiti and Konings (2007) for Indonesia, and Attanasio et al. (2004) for Colombia. In China, Brandt et al. (2017) follow a similar approach using as instruments tariff rates from the accession agreement, which were mostly fixed by 1999. We cannot use the initial tariffs alone as an instrument because our regressions have firm fixed effects.

where $X$ is output, $L$ is number of employees, $K$ is capital, $M$ is material inputs, and $\alpha_{0j}$, $\alpha_{Lj}$, $\alpha_{Kj}$ and $\alpha_{Mj}$ are sector-specific parameters to be estimated. Output and cost variables are deflated with the sector-specific price indices.[8] Our estimated $\log TFP_{it}$ is the predicted value of $\log X_{it} - \hat{\alpha}_{Lj(i,t)} \log L_{it} - \hat{\alpha}_{Mj(i,t)} \log M_{it} - \hat{\alpha}_{Kj(i,t)} \log K_{it}$.

We estimate (2) using the standard two-stage procedure in Olley and Pakes (1996), with OLS and time fixed effects, and following Ackerberg et al. (2015) in Appendix A.3. When TFP is the dependent variable in (1), we add sector fixed effects due to the concern that TFP is not comparable across sectors.[9]

For the introduction of new goods, we use the share of new products in total sales, reported in the survey, and a dummy variable equal to one if firm $i$ introduces a new product in year $t$ and zero otherwise.

Unfortunately, we only observe the composition of the workforce in the 2004 survey. We define skilled workers as those who have completed a senior-high degree, or a three- or four-year college degree.[10] We calculate the share of skilled workers in the total labor force of each sector in 2004 and rank sectors according to these shares. Of the 450 sectors in the data, the least skill-intensive sector is the production of packaging and bags, and the most skill intensive sector is a subsector in aircraft manufacturing. We use for the dependent variable $y_{it}$ in (1) the ranking of sector $j(i,t)$.

## 2.3 Empirical Results

**Basic Results** Table 1 presents the coefficient on tariffs from regression (1). The coefficient is negative in all specifications. It is statistically significant in all IV specifications,

[8] All output and input variables are deflated. Output value 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 using the Chinese input-output table. 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.

[9] For the other outcome variables, we do not include sector fixed effects to capture product innovation that may be accompanied by firms switching between 4-digit sectors.

[10] Changing the educational cutoffs in the definition of skill intensity yields highly correlated measures.

Table 1: Regressions of Productivity, New Goods, and Sectoral Skill Intensity on Tariffs

| **dependent variable ↓** | **coefficient on tariffs** | **standard error** | | **sample**[1] | **number of observations** | **First stage F statistic** |
|---|---|---|---|---|---|---|
| **Panel A** | | | | | | |
| Revenue TFP, Olley-Pakes | -0.0304*** | 0.0027 | OLS | all | 1,037,738 | - |
| Revenue TFP, Olley-Pakes | -0.0505*** | 0.0169 | IV | all | 1,037,738 | 278 |
| Revenue TFP, Olley-Pakes | -0.0617*** | 0.0158 | IV | non-exporters | 826,072 | 350 |
| Revenue TFP, fixed effects | -0.0322*** | 0.0028 | OLS | all | 1,037,738 | - |
| Revenue TFP, fixed effects | -0.0477*** | 0.0184 | IV | all | 1,037,738 | 278 |
| Revenue TFP, fixed effects | -0.0580*** | 0.0170 | IV | non-exporters | 826,072 | 350 |
| **Panel B** | | | | | | |
| new product share | -0.000356 | 0.0012 | OLS | all | 1,037,738 | - |
| new product share | -0.0157** | 0.0068 | IV | all | 1,037,738 | 278 |
| new product share | -0.00976** | 0.0045 | IV | non-exporters | 826,072 | 350 |
| 0-1 dummy for introducing new products | -0.000687 | 0.0029 | OLS | all | 1,037,738 | - |
| 0-1 dummy for introducing new products | -0.0405** | 0.0168 | IV | all | 1,037,738 | 278 |
| 0-1 dummy for introducing new products | -0.0279*** | 0.0102 | IV | non-exporters | 826,072 | 350 |
| **Panel C** | | | | | | |
| Sector ranking in skill intensity | -17.82*** | 1.00 | OLS | all | 1,037,738 | - |
| Sector ranking in skill intensity | -26.20*** | 3.81 | IV | all | 1,037,738 | 278 |
| Sector ranking in skill intensity | -18.80*** | 3.14 | IV | non-exporters | 826,072 | 350 |
| (higher ranking corresponds to higher skill intensity) | | | | | | |

The table reports the coefficient on log of tariffs from (1). Standard errors are clustered by firm and initial sector. All regressions contain fixed effects for firm and time, and the control variables summarized in the text. TFP regressions in Panel A also include two-digit sector and a dummy variable equal to 1 if the firm changes a 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 $p < 0.1$. [1] "All" indicates all establishments excluding SOE's and multinationals. "Non-exporters" is the subsample of these establishments that do not export.

including the ones in which we restrict the sample to non-exporting establishments.[11] Greater import competition, captured through tariff cuts, is associated with increases in revenue TFP, the introduction of new goods, and shifts toward skill-intensive sectors.

In Panel A, the dependent variable is revenue TFP. The coefficient is -0.05 in the IV specification with all establishments (excluding SOE's and multinationals). A one standard deviation in log of tariffs, around 0.5, is associated with an increase in revenue TFP by about 2.5 percent.

In Panel B the dependent variables capture the introduction of new goods. A one standard deviation in log of tariffs is associated with an increase of 0.8 percentage points in the share of new products in total sales (0.5 $\times$ -0.0157), and with an increase of 2 percentage points in the probability of introducing a new product (0.5 $\times$ -0.0405).

In Panel C, the dependent variable is the ranking of sectors in ascending order of skill intensity. Since all specifications include firm fixed effects, the identification stems from firms switching sectors. Approximately 15 percent of firms in the sample switch sectors over the period from 1998 to 2007. With point estimates ranging from -18 to -26, a one standard deviation reduction in log tariffs is associated with a movement up the rank of 9 to 13 sectors. Among non-exporting firms, the sector switches with the largest number of firms include switches from cotton and chemical fibers (1761) to textile and garments manufacturing (1810), from steel rolling processing (3230) to the manufacture of metal structures (3411), and from non-ferrous rolling process (3351) to optical fiber and cable manufacturing (3931). In all cases, these switches are from lower value-added products or stages of production to higher value-added products, where the scope for differentiation is arguably greater. They are thus consistent with our thesis that firms escape import competition by differentiating their products.

[11] A possible explanation for the IV results is that firms responded to the large tariff cuts of the WTO accession, but not to smaller tariff cuts in other years.

Table 2: Responses of Firms to Output Tariff Cuts by Quartile of Sales

**Panel A: Dependent variable is TFP à la Olley-Pakes or OLS with fixed effects (FE)**

| | All establishments excluding SOEs and multinationals | | | | Only non-exporters | |
|---|---|---|---|---|---|---|
| | OP OLS | FE OLS | OP IV | FE IV | OP IV | FE IV |
| tariff*q1$_{i,t-1}$ | -0.0337*** | -0.0344*** | -0.0334** | -0.0276 | -0.0435*** | -0.0365** |
| | (0.00341) | (0.00350) | (0.0169) | (0.0175) | (0.0167) | (0.0172) |
| tariff*q2$_{i,t-1}$ | -0.0302*** | -0.0312*** | -0.0277 | -0.0249 | -0.0396** | -0.0353* |
| | (0.00313) | (0.00322) | (0.0179) | (0.0189) | (0.0173) | (0.0181) |
| tariff*q3$_{i,t-1}$ | -0.0261*** | -0.0273*** | -0.00859 | -0.00510 | -0.0180 | -0.0132 |
| | (0.00314) | (0.00324) | (0.0190) | (0.0198) | (0.0189) | (0.0196) |
| tariff*q4$_{i,t-1}$ (largest) | -0.0240*** | -0.0253*** | -0.0129 | -0.0118 | -0.0259 | -0.0233 |
| | (0.00327) | (0.00340) | (0.0168) | (0.0178) | (0.0173) | (0.0182) |
| H0: tariff*q1 < tariff*q4 (p-value) | 0.0006 | 0.002 | 0.041 | 0.093 | 0.098 | 0.169 |
| Observations (panels A, B, C) | 701,765 | 701,765 | 701,765 | 701,765 | 548,283 | 548,283 |

**Panel B: Dependent variable is a measure of introduction of new goods**

| | All establishments excluding SOEs and multinationals | | | | Only non-exporters | |
|---|---|---|---|---|---|---|
| | new product share OLS | 0-1 dummy for new product OLS | new product share IV | 0-1 dummy for new product IV | new product share IV | 0-1 dummy for new product IV |
| tariff*q1$_{i,t-1}$ | 0.000531 | -0.00138 | -0.0152** | -0.0513*** | -0.0123** | -0.0327*** |
| | (0.00144) | (0.00348) | (0.00746) | (0.0184) | (0.00582) | (0.0124) |
| tariff*q2$_{i,t-1}$ | 0.000509 | 0.000862 | -0.0169** | -0.0337* | -0.0117** | -0.0252** |
| | (0.00142) | (0.00328) | (0.00747) | (0.0177) | (0.00575) | (0.0120) |
| tariff*q3$_{i,t-1}$ | 0.000192 | 0.00117 | -0.0148* | -0.0293 | -0.00981 | -0.0168 |
| | (0.00153) | (0.00343) | (0.00786) | (0.0191) | (0.00612) | (0.0134) |
| tariff*q4$_{i,t-1}$ (largest) | -0.000867 | -0.00185 | -0.0189** | -0.0264 | -0.0131** | -0.0290** |
| | (0.00179) | (0.00377) | (0.00834) | (0.0194) | (0.00628) | (0.0135) |

**Panel C: Dependent variable is the sector ranking in skill intensity (higher ranking corresponds to greater skill intensity)**

| | All establishments excluding SOEs and multinationals | | Only non-exporters | |
|---|---|---|---|---|
| | OLS | IV | OLS | IV |
| tariff*q1$_{i,t-1}$ | -17.70*** | -21.31*** | -18.51*** | -15.49*** |
| | (1.067) | (3.914) | (1.012) | (3.441) |
| tariff*q2$_{i,t-1}$ | -17.62*** | -19.51*** | -18.32*** | -13.33*** |
| | (1.070) | (3.662) | (1.015) | (3.283) |
| tariff*q3$_{i,t-1}$ | -17.41*** | -20.63*** | -18.07*** | -15.17*** |
| | (1.079) | (3.835) | (1.011) | (3.446) |
| tariff*q4$_{i,t-1}$ (largest) | -16.95*** | -23.32*** | -17.89*** | -17.71*** |
| | (1.105) | (3.890) | (1.078) | (3.499) |

The table repeats the results of Table 1 substituting the independent variable tariff for an interaction of tariff with a dummy indicating the firm's quartile of sales in the sector and lagged year (q1, q2, q3, q4) plus the lagged quartiles q1, q2, q3, q4 by themselves. Standard errors are clustered by firm and initial sector. Tariffs and TFP are in logs. Appendix A.1 reports the coefficients on the other control variables.

**Firm Heterogeneity** To investigate whether the responses to tariff cuts differ across firms of different sizes, we split firms in each sector-year into quartiles of sales, and we repeat the regressions in Table 1 replacing log $\text{Tariff}_{j(i,t)t}$ with four variables: log $\text{Tariff}_{j(i,t)t}$ interacted with dummies indicating the firm's quartile of sales within the sector in the lagged year, $t-1$. We also add these quartiles as independent variables.

Table 2 reports the coefficients on the interaction terms. As in Table 1, the dependent variable measures revenue TFP in Panel A, the introduction of new goods in Panel B, and the ranking of sector skill intensity in Panel C. In Panels B and C, the coefficients on tariffs are very similar across quartiles of firm sales. In Panel A, the coefficient on tariffs generally increases with quartile of sales. The coefficient on the smallest quartile is 0.4 to 2.6 times larger in absolute value than in the coefficient in the largest quartile. The difference is statistically significant in the OLS but not all in IV, in which the coefficient in the largest quartile is imprecisely estimated and statistically insignificant. In sum, tariff cuts are associated with increases in revenue productivity for smaller firms, and with a smaller, if existent, effect for larger firms.

**Existing Models** It is difficult to explain the coefficients on tariffs in Table 1 with existing models of international trade. In models in which economies of scale determine firm productivity, such as Bustos (2011), Caliendo and Rossi-Hansberg (2012), Helpman et al. (2017), tighter import competition decreases firm sales and investments in technologies among non-exporting firms. In contrast in the data, import competition captured through tariff cuts is linked to higher TFP within firms, especially among non-exporting firms (Panel A).[12] In recent models of multiproduct firms such as Bernard et al. (2011),

[12] Appendix A.2 analyzes the relation between revenue and TFP. In Table A.10, TFP and revenue are correlated, even after controlling for time and sector fixed effects. In Table A.9, tariff cuts are associated with decreases in sales. These patterns are consistent with the models above and with previous findings.

Typically in models with endogenous markups, Bernard et al. (2003a), Atkeson and Burstein (2008), and Melitz and Ottaviano (2008), tighter competition decreases markups within firms, similar to the predictions of the models with economies of scale above. In Impullitti and Licandro (2017), import competition may lead to sufficient exit of domestic firms for competition to be looser for surviving plants. This is also true in our model, but our results hold for sufficiently large shocks that tighten competition

Mayer et al. (2014) and Dhingra (2013) firms respond to tighter competition by dropping their least productive varieties, not by introducing new varieties as in Panel B.

Although the classic Heckscher-Ohlin model predicts that trade shifts production across sectors, it predicts shifts toward unskill-intensive sectors in an unskill-abundant country like China, the opposite direction of the data (Panel C). Starting with Feenstra and Hanson (1997), some recent models predict that trade increases the demand for skills even in developing countries through an export expansion or imported inputs and capital equipment.[13] Our empirical results, however, exploit variations in tariffs imposed by China and hold for the subsample of non-exporting firms, suggesting that import competition also plays a role.

We interpret the introduction of new goods and shifts to skill-intensive sectors as proxies for product innovation. We propose a stylized model where import competition increases product innovation. Although it would be simple to add skills to the model, we do not add them to keep the focus on innovation. To address revenue TFP, a measure of the ratio of revenue to cost (equation (2)), our setup features endogenous markups. We first present the model of a closed economy to highlight the main mechanisms.

# 3 A Closed Economy

## 3.1 Model of the Closed Economy

The set up is in Section 3.1 and the results are in Section 3.2. There is a continuum of sectors $S \in [0, 1]$, each containing a finite and exogenous set of firms. Firms are heterogeneous in unit costs. Each firm produces a single variety. Within each sector $S$, firms that do not exit are partitioned into nests according to the outcome of the strategic game below. We write $i \in n$ whenever firm $i$ is in nest $n$ and $n \in S$ whenever nest $n$ is

for all firms. Dhingra (2013) combines variable markups with multi-product firms.

[13] See Yeaple (2005), Burstein and Vogel (2016), Burstein et al. (2016), Helpman et al. (2017), Lee (2018), and Fieler et al. (2018).

in sector $S$. Labor is the unique input into production. Worker-households inelastically supply their labor endowments in a perfect labor market. We normalize the total labor endowment to one, and take wages to be the numeraire.

**Demand** Consumer demand follows a standard nested CES system. Spending on a variety with price $p$ in nest $n$ is

$$x(p,n) = \overline{P}^{\eta-1} P_n^{\sigma-\eta} p^{1-\sigma} y \tag{3}$$

$$\text{where} \quad P_n = \left[ \sum_{i \in n} p_i^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{4}$$

$$\overline{P} = \left[ \int_0^1 \sum_{n' \in S} P_{n'}^{1-\eta} dS \right]^{\frac{1}{1-\eta}}, \tag{5}$$

$y$ is total spending. The elasticity of substitution between nests is $\eta$, irrespective of whether nests are in the same sector or not for simplicity. The elasticity of substitution between varieties within a nest is $\sigma$. Assume $\sigma > \eta > 1$.

**Technology** Each firm $i$ chooses among three discrete choices: (i) to exit, (ii) to produce a less-differentiated variety, or (iii) to produce a differentiated variety. If the firm exits, it gets zero profits. All less-differentiated varieties in sector $S$ are in the same nest, denoted with $\mathcal{L}_S$. Each differentiated variety has its own nest. In (4) $P_n = p$, and in (3) demand reduces to $x(p,n) = (p/\overline{P})^{1-\eta} y$.

If firm $i$ is less-differentiated, it pays a fixed cost $f_L$ and a per-unit cost $c_{iL}$. If it is differentiated, its fixed cost is $f_D$ and its unit cost is $c_{iD}$. These costs are all in units of labor, whose wage is one.

The only distinction among sectors is the set of firms with their corresponding unit costs. Rank firms in each sector by ascending order of unit costs under less-differentiation, $c_{iL}$. Let $\tilde{i}(r,S)$ be the $r^{th}$ ranked firm in sector $S$. Sector $S$ is then characterized by a number of firms $m_S$, and costs $(c_{\tilde{i}(1,S)L}, ..., c_{\tilde{i}(m_S,S)L})$ and $(c_{\tilde{i}(1,S)D}, ..., c_{\tilde{i}(m_S,S)D})$. Assume

that these cost vectors are bounded below by some $\underline{c} > 0$, and that they are continuous in $S \in [0,1]$ in all but at most a finite number of sectors in which $m_S$ may change.

**Game within a Sector.** In ascending order of costs $c_{iL}$, each firm in sector $S$ decides among the three discrete choices above (i) exit, (ii) less-differentiation, and (iii) differentiation. Once all discrete choices are made, firms simultaneously set prices. We consider the subgame perfect equilibrium (SPE).[14]

We solve for the SPE by backward induction. Consider first prices and payoffs after all discrete choices are made. From (3), firm $i$ in nest $n$ with unit cost $c$ solves

$$\begin{aligned} \max_{p} \quad & \overline{P}^{\eta-1} P_n^{\sigma-\eta} p^{-\sigma} (p-c) y \\ \text{subject to} \quad & P_n = \left( p^{1-\sigma} + \sum_{i' \in n, i' \neq i} p_{i'}^{1-\sigma} \right)^{1/(1-\sigma)}. \end{aligned} \tag{6}$$

The firm best responds to the prices of other firms in its nest. Following Atkeson and Burstein (2008), the markup over marginal cost is $\epsilon/(\epsilon-1)$ where

$$\begin{aligned} \epsilon &= \sigma(1-s) + \eta s, \\ s &= \left( \frac{p}{P_n} \right)^{1-\sigma}. \end{aligned} \tag{7}$$

The endogenous elasticity of demand $\epsilon$ is a weighted average between the elasticity within nest $\sigma$ and the elasticity across nests $\eta$, where the weight $s$ is the firm's market share in revenue. Equation (7) implicitly defines the vector of prices in a nest as a function of unit costs.

If the firm $i$ is differentiated, $s = 1$ and $\epsilon = \eta$. Its operating profit (6) is

$$\pi_D(c_{iD}) = \frac{\overline{P}^{\eta-1}}{\eta} \left( \frac{\eta c_{iD}}{\eta - 1} \right)^{1-\eta} y. \tag{8}$$

[14]The timing of firms' discrete choices according to productivity is a standard equilibrium selection mechanism, also used in Atkeson and Burstein (2008), Edmond et al. (2015).

Define function $P_L(\mathbf{c})$ as the price index (4) of a nest with a vector of unit costs $\mathbf{c}$ and $P_L(\mathbf{c}) = \infty$ if $\mathbf{c} = \emptyset$, and define $\epsilon_L(c, \mathbf{c})$ as the elasticity of demand (7) of a firm with unit cost $c$ when the vector of unit costs of the other firms in the same nest is $\mathbf{c}$. When firm $i$ does not differentiate and the vector of other firms' unit costs in $\mathcal{L}_S$ is $\mathbf{c}_{-iL}$, its operating profit (6) is

$$\pi_L(c_{iL}, \mathbf{c}_{-iL}) = \overline{P}^{\eta-1} \frac{P_L(\{c_{iL}, \mathbf{c}_{-iL}\})^{\sigma-\eta}}{\epsilon_L(c_{iL}, \mathbf{c}_{-iL})} \left( \frac{c_{iL}\epsilon_L(c_{iL}, \mathbf{c}_{-iL})}{\epsilon_L(c_{iL}, \mathbf{c}_{-iL}) - 1} \right)^{1-\sigma} y. \tag{9}$$

Name firms in sector $S$ according to their rank $c_{1L} \leq ... \leq c_{m_S L}$. Denote an action of firm $i$ with $g_i \in \{exit, less\ differentiation, differentiation\}$. A vector of actions $(g_1, ..., g_{m_S})$ determines the sets of exiting, less-differentiated, and differentiated firms. By backward induction, starting with the least productive firm, for $i = m_S, ..., 1$ and all possible actions $(\tilde{g}_1, ..., \tilde{g}_{i-1})$, firm $i$ chooses among three subgames with starting nodes $(\tilde{g}_1, ..., \tilde{g}_{i-1}, g_i)$ for $g_i = exit, less\ differentiation, differentiation$. Since it anticipates the actions of firms $i+1, ..., m_S$ following $(\tilde{g}_1, ..., \tilde{g}_{i-1}, less\ differentiation)$, it anticipates its competitors' costs $\mathbf{c}_{-iL}$ in $\mathcal{L}_S$. The firm then picks $\max\{0, \pi_L(c_{iL}, \mathbf{c}_{-iL}) - f_L, \pi_D(c_{iD}) - f_D\}$. These decisions are unique in every node up to a perturbation of parameters. So, the subgame perfect equilibrium is also unique up to a perturbation. Throughout, we ignore these indifference cases and cases in which two or more firms have the same unit cost $c_{iL}$ or $c_{iD}$.

**Equilibrium** All sectors are in SPE. Let $\mathcal{D}_S$ be the equilibrium set of differentiated firms in sector $S$. The equilibrium set of nests in sector $S$ is one nest $\{i\}$ for each $i \in \mathcal{D}_S$ plus $\mathcal{L}_S$ if $\mathcal{L}_S \neq \emptyset$.

The price index in (5) is

$$\overline{P} = \left[ \int_0^1 [P_L(\mathbf{c}_{LS})]^{1-\eta} + \sum_{i \in \mathcal{D}_S} \left( \frac{\eta c_{iD}}{\eta - 1} \right)^{1-\eta} dS \right]^{1/(1-\eta)}. \tag{10}$$

where $\mathbf{c}_{LS}$ is the vector of unit costs in the less-differentiated nest $\mathcal{L}_S$.

The representative household gets income from wages and profits:

$$y = 1 + \int_0^1 \left[ \sum_{i \in \mathcal{L}_S} \pi_L(c_{iL}, \mathbf{c}_{-iL}) + \sum_{i \in \mathcal{D}_S} \pi_D(c_{iD}) \right] dS \tag{11}$$

Given the assumptions on costs, the terms inside the integrals in (10) and (11) are bounded, and they are continuous in $S$ in all but a zero-measure set of sectors where $\mathcal{L}_S$ or $\mathcal{D}_S$ change exogenously or endogenously through firms' discrete choices. Hence, the integrals exist when all sectors are in SPE.

An equilibrium is a set of firm strategies, a price $\overline{P}$, and income $y$ such that all sectors are in subgame perfect equilibrium, and equations (10) and (11) hold.

## 3.2 Results in the Closed Economy

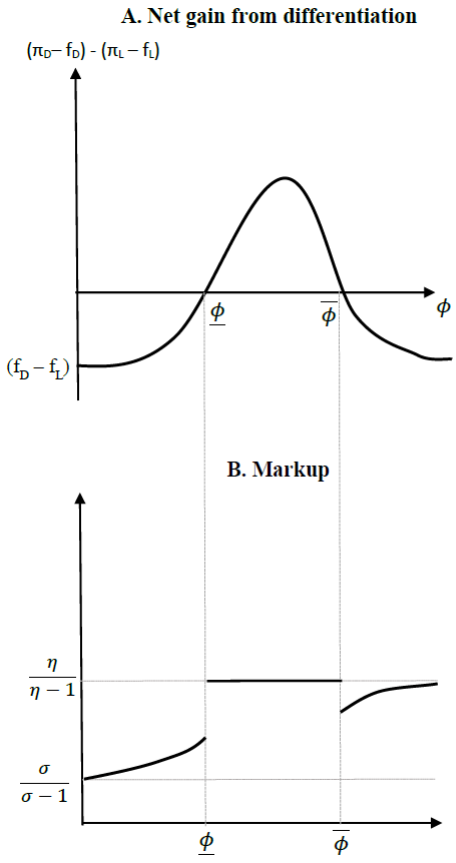
**Exit** Because more productive firms move first, if firms can be ranked in terms of costs, $c_{iD} < c_{i'D}$ if and only if $c_{iL} < c_{i'L}$ for all $i$ in sector $S$, then there exists $\overline{c}_S > 0$ such that firms in $S$ produce if and only if $c_{iL} \leq \overline{c}_S$. (See proof in Appendix B.1.)

**Productivity and a firm's decision to differentiate** The effect of changes in unit costs on a firm's decision to differentiate its product is straightforward: An efficient firm disproportionately gains if $c_{iD} < c_{iL}$, and loses from differentiation if $c_{iD} > c_{iL}$.[15] So to isolate the novel mechanism, assume for the moment $c_{iD} = c_{iL} \equiv c_i$ and $f_D > f_L$ (to make the firm's choice non-trivial). Fix the level of competition that firm $i$ faces in a particular subgame, $\mathbf{c}_{-iL}$, and vary the firm's productivity $\phi \equiv (c_i)^{-1}$.

Figure 1 illustrates this exercise. It plots the net profit from differentiation $\pi_D(c_i) - \pi_L(c_i, \mathbf{c}_{-iL}) - (f_D - f_L)$ in Panel A and markups in Panel B as functions of $\phi$. Appendix B.3 proves that the set of productivities $\phi$ in which the firm differentiates is convex, and the net profit is $(f_L - f_D) < 0$ when $\phi = 0$ because $\lim_{c_i \to \infty} \pi_D(c_i) = \lim_{c_i \to \infty} \pi_L(c_i, \mathbf{c}_{-iL}) = 0$.

[15] Innovation is often modelled as a fixed cost to decrease unit costs—e.g, Lileeva and Trefler (2010) and Bustos (2011). Differentiation involves the same considerations in the special case $f_D > f_L$ and $c_{iD} < c_{iL}$. We deal with the cases $c_{iL} \gtrless c_{iD}$ in Appendix B.3.

Figure 1: Example of a firm's profit from differentiation and markups ($\phi = c_{iD}^{-1} = c_{iL}^{-1}$)



The limit $c_i \to 0$ is more didactic. Let $p_{iD} = \eta c_i/(\eta - 1)$ be the price under differentiation, and $P_{-iL}$ be the CES price index in nest $\mathcal{L}_S$ excluding firm $i$ from the sum, where we omit its argument $(c_i, \mathbf{c}_{-iL})$.[16] Then

$$\begin{aligned}
\pi_D(c_i) &= \frac{y\overline{P}^{\eta-1}}{\eta} p_{iD}^{1-\eta} \\
&\leq \frac{y\overline{P}^{\eta-1}}{\eta} \left(P_{-iL}^{1-\sigma} + p_{iD}^{1-\sigma}\right)^{\frac{\sigma-\eta}{1-\sigma}} P_{-iL}^{1-\sigma} + \frac{y\overline{P}^{\eta-1}}{\eta} \left(P_{-iL}^{1-\sigma} + p_{iD}^{1-\sigma}\right)^{\frac{\sigma-\eta}{1-\sigma}} p_{iD}^{1-\sigma} \\
&\leq \frac{y\overline{P}^{\eta-1}}{\eta} \left(P_{-iL}^{1-\sigma} + p_{iD}^{1-\sigma}\right)^{\frac{\sigma-\eta}{1-\sigma}} P_{-iL}^{1-\sigma} + \pi_L(c_i, \mathbf{c}_{-iL}).
\end{aligned}$$

The second line is the operating profit of a hypothetical, differentiated firm that charges $\left[P_{-iL}^{1-\sigma} + p_{iD}^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \leq p_{iD}$ and gets a share $1/\eta$ of revenue as profits. The third line comes from profit maximization of the less-differentiated firm. Both inequalities hold strictly if $P_{-iL} < \infty$. Rearranging and taking limits,

$$\lim_{c_i \to 0} \left[\pi_D(c_i) - \pi_L(c_i, \mathbf{c}_{-iL})\right] \leq \lim_{p_{iD} \to 0} \frac{y\overline{P}^{\eta-1}}{\eta} \left(P_{-iL}^{1-\sigma} + p_{iD}^{1-\sigma}\right)^{\frac{\sigma-\eta}{1-\sigma}} P_{-iL}^{1-\sigma} = 0.$$

In words, the gain in operating profit from differentiation is bounded above by the profit from acquiring the residual demand of competitors in nest $\mathcal{L}_S$. Since this residual demand goes to zero as the firm's own cost $c_i$ goes to zero, the gain must also go to zero.[17]

**Small Shocks to Competition in Sector $S$.** Sector $S$ is in SPE. The unit cost $c_{iL}$ decreases for some firm $i \in S$. All firms adjust their strategies to a new SPE. In (9), the operating profit under less differentiation $\pi_L(c_{i'L}, \mathbf{c}_{-i'L})$ is decreasing in any element

[16]
$$P_{-iL} = \left( \sum_{i' \in \mathcal{L}, i' \neq i} p_{i'}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$
where prices $p_{i'}$ are implicitly defined in (7) when the productivity vector in $\mathcal{L}_S$ is $(c_i, \mathbf{c}_{-iL})$.

[17] The claim $\lim_{c_i \to 0}(\pi_D - \pi_L) = 0$ is trivial in the limiting case $\sigma = \infty$ in Bernard et al. (2003b). The price is the minimum between the second lowest cost and the monopoly price. When the firm is sufficiently productive to charge monopoly price, $\pi_D(c_{iD}) = \pi_L(c_{iL}, \mathbf{c}_{-iL})$. We thank Samuel Kortum for pointing out this case.

of $\mathbf{c}_{-i'L}$, while the profit $\pi_D(c_{iD})$ depends only on general equilibrium variables and is unaffected by shocks to a single sector. Then, it is easy to generate examples where a decrease in $c_{iL}$ increases exit and differentiation among other firms $i' \in S$.

Now consider a numerical example with three firms and unit costs $c \equiv c_L = c_D = (1, 1.1, 1.2)$. The fixed costs are $f_L = 0.044$ and $f_D = 0.102$, and $\overline{P}^{\sigma-1} y = 1$. Figure 2(a) illustrates the equilibrium strategies and Appendix Table B1 shows all payoffs. Letters $E$, $L$, $D$ represent actions *exit*, *less-differentiation*, *differentiation*, respectively. We chose fixed costs so that firm 3 is close to exit in the subgame following actions $(L, L)$ of firms 1 and 2, $\pi_L(c_3, \{c_1, c_2\}) = 0.045 > f_L = 0.044$, and the gain from differentiation is small for firm 2, $\pi_D(c_2) - \pi_L(c_2, \{c_1, c_3\}) = 0.059 > 0.058 = f_D - f_L$. The thick red arrows indicate the actions in the equilibrium path: $(L, D, L)$.

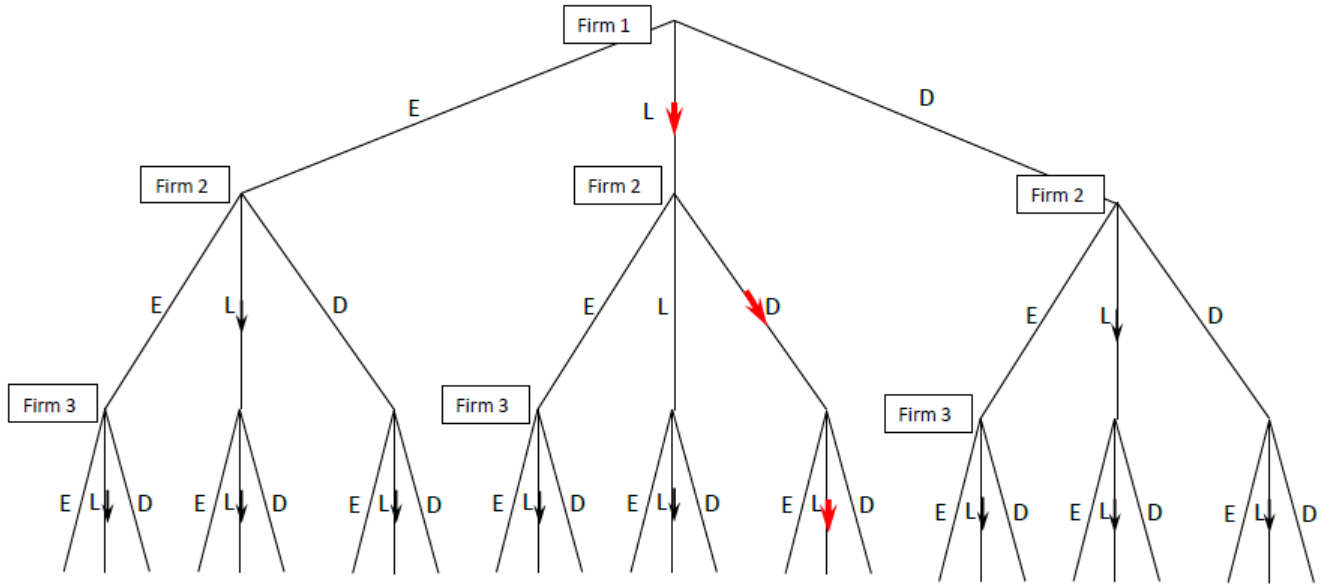
Figure 2(b) illustrates the effects of this SPE of a decrease in firm 1's cost from $c_1 = 1$ to $c_1 = 0.9$. Now, $\pi_L(c_3, \{c_1, c_2\}) = 0.041 < f_L$. Then, firm 3 exits in the subgame following actions $(L, L)$. The gross gain from product differentiation for firm 2 becomes $\pi_D(c_2) - \pi_L(c_2, \{c_1\}) = 0.055 < f_D - f_L$. Actions in the new equilibrium path are $(L, L, E)$. A decrease in cost $c_1$ leads firm 2 to switch from differentiation to less-differentiation.

Similar examples exist in which a decrease in firm $i$'s unit cost leads some firms $i'$ to differentiate and yet other firms $i''$ to switch from exiting to producing a less-differentiated variety. In sum, small changes in the cost of a firm have ambiguous effects on the discrete actions of other firms in the same sector.

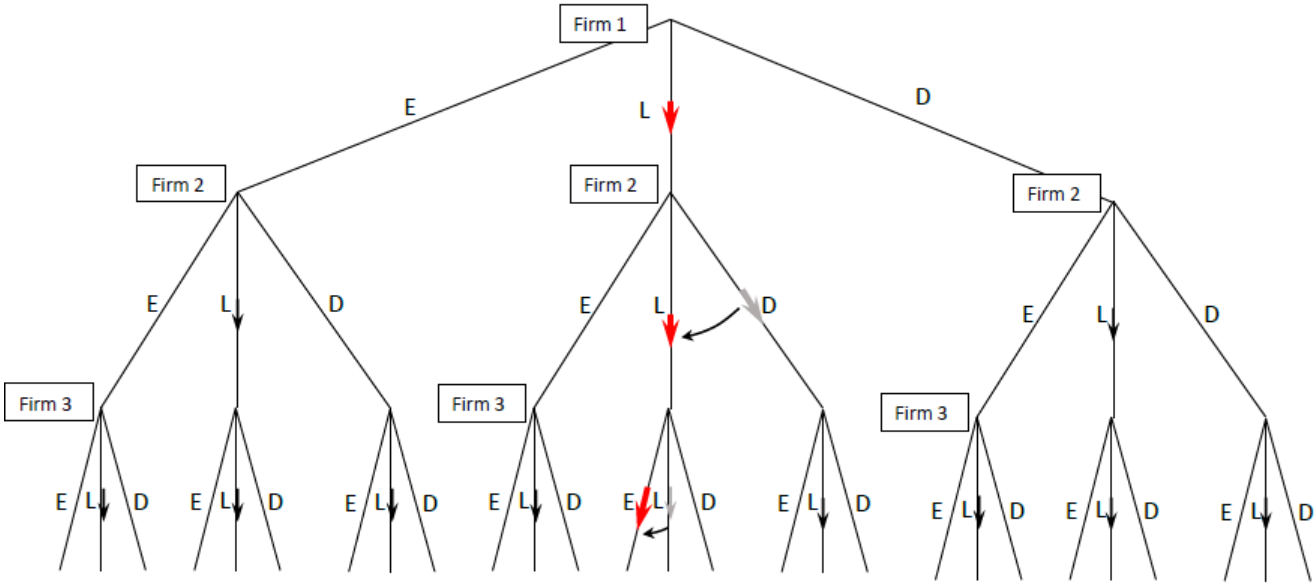
**Large Shocks to Competition in Sector $S$.** The key statistic summarizing the level of competition that firm $i$ faces in the less-differentiated nest is

$$P_{-\bullet L}(c_{iL}, \mathbf{c}_{-iL}) = \left( \sum_{i' \in \mathcal{L}_S, i' \neq i} p_{i'}^{1-\sigma} \right)^{1/(1-\sigma)} \tag{12}$$

where $\mathbf{c}_{-iL}$ is the vector of unit costs in $\mathcal{L}_S$, excluding firm $i$, in the subgame in which firm $i$ is less differentiated and all other firms play their SPE strategies. The operating




(a) Initial SPE




(b) SPE after shock (decrease in $c_1$)

Figure (a) illustrates the SPE when $\overline{P}^{\sigma-1}y = 1$, costs are $c_L = c_D = (1, 1.1, 1.2)$ and fixed costs are $f_L = 0.044$, $f_D = 0.102$. Letters E, L, D indicate actions exit, less-differentiation, and differentiation, respectively. The arrows indicate all equilibrium strategies and the thick arrows indicate the actions in the equilibrium path. Figure (b) illustrates how the subgame perfect equilibrium changes when the $c_1$ decreases from 1 to 0.9. Firm 2 switches from a differentiated to a less-differentiated product because it knows that firm 3 will exit in the subgame following actions (L,L) by firms 1 and 2.

Figure 2: Example of the effect of a small decrease in $c_1$ on the SPE strategies

profit in (6) depends on $\mathbf{c}_{-iL}$ only through $P_{-\bullet L}(c_{iL}, \mathbf{c}_{-iL})$. In the example of Figure 2, $P_{-\bullet L}(c_{2L}, \mathbf{c}_{-2L})$ increased with the decrease in $c_1$.

A decrease in $c_{iL}$ for some firm $i$ in sector $S$ is sufficiently large if it decreases the SPE value of $P_{-\bullet L}(c_{i'L}, \mathbf{c}_{-i'L})$ for all $i' \neq i$ in sector $S$. With a finite number of firms in sector $S$, it is always possible to construct such shocks since $P_{-\bullet L}(c_{i'L}, \mathbf{c}_{-i'L}) < \eta c_{iL}/(\eta - 1)$ for all $i' \neq i$, when firm $i$ chooses less-differentiation in all subgames (which occurs if $c_{iL}$ is small enough).

A sufficiently large decrease in $c_{iL}$ differentiation and exit among firms $i' \neq i$ and $i' \in S$. Among surviving firms, the shock decreases the markup of firms $i' \neq i$ that remain less-differentiated, and it increases the markup of newly-differentiated firms. If two firms $a, b \neq i$ have costs $c_{aL} < c_{bL}$ and they are in $\mathcal{L}_S$ in the initial SPE, the decrease in $c_{iL}$ increases the markup of firm $b$ relative to firm $a$ if both firms $a$ and $b$ remain in $\mathcal{L}_S$ or if they both differentiate their products in the new SPE.

This last claim is trivial when both firms differentiate, because markups of $a$ and $b$ go to $\eta/(\eta-1)$, and markups in $\mathcal{L}_S$ are strictly decreasing in costs $c_{i'L}$ in any SPE. Appendix B.4 proves the case in which firms $a$ and $b$ remain in $\mathcal{L}_S$, and they best respond to the shock and to other endogenous price changes. We only note that tighter competition in $\mathcal{L}_S$ cannot decrease the markups of small firms beyond the lower bound $\sigma/(\sigma - 1)$.

**Shock to Competition in a Non-Zero Mass of Sectors.** An economy is in equilibrium. The unit cost $c_{iL}$ of a non-zero measure of firms in a connected subset of sectors decreases. Denote the set of firms affected by the shock with $\mathcal{I}$ and the subset of sectors with $\mathcal{S}$. The shock is such that the vectors of costs after the shock are still bounded from below and continuous almost everywhere. The economy adjusts to a new equilibrium.

Assume that the shock is large enough to decrease $\overline{P}^{\eta-1}y$, and to decrease $P_{-\bullet L}(c_{iL}, c_{-iL})$ for all firms $i \notin \mathcal{I}$ in a sector $S \in \mathcal{S}$. A large enough shock decreases $\overline{P}^{\eta-1}y$ because the

profit share of the economy is bounded, and the shock can make $\overline{P}$ arbitrarily small. For the second condition, note that the number of firms in each sector is finite and smaller than some upper bound $\overline{m}$, and the unit costs are bounded from below. Then, there exists $\underline{p} > 0$ such that $P_{-\bullet L}(c_{iL}, c_{-iL}) > \underline{p}$ in the initial equilibrium. A shock that makes the lowest cost firm in each sector $C$ lower than $\underline{p}(\eta-1)/\eta$ and the firm remain in $\mathcal{L}_S$ satisfies this condition.

For firms in a sector $S \in \mathcal{S}$ but not in $\mathcal{I}$, the shock increases exit. It increases differentiation if $f_D \leq f_0$. The effect of the shock on the ratio $\pi_D(c_{iD})/\pi_L(c_{iL}$ is the same as in the single-sector shock above. The additional condition $f_D \leq f_0$ arises because the general equilibrium decrease in $\overline{P}^{\eta-1}y$ decreases profits $\pi_D$ and $\pi_0$. So, it decreases the incentives for firms to make costly investments, as in standard models.

The shock only affects firms in a sector $S \notin \mathcal{S}$ through its decrease in $\overline{P}^{\eta-1}y$. Like in the case of small sectoral shocks, the shock has an ambiguous effect on discrete choices. In general, a decrease in $\overline{P}^{\eta-1}y$ increases exit, and it increases differentiation if $f_D < f_L$. But because firms interact strategically, the increase in exit may push some originally-differentiated firms to switch to less-differentiation, and differentiation among some firms may push originally-inactive firms to enter the less-differentiated nest.

We have derived conditions for a shock to competition in the less-differentiated nest(s) to push firms to escape to new nests. These shocks are akin to shocks to international trade in the open economy model.

# 4 A Small Open Economy

## 4.1 Model of the Open Economy

We present the set up here and the results in section 4.2. Section 4.3 uses the model to interpret the empirical findings of Section 2. Home is a small country that trades with large Foreign. There is an exogenous set of sectors $S \in [0, 1]$ that are split into nests

according to the outcome of the game below. Labor is the only input into production. Households sell their one unit of labor in a perfect labor market at a wage rate of one. Their demand in (3) and the technologies of Home firms are as in Section 3. There is a finite set of Foreign firms in each sector, and Home firms may export.

**Foreign firms** Each Foreign firm $i$ chooses between *two* discrete choices: (i) to exit the Home market, or (ii) to supply Home with a less-differentiated variety. All less-differentiated varieties of sector $S$, foreign and domestic, are in the same nest $\mathcal{L}_S$.

If Foreign firm $i$ exits, it gets zero profits. Otherwise, it pays a fixed cost $w^* f_L^*$ and a cost $c_{iL} = w^* c_{iL}^*$ for each unit of its variety delivered in Home, where $w^*$ is the Foreign wage. Rank foreign firms in each sector by ascending order of unit costs $c_{iL}$. Let $m_S^*$ be the number of foreign firms in sector $S$ and $i^*(r, S)$ be the $r^{th}$ ranked foreign firm in sector $S$. Assume labor requirements $(c_{i^*(1,S)L}, ..., c_{i^*(m_S^*,S)L})$ are bounded below by some $\underline{c} > 0$, and that they are continuous in $S \in [0, 1]$ in all but at most a finite number of sectors.

**Game within a Sector in the Open Economy** In ascending order of costs $c_{iL}$, each firm in sector $S$ makes its discrete choice. Home firms decide among (i) exit, (ii) less-differentiation, and (iii) differentiation. Foreign firms decide between (i) exit and (ii) less-differentiation. Once all discrete choices are made, firms simultaneously set prices.

The solution to the subgame perfect equilibrium (SPE) in the open economy is similar to the closed economy game. The pricing rule is in (7). Given a set of actions, the operating profit of firm $i$ is $\pi_L(c_{iL}, \mathbf{c}_{-iL})$ in (9) if the firm is less differentiated, and it is $\pi_D(c_{iD})$ in (8) if the firm is differentiated. The fixed cost is $w^* f_L^*$ for Foreign firms. It is $f_L$ for less-differentiated Home firms and $f_D$ for differentiated firms.

Name firms in sector $S$ according to their rank $c_{1L} \leq ... \leq c_{m_S L}$. Starting with the least productive firm, for $i = m_S, ..., 1$ and all possible actions $(\tilde{g}_1, ..., \tilde{g}_{i-1})$, firm $i$ chooses among subgames with starting nodes $(\tilde{g}_1, ..., \tilde{g}_{i-1}, g_i)$. For Home firms, $g_i =$ *exit*, *less differentiation*, *differentiation*, and for Foreign firms, $g_i =$ *exit*, *less differentiation*.

These decisions and the SPE are unique up to a perturbation of parameters.

**Home exports** We take the simplest possible setting since our empirical application does not concern exporting decisions. In addition to supplying Home, domestic firms may export to Foreign. If firm $i$ exports, it incurs a fixed cost $f^*$ units of labor, and its sales and net profits from exporting are respectively

$$\begin{aligned} X^*(c_{iL}, w^*) &= (c_{iL}/w^*)^{1-\sigma} w^* Y^*, \\ \pi^*(c_{iL}, w^*) &= \frac{X^*(c_{iL}, w^*)}{\sigma} - f^* \end{aligned} \tag{13}$$

where $Y^* > 0$ is a parameter. The firm exports if and only if $c_{iL} \leq c^*(w^*)$, where

$$c^*(w^*) = \left(\frac{w^* Y^*}{\sigma f^*}\right)^{1/(\sigma-1)} w^*.$$

**Equilibrium in the Open Economy** All sectors are in SPE. The definitions of the equilibrium set of nests and of the price index $\overline{P}$ in (10) do not change, only the vectors of less-differentiated unit costs $\mathbf{c}_{LS}$ include Home and Foreign firms. Let $S_H$ be the set of Home firms in sector $S$, $\mathcal{L}_{HS}$ be the set of less-differentiated Home varieties, and $\mathcal{L}_{FS}$ be the set of Foreign varieties in Home, $\mathcal{L}_{HS} \cup \mathcal{L}_{FS} = \mathcal{L}_S$.

The representative household gets income from labor and profits:

$$y = 1 + \int_0^1 \left[ \sum_{\{i \in S_H : c_{iL} \leq c^*(w^*)\}} \pi^*(c_{iL}, w^*) + \sum_{i \in \mathcal{D}_S} \pi_D(c_{iD}) + \sum_{i \in \mathcal{L}_{HS}} \pi_L(c_{iL}, \mathbf{c}_{-iL}) \right] dS. \tag{14}$$

Trade balances if

$$\int_0^1 \sum_{\{i \in S_H : c_{iL} \leq c^*(w^*)\}} X^*(c_{iL}, w^*) dS = \int_0^1 \sum_{i \in \mathcal{L}_{FS}} \overline{P}^{\eta-1} P_L(\mathbf{c}_{LS})^{\sigma-\eta} \left( \frac{c_{iL} \epsilon_L(c_{iL}, \mathbf{c}_{-iL})}{\epsilon_L(c_{iL}, \mathbf{c}_{-iL}) - 1} \right)^{1-\sigma} y. \tag{15}$$

As before, the assumptions that cost vectors are bounded and continuous almost

everywhere imply that integrals (10), (14) and (15) exit when all sectors are in SPE. An equilibrium of the open economy is a set of strategies, one for each firm, Foreign wages $w^*$, price index $\overline{P}$, and income $y$ such that the strategies are SPE in all sectors, and (10), (14) and (15) hold.

## 4.2 Results in the Open Economy

**Exit** Given that more productive firms make discrete choices first, there is a unique threshold $\overline{c}_{FS}$ such that Foreign firms in sector $S$ enter only if $c_{iL} < \overline{c}_{FS}$. For Home firms, the exit threshold $\overline{c}_{HS}$ exists when firms can be ranked according to costs, i.e., $c_{iD} < c_{i'D}$ if and only if $c_{iL} < c_{i'L}$ for all $i$ in sector $S$.

**Shocks to International Trade** The economy is in equilibrium. The cost parameters $c^*_{iL}$ decrease for all Foreign firms in sector $S$ and firms in sector $S$ change their strategies to a new SPE. Following Section 3.2, if the shock is small, it has an ambiguous effect in Home firms' discrete choices.

If the shock is large enough to decrease $P_{-\bullet L}(c_{iL}, \mathbf{c}_{-iL})$ for all $i \in S_H$, then Home firms in sector $S$ increase exit and differentiation. Among surviving firms, the markup decreases for firms that remain less-differentiated and increases for firms that switch to differentiation. If two firms $a$ and $b$ with $c_{aL} < c_{bL}$ are initially less-differentiated, then the markup of firm $b$ increases relative to firm $a$ if both firms remain in $\mathcal{L}_S$ or if they both differentiate.

A large trade shock that decreases the costs of foreign firms in a non-zero measure of sectors $\mathcal{S} \subset [0,1]$, increases exit and differentiation of Home firms in sectors $S \in \mathcal{S}$ if $f_D \leq f_0$. For sectors $S \notin \mathcal{S}$ the shock has an ambiguous effect on Home firms' discrete choices.[18]

[18]Compared to the closed economy, the shock that affects a non-zero measure of sectors has the additional effect of increases Foreign wages $w^*$. Then, competition in $\mathcal{L}_S$ may loosen in sectors $S \notin \mathcal{S}$

## 4.3 Empirical Results through the Lenses of the Model

As argued in the introduction, we interpret differentiation as strategies undertaken by domestic firms to insulate themselves from foreign competition. These strategies include catering to domestic tastes, offering greater customization, and bundling products with non-tradable services. This interpretation justifies our assumption that foreign firms cannot offer differentiated varieties. Nothing in the model changes if we allow for the existence of nests that are supplied only by foreign firms, such as market niches with luxuries and high-tech goods.[19] The key assumption is that import competition decreases the profits from producing more standardized, tradable varieties relative to less-tradable, customizable varieties for domestic firms.

Since strategies to escape import competition are not directly observed, we take the introduction of new goods and shifts to skill-intensive four-digit sectors as proxies for product differentiation. Our empirical results exploit cross-sectoral variation in tariff changes. We interpret tariff cuts in individual sectors in the data as a decrease in the cost of foreign varieties in a single sector $S$ in the model.

In the model, a large reduction in foreign costs increases exit and product differentiation. Consistent with these predictions, tariff cuts in the data are associated with the introduction of new goods and shifts toward skill-intensive sectors. Appendix Tables A7 and A8 show that such tariff changes are also associated with exit and more sectoral shifts (in any direction of skill-intensity rank).

Revenue TFP in equation (2) is an estimate of the ratio of revenue to costs which corresponds to the markup in the model. The model has no specific predictions for markup changes or for whether small or large firms are more prone to differentiate their products in response to a decrease in Foreign costs. But if two firms of different sizes make the same discrete choice—both remain less-differentiated or both differentiate their

[19] A decrease in the price index of these nests has the same general equilibrium effects of decreasing $\overline{P}^{\eta-1}y$ as decreases in the cost of foreign varieties in $\mathcal{L}_S$.

varieties—then the markup of the smaller firm increases relative to the large firm. In Table 2, tariff cuts are associated with similar changes in the probability of switching to skill-intensive sectors or to introduce new goods. Then the model predicts that the coefficient on revenue TFP should increase systematically with firm size in the data. Panel A of Table 2 provides some support for this prediction.

This interpretation of revenue productivity is valid as long as our measure is correlated with the true unobserved revenue to cost ratio in the data. But even if it is, revenue productivity is inadequate to evaluate firms in the model for two reasons. First, measures of TFP generally assume a Markov path for productivity, Hicks neutrality, and product homogeneity. These assumptions are all violated in the model and arguably in the data as import competition reshapes firms' residual demand and innovation changes output and production processes.[20] The usual decomposition of revenue TFP into quantity TFP and prices is not applicable either because varieties in the model are differentiated and costs $c_{iL}$ and $c_{iD}$ are quality-adjusted like in Melitz (2003).[21]

Second, even if revenue productivity perfectly measured the ratio of revenue to cost, it would still be a poor proxy for product differentiation. This ratio confounds the positive effect of differentiation on markups with the negative effect of greater competition on firms that do not differentiate. These opposing effects may explain the mixed findings linking tariff cuts to firm productivity in the empirical literature.[22]

The Chinese accession to the WTO was a large trade liberalization. Average tariffs on manufacturing in China fell from 43 percent in 1992 to 9.4 percent in 2004, while imports as a share of GDP more than doubled from 12 to 28 percent. In the model, large and

[20]Harrison (1994), De Loecker (2007) and De Loecker and Warzynski (2012) make similar points on changes in measured productivity during trade reforms. DeLoecker et al. (2016) allow for vertically-differentiated goods, but maintain the other assumptions above. Recent papers relax the assumption of Hicks neutral technologies and allow for skill-biased technical change in productivity measures, e.g., Bøler (2019), Harrigan et al. (2019). We cannot apply these methods because we do not observe worker skills.

[21]For recent work on this decomposition, see Ackerberg et al. (2015), DeLoecker et al. (2016), and Gandhi et al. (2017). As Foster et al. (2008) explain, these methods apply to sectors with homogeneous goods, where TFPQ is meaningful.

[22]See references in footnote 1.

widespread decreases in foreign costs generally increase differentiation if $f_D \leq f_0$. Table 2 shows that small firms in sectors with larger tariff cuts disproportionately introduced more new goods and switched to skill-intensive sectors. The model can only rationalize discrete changes in small firms if these changes do not involve large fixed costs, $f_D \approx f_0$. So, through the lenses of the model, these findings suggest that the WTO accession increased overall product differentiation in China, not just in some sectors relative to others. Next, we investigate the welfare effects of such differentiation.

# 5 Differentiation and Welfare

It is well-known that heterogeneous markups lead to misallocation of labor because the consumer chooses quantities based on prices, and the planner does it based on costs. Consider a planner that can reallocate labor used for domestic production but cannot change discrete choices. Appendix C proves that, compared to the market, the planner allocates relatively more labor to differentiated than to less-differentiated varieties. And within less-differentiated nests, the planner allocates more labor to more productive varieties.[23]

We focus on the more novel results on discrete choices. Section 5.1 evaluates the marginal welfare effects of a single variety. Section 5.2 studies changes in the discrete choices of a non-zero mass of firms. Throughout, denote the markup of firm $i$ with $\mu_{iL}$ if $i \in \mathcal{L}_S$ and with $\mu_D = \eta/(\eta-1)$ if $i \in \mathcal{D}_S$. Markup $\mu_{iL}$, implicitly defined in (7), depends on the vector of all unit costs in $\mathcal{L}_S$ but we omit its argument for ease of notation.

[23] Edmond et al. (2015) study missallocation in the Atkeson and Burstein (2008) model. Take two domestic less-differentiated varieties $i, i' \in \mathcal{L}_{HS}$. From standard CES maximization, the planner's and the market's labor allocations satisfy

$$\frac{\text{labor}_i^{\text{planner}}}{\text{labor}_{i'}^{\text{planner}}} = \left(\frac{c_{iL}}{c_{i'L}}\right)^{-\sigma} > \left(\frac{c_{iL}/\mu_{iL}}{c_{i'L}/\mu_{i'L}}\right)^{-\sigma} = \frac{\text{labor}_i^{\text{market}}}{\text{labor}_{i'}^{\text{market}}}.$$

So, the planner allocates more labor to the high-markup variety compared to the market.

## 5.1 Marginal Welfare Effect of a Firm's Discrete Choice

Sector $S$ is in a subgame after all discrete choices are made. A planner can change a single firm's discrete choice. Prices maximize profits and quantities clear markets before and after the shock. We compare the social benefit of a variety to the private profit.

The marginal cost of labor in the economy is $C = wK/Q$ where $Q$ is the standard aggregate quantity, $Q = y/\overline{P}$, and $K$ is labor allocated for production[24]

$$K = 1 - \int_0^1 \left( \left|\mathcal{L}_{HS}\right| f_L + \left|\mathcal{D}_S\right| f_D + \left|\{i \in S_H : c_{iL} \leq c^*(w^*)\}\right| f^* \right) dS$$

where $|x|$ denotes the number of elements in set $x$. Define the average markup as $\overline{\mu} = \overline{P}/C$, price over marginal cost.

By Roy's identity, the valuation of a differentiated variety $i \in \mathcal{D}_S$ for a planner who cannot determine prices or quantities is:

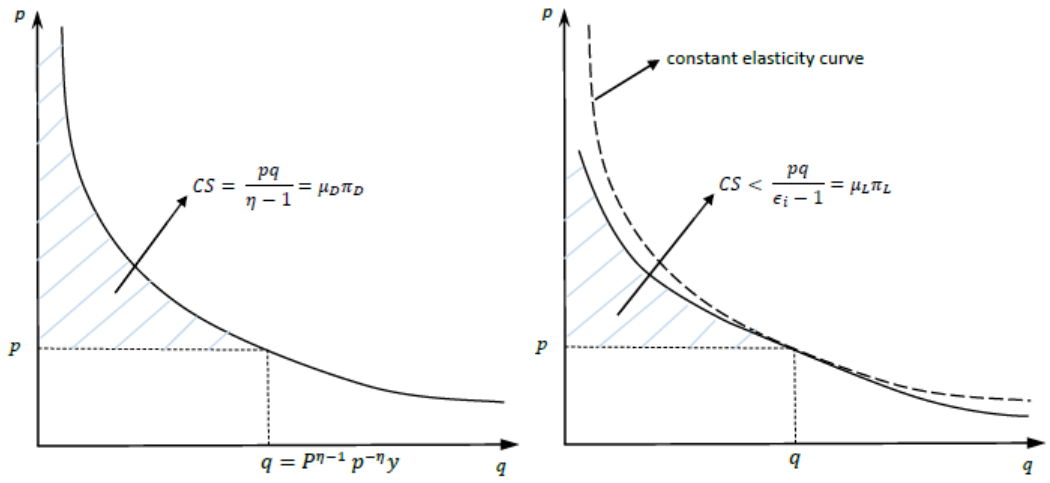
$$u_D(c_{iD}) = \overline{P}^{-1} \underbrace{\int_{\mu_D c_{iD}}^{\infty} q_D(p')dp'}_{\text{consumer surplus}} - C^{-1} f_D \tag{16}$$

where $\overline{P}^{-1}$ is the marginal utility of income, $\mu_D c_{iD}$ is the firm's price, and $q_D(p')$ is the demand function. Substituting $q_D(p') = \overline{P}^{\eta-1}(p')^{-\eta} y$ from (3), the integral equals

[24]The expression $C = K/Q$ holds because net of fixed costs, the economy exhibits constant returns to scale. Net of fixed costs, international trade also effectively transforms domestic goods into imports with constant returns. Aggregate quantity with nested CES is:

$$Q = \left[ \int_0^1 \sum_{n \in S} Q_n^{(\eta-1)/\eta} dS \right]^{\eta/(\eta-1)}$$

$$\text{where} \quad Q_n = \left[ \sum_{i \in n} q_i^{(\sigma-1)/\sigma} \right]^{\frac{\sigma}{\sigma-1}}.$$




(a) Differentiated Variety (b) Less-Differentiated Variety

Figure 3: Consumer surplus terms (CS) in equations (16) and (18)

$\mu_D \pi_D(c_{iD})$, and (16) becomes

$$\begin{aligned} u_D(c_{iD}) &= \overline{P}^{-1} \mu_D \pi_D(c_{iD}) - C^{-1} f_D \\ &= C^{-1} \left[ \left( \frac{\mu_D}{\overline{\mu}} \right) \pi_D(c_{iD}) - f_D \right] \\ &\geq C^{-1} [\pi_D(c_{iD}) - f_D] \end{aligned} \tag{17}$$

because $\mu_D \geq \overline{\mu}$. Figure 3(a) illustrates the consumer surplus.

For a less-differentiated domestic variety $i$, define $q_L(p', \mathbf{p}_{-iL})$ as its residual demand when its price is $p'$ and its competitors' prices are at their subgame equilibrium level, vector $\mathbf{p}_{-iL}$ with elements $p_{i'L}$. From (3),

$$q_L(p', \mathbf{p}_{-iL}) = \overline{P}^{\eta-1} y \left( (p')^{1-\sigma} + \sum_{i' \in \mathcal{L}_S, i' \neq i} (p_{i'L})^{1-\sigma} \right)^{\frac{\sigma-\eta}{1-\sigma}} (p')^{-\sigma}.$$

Define $\tilde{q}_i(p) = Ap^{-\epsilon}$ as a hypothetical demand function where $\epsilon$ is the endogenous elasticity of demand of the firm and $\tilde{q}_i(\mu_{iL} c_{iL}) = q_L(\mu_{iL} c_{iL}, \mathbf{p}_{-iL})$. These demand functions are illustrated in Figure 3(b). The dashed line of $\tilde{q}_i(p)$ is above the solid line of $q_L(p', \mathbf{p}_{-iL})$,

because the elasticity of demand in (7) is strictly increasing in the firm's price.

These demand functions are implicitly functions of unit costs in $\mathcal{L}_S$, $(c_{iL}, \mathbf{c}_{-iL})$. The contribution of variety $i$ to welfare

$$u_L(c_{iL}, \mathbf{c}_{-iL}) \leq \overline{P}^{-1} \underbrace{\int_{\mu_{iL} c_{iL}}^{\infty} q_L(p', \mathbf{p}_{-iL}) dp'}_{\text{consumer surplus}} - C^{-1} f_L \tag{18}$$

$$\leq \overline{P}^{-1} \int_{\mu_{iL} c_{iL}}^{\infty} \tilde{q}_i(p') dp' - C^{-1} f_L$$

$$= \overline{P}^{-1} \mu_{iL} \pi_L(c_{iL}, \mathbf{c}_{-iL}) - C^{-1} f_L. \tag{19}$$

The first inequality holds because when variety $i$ is taken out of nest $\mathcal{L}_S$, the consumer's valuation of other varieties in $\mathcal{L}_S$ increases.[25] The second inequality is the difference between the areas delineated by $q_L$ and $\tilde{q}$ in Figure 3(b).[26] Both inequalities are strict if firm $i$ is not a monopolist in nest $\mathcal{L}_S$.

Since $\mu_D \geq \mu_{iL}$, inequalities (17) and (19) imply that the marginal social benefit of a differentiated variety is always greater than the private profit, whether the comparison is to exiting or to producing a less-differentiated variety. The marginal social benefit of a less-differentiated variety is smaller than the private profit if the firm is sufficiently less productive than its competitors so that $\mu_{iL} < \overline{\mu}$.

## 5.2 Welfare and the Discrete Choices of a Set of Firms

The economy is in equilibrium. A planner selects a non-zero set of differentiated firms $\mathcal{I}$ and shifts them from differentiation to less-differentiation. Set $\mathcal{I}$ is picked so that the conditions on continuity of costs (except for a finite number of sectors) hold conditional

[25] By Roy's identity, their valuation increases because their demand and prices go up.

[26] The area under this dashed line is

$$\int_{\mu_{iL} c_{iL}}^{\infty} A p^{-\epsilon} dp = \frac{A(\mu_{iL} c_{iL})^{-\epsilon+1}}{\epsilon - 1} = \frac{\mu_{iL} c_{iL} [q_L(\mu_{iL} c_{iL}, \mathbf{p}_{-iL})]}{\epsilon - 1} = \mu_{iL} \pi_L(c_{iL}, \mathbf{c}_{-iL})$$

on discrete choices. All other firms cannot change their original discrete choices. All firms then set prices to maximize profits and general equilibrium variables $(w^*, \overline{P}, y)$ simultaneously adjust to satisfy (10), (14) and (15). If the profit share in the economy decreases in the counterfactual, then welfare is lower in the counterfactual than in the original equilibrium.

Before proving this claim, we note that the results on the marginal value of varieties do not imply that a planner would never gain from forcibly shifting a firm from differentiation to a less-differentiated nest. Such a change may correct other market distortions and increase welfare. For example, it may lead other Home firms to exit or to differentiate their products, or it may decrease the sales of less-differentiated Foreign firms. To avoid such scenarios, the counterfactual restricts the discrete choices of firms not undergoing the shock. It assumes that Home income decreases to preclude a large shift of labor from exporting activities to Home production of differentiated varieties, which defeats the spirit of the counterfactual to forcibly decrease differentiation.

*Proof.* Suppose not, suppose real income $y/\overline{P}$ increases with the counterfactual. Then, $\overline{P}^{\eta-1}y$ must decrease because the profit share in the economy $y$ decreases. Now suppose that $w^*$ increases. Then, exports by Home firms in (13) increase. To balance trade, Foreign sales in Home must also increase. But this is a contradiction since $w^*$ increases and $\overline{P}^{\eta-1}y$ decreases.

Then, $w^*$ decreases. For any firm $i$,

$$\pi_L(c_{iL}, \mathbf{c}_{-iL}) - \pi_D(c_{iD}) =$$
$$\overline{P}^{\eta-1}y\left[\frac{1}{\epsilon(c_{iL}, \mathbf{c}_{-iL})}\left(\frac{c_{iL}\epsilon(c_{iL}, \mathbf{c}_{-iL})}{\epsilon(c_{iL}, \mathbf{c}_{-iL})-1}\right)^{1-\sigma} P_L(\{c_{iL}, \mathbf{c}_{-iL}\})^{\sigma-\eta} - \frac{1}{\eta}\left(\frac{c_{iD}\eta}{\eta-1}\right)^{\eta-1}\right]$$

decreases because $\overline{P}^{\eta-1}y$ decreases and there are (weakly) more elements in $\mathbf{c}_{-iL}$ and costs $c_{iL} = w^* c^*_{iL}$ for foreign firms go down. In Section 5.1 we proved that the marginal gain from transferring a firm from differentiation to less-differentiation was larger for the firm

than for the planner. Then, the only way for the planner to benefit from transferring firms from differentiation to less-differentiation is if the profits from less-differentiation increase with general equilibrium effects for at least a non-zero measure of firms in $\mathcal{I}$. This contradicts the decrease in $\pi_L(c_{iL}, \mathbf{c}_{-iL}) - \pi_D(c_{iD})$ for all $i$. ■

Using the model to interpret the empirical results in Section 4.3, we argued that the evidence supports the hypothesis that differentiation increased among surviving Chinese firms during China's accession to the WTO. Then, the welfare gains from the trade shock were probably larger than in a scenario in which Home firms do not have the option to differentiate, as in standard models.

A back of the envelope calculation suggests that gains from trade due to differentiation may be sizable. In Panel B of Table 1, the coefficient on column (2) indicates that a one standard deviation reduction in log output tariffs (around 0.5) is associated with an increase in new products of 0.8 percentage points in total sales (multiplied by -0.0157). If we set $\eta = 2$ and $\sigma = 10$ the welfare gain from increasing the mass of differentiated products by 0.8 percent and decreasing more substitutable products by the same share increases welfare by 0.7 percent, a significant value relative to standard estimates of gains from trade.[27]

# 6 Robustness and Extensions of Empirical Results

Detailed procedures and tables for the exercises below are in Appendix A. Appendix A.2 tests other predictions of the model. Output and downstream tariff reductions increase the probability of exiting (Table A.7) and of switching four-digit sectors (Table A.8). The

[27]Using the definition of $\overline{P}$ in (3), the estimated decrease in price is $\hat{\overline{P}} \approx 1.008^{1/(1-\eta)} * 0.992^{1/(1-\sigma)}$. The value $\eta = 2$ is between Edmond et al. (2015)'s estimate $\eta = 1.28$ and Broda and Weinstein (2006)'s median elasticity of 5-digit SITC codes, estimated to 2.7. To get a sense magnitude for the standard gain from trade, imports as a share of GDP increased from 14% to 28% in the period of our data. Then, the welfare gain in Arkolakis et al. (2012) with an elasticity $\sigma = 5$ (between 2 and 10, and no intermediate inputs) is $(0.72/0.86)^{-1/5} - 1 = 3.6$ percent.

latter result is not statistically significant in all specifications, but it is indicative that the firm changes its output in response to tariff cuts, as predicted by the model.

Appendix A.3.1 checks the robustness of Table 1. The dependent variable is revenue TFP in Table A11, measures of the introduction of new goods in Table A12, and the ranking of sectoral skill intensity in Table A13. In each table, r,ow 1 presents the results with all firms, including multinationals and SOE's. The coefficients decrease in magnitude and significance. Multinationals are more engaged in offshoring and exporting and they may have higher costs to tailor their goods to domestic tastes and deliver non-tradable services. Reassuringly, all results hold when we include only non-exporting firms in the sample.

Rows 2 through 4 check whether collinearity among tariff measures affect the results. To check for selection, row 5 uses only a balanced panel of firms that survived in all ten years of data. The number of observations decreases from 1,037,738 to 65,809. Row 6 follow Wooldridge (2010) in estimating a selection equation using a probit, and then including the estimated Mills ratio in the main specification. We use the profit share of the firm in the previous period as the selection variable in the probit excluded from the main specification. Row 7 excludes textiles and apparel, which were affected by the expiration of the multifiber agreement (MFA) in the period of our data. Row 8 excludes computers and peripherals, which experienced a large growth in offshoring.

The results are mostly robust to these tests. The coefficients decrease in magnitude when input tariffs are excluded from the regression. When the panel is balanced and the dependent variable is the share of new goods in trade, the coefficient loses statistical significance. Firms that survive through the ten years or our sample are more likely to have introduced successful products that hold a large share of sales. Overall, as in Table 1, tariff cuts are associated with increases in TFP and in the introduction of new goods, and with switches to skill-intensive sectors. These results hold in all IV specifications when we include only non-exporters. Since import competition drives theory, we expect

the results to be stronger for this subset of firms.

# 7 Conclusion

We set out to narrow the gap between the academic literature and the prevailing view among policy makers and economists that tariff cuts are good for the performance of import-competing firms. We develop a stylized extension of Atkeson and Burstein (2008), in which import-competing firms escape foreign competition by specializing in new market niches (nests). Since these product-differentiation strategies to escape import competition improve welfare in the model, they provide a rationale for policy makers' view.

Revenue productivity, the standard measure of firm performance in the empirical literature, is a poor measure of product differentiation because it confounds the positive effects of import competition on innovation with negative pro-competitive effects on markups. These opposing effects may explain the mixed evidence in the literature relating tariff cuts to firm productivity. We circumvent this difficulty using data on new goods and sectoral skill intensity which are comparable across time even in periods of large changes in demand, technologies and output, such as trade liberalization episodes.

Our proposed mechanism may be relevant in other economic contexts. The impetus to escape competition may drive firms out of existing market segments and spur economic growth. Fort et al. (2018) associate import penetration in the United States to shifts of manufacturing firms to the service sector, suggesting the bundling of products with non-tradable services. Differentiation may also factor in a multinational's decision to serve a foreign market through exports or an affiliate, to the extent that the affiliate may be better positioned to offer non-tradable services and greater customization.

# References


Ackerberg, D. A., K. Caves, and G. Frazer (2015). Identification properties of recent production function estimators. *Econometrica 83*(6), 2411–2451.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt (2005). Competition and innovation: An inverted-u relationship. *The Quarterly Journal of Economics 120*(2), 701–728.

Aghion, P., J. Cai, M. Dewatripont, L. Du, A. Harrison, and P. Legros (2015). Industrial policy and competition. *American Economic Journal: Macroeconomics 7*(4), 1–32.

Amiti, M., O. Itskhoki, and J. Konings (2014). Importers, exporters, and exchange rate disconnect. *American Economic Review 104*(7), 1942–78.

Amiti, M. and J. Konings (2007). Trade intermediate and productivity: Liberalization, inputs, from indonesia evidence. *The American Economic Review 97*(5), 1611–1638.

Arkolakis, C., A. Costinot, and A. Rodríguez-Clare (2012). New trade models, same old gains? *American Economic Review 102*(1), 94–130.

Atkeson, A. and A. Burstein (2008). Pricing-to-market, trade costs, and international relative prices. *The American Economic Review 98*(5), 1998–2031.

Attanasio, O., P. K. Goldberg, and N. Pavcnik (2004). Trade reforms and wage inequality in colombia. *Journal of Development Economics 74*(2), 331–366.

Bernard, A. B., J. Eaton, J. B. Jensen, and S. Kortum (2003a). Plants and productivity in international trade. *American economic review 93*(4), 1268–1290.

Bernard, A. B., J. Eaton, J. B. Jensen, and S. S. Kortum (2003b). Plants and productivity in international trade. *American Economic Review 93*(4), 1268–1290.

Bernard, A. B., S. J. Redding, and P. K. Schott (2011). Multiproduct firms and trade liberalization. *The Quarterly Journal of Economics 126*(3), 1271–1318.

Bøler, E. A. (2019). Technology-skill complementarity in a globalized world. CEPR `http://www.estherboler.com/files/boler_jmp.pdf`.

Boyd, G., N. Abhijeet, C. Richter, and S. Laprise (2008). Asian automakers: Sector outlook. *CLSA Report*.

Brandt, L. and E. Thun (2010). The fight for the middle: upgrading, competition, and industrial development in china. *World Development 38*(11), 1555–1574.

Brandt, L. and E. Thun (2016). Constructing a ladder for growth: policy, markets, and industrial upgrading in china. *World Development 80*, 78–95.

Brandt, L., J. Van Biesebroeck, L. Wang, and Y. Zhang (2017). Wto accession and performance of chinese manufacturing firms. *American Economic Review 107*(9), 2784–2820.

Broda, C. and D. E. Weinstein (2006). Globalization and the gains from variety. *The Quarterly Journal of Economics 121*(2), 541–585.

Burstein, A., J. Cravino, and J. Vogel (2016). Importing skill-bias technology. *American Economic Journal: Macroeconomics 5*(2), 32–71.

Burstein, A. and J. Vogel (2016). International trade, technology, and the skill premium. forthcoming.

Bustos, P. (2011). Trade liberalization, exports and technology upgrading: Evidence on the impact of mercosur on argentinian firms. *The American Economic Review 101*(1), 304–340.

Caliendo, L. and E. Rossi-Hansberg (2012). The impact of trade on organization and productivity. *The Quarterly Journal of Economics 127*(3), 1393–1467.

Chen, C. and C. Steinwender (2019). Import competition, heterogeneous preferences of managers, and productivity. NBER Working Paper, No w25539.

De Loecker, J. (2007). Do exports generate higher productivity? evidence from slovenia. *Journal of international economics 73*(1), 69–98.

De Loecker, J. and F. Warzynski (2012). Markups and firm-level export status. *The American Economic Review 102*(6), 2437–2471.

DeLoecker, J., P. K. Goldberg, A. Khandelwal, and N. Pavcnik (2016). Prices, markups and trade reform. *Econometrica 84*(2), 445–510.

Dhingra, S. (2013). Trading away wide brands for cheap brands. *American Economic Review 103*(6), 2554–84.

Dhingra, S. and J. Morrow (2018). Monopolistic competition and optimum product diversity under firm heterogeneity. *Journal of Political Economy*.

Dixit, A. K. and J. E. Stiglitz (1977). Monopolistic competition and optimum product diversity. *The American Economic Review 67*(3), 297–308.

Du, L., A. Harrison, and G. H. Jefferson (2012). Testing for horizontal and vertical foreign investment spillovers in china, 1998–2007. *Journal of Asian Economics 23*(3), 234–243.

Edmond, C., V. Midrigan, and D. Y. Xu (2015). Competition, markups, and the gains from international trade. *The American Economic Review 105*(10), 3183–3221.

Eslava, M., J. Haltiwanger, A. Kugler, and M. Kugler (2013). Trade and market selection: Evidence from manufacturing plants in colombia. *Review of Economic Dynamics 16*(1), 135–158.

Farhoomand, A. and M. Schuetz (2007). Chery automobile company: Evolution of the chinese automotive industry. *Asia Case Research Center at the University of Hong Kong HKU676*.

Feenstra, R. C. and G. H. Hanson (1997). Foreign direct investment and relative wages: Evidence from mexico's maquiladoras. *Journal of International Economics 42*(3), 371–393.

Feng, D. and X. Wei (2015). Haier electronics. *CLSA Report*.

Fieler, A. C., M. Eslava, and D. Y. Xu (2018). Trade, quality upgrading, and input linkages: Theory and evidence from colombia. *The American Economic Review 108*(1), 109–46.

Fort, T. C., J. R. Pierce, and P. K. Schott (2018). New perspectives on the decline of us manufacturing employment. *Journal of Economic Perspectives 32*(2), 47–72.

Foster, L., J. Haltiwanger, and C. Syverson (2008). Reallocation, firm turnover, and efficiency: Selection on productivity or profitability? *American Economic Review 98*(1), 394–425.

Gandhi, A., S. Navarro, D. Rivers, et al. (2017). How heterogeneous is productivity? a comparison of gross output and value added. *Journal of Political Economy*.

Goldberg, P. K., A. K. Khandelwal, N. Pavcnik, and P. Topalova (2009). Trade liberalization and new imported inputs. *The American Economic Review, Papers and Proceedings 99*(2), 494–500.

Harrigan, J., A. Reshef, and F. Toubal (2019). Techies, trade, and skill-biased productivity. Paris School of Economics `http://www.parisschoolofeconomics.com/reshef-ariell/papers/HRT_productivity_nov18.pdf`.

Harrison, A. E. (1994). Productivity, imperfect competition and trade reform: Theory and evidence. *Journal of international Economics 36*(1-2), 53–73.

Helpman, E., O. Itskhoki, M.-A. Muendler, and S. J. Redding (2017). Trade and inequality: From theory to estimation. *The Review of Economic Studies 84*(1), 357–405.

Holmes, T. J. and J. A. Schmitz (2010). Competition and productivity: A review of evidence. *Annual Review of Economics 2*(1), 619–642.

Holmes, T. J. and J. J. Stevens (2014). An alternative theory of the plant size distribution, with geography and intra-and international trade. *Journal of Political Economy 122*(2), 369–421.

Impullitti, G. and O. Licandro (2017). Trade, firm selection and innovation: The competition channel. *The Economic Journal 128*(608), 189–229.

Javorcik, B. S. (2004). Does foreign direct investment increase the productivity of domestic firms? in search of spillovers through backward linkages. *The American Economic Review 94*(3), 605–627.

Lee, E. (2018). Trade, inequality, and the endogenous sorting of heterogeneous workers. https://www.dropbox.com/s/t0ygwauqmeu61lr/Lee_JMP_latest.pdf?dl=0.

Lileeva, A. and D. Trefler (2010). Improved access to foreign markets raises plant-level productivity...for some plants. *The Quarterly Journal of Economics 125*(3), 1051–1099.

Mayer, T., M. J. Melitz, and G. I. Ottaviano (2014). Market size, competition, and the product mix of exporters. *American Economic Review 104*(2), 495–536.

Melitz, M. J. and G. I. Ottaviano (2008). Market size, trade, and productivity. *The review of economic studies 75*(1), 295–316.

Olley, G. S. and A. Pakes (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica 64*(6), 1263–1297.

Rose, G. (2015). Special entrepreneurship issue: Here come the disruptors. *Foreign Affairs 94*(1).

Spence, M. (1976a). Product differentiation and welfare. *The American Economic Review 66*(2), 407–414.

Spence, M. (1976b). Product selection, fixed costs, and monopolistic competition. *The Review of economic studies 43*(2), 217–235.

Teagarden, M. B. and C. Fifi (2015). Xiaomi, inc.: The rise of a chinese indigenous competitor. *Thunderbird School of Global Management TB0417*.

Tybout, J. R. (2003). Plant- and firm-level evidence on the 'new' trade theories. In E. K. Choi and J. Harrigan (Eds.), *Handbook of International Trade*. Blackwell Publishing Ltd.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.

Yeaple, S. R. (2005). A simple model of firm heterogeneity, international trade, and wages. *Journal of International Economics 65*(1), 1–20.

# Escaping import competition and Downstream Tariffs in China

*Appendix*

Ana Cecília Fieler, and Ann Harrison *

June 2019

## Contents

**A Additional Empirical Results** **42**

A.1 Control Variables . . . . . 42

A.1.1 Definition of Control Variables . . . . . 42

A.1.2 Coefficients on Control Variables . . . . . 43

A.2 Other Firm Outcomes . . . . . 50

A.3 Robustness of Empirical Results . . . . . 54

A.3.1 Basic Regression Specification . . . . . 54

**B Proofs of Basic Model** **58**

B.1 Exit . . . . . 58

B.2 Numerical Example . . . . . 59

B.3 Product Differentiation and Productivity . . . . . 59

B.4 Markup Responses of Firms of Different Sizes . . . . . 62

**C Miss-allocation of Labor** **65**

**D Robustness of the Theory** **67**

D.1 Free Entry . . . . . 67

D.2 Two Symmetric Countries . . . . . 67

*Fieler: Department of Economics at Yale University and NBER. Harrison: Haas School of Business at the University of California Berkeley and NBER.

# A Additional Empirical Results

This Appendix presents additional empirical results. The main text shows only the variables of interest. Appendix A.1 details the construction of control variables and reports their coefficients for the regressions in the main text. Appendix A.2 studies other firm outcomes such as exit, sector switching, and sales. Appendix A.3 checks the robustness of main results.

## A.1 Control Variables

### A.1.1 Definition of Control Variables

In addition to the tariff measures below, control variables capture exposure to foreign investment and state ownership at the sector-time level, and policy variables at the firm-time level. We control for the share of state ownership in the sector of the firm at time $t$. We define three sector-level FDI variables following Javorkic (2004). Horizontal_FDI$_{jt}$ captures foreign presence in sector $j$ at time $t$, and it is a weighted average of foreign equity participation in each firm in sector $j$, where the weights are the firm's share in sectoral output. Downstream_FDI$_{jt}$ is a measure of foreign participation in the sectors that are supplied by sector $j$, i.e., in sectors downstream from $j$. Upstream_FDI$_{jt}$ is a measure of foreign participation in sectors upstream from $j$. We refer the reader to Javorcik (2004) for details on the construction of these FDI variables. We control for industrial policy through zero-one 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).

We construct three measures of tariffs that China imposes on its imports. *Output_tariff*$_{jt}$ is the tariff on sector $j$ at time $t$. *Upstream_tariff*$_{jt}$ are tariffs at time $t$ on the sectors that provide inputs to sector $j$ (referred to as input tariffs in the literature). *Downstream_tariff*$_{jt}$ are tariffs on the sectors to which firms in sector $j$ provide inputs.

For example, a firm that produces car engines is impacted by Chinese entry into the WTO if the tariffs on the pistons that go into engines decrease (upstream tariffs), 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.

To measure tariffs on sectors upstream and downstream from each firm's own sector, we use the Chinese Input-Output table (2002). The sectoral classification in the input-output table is more aggregate than the 4-digit classification in the firm survey. We create a concordance between the tariff data, the input-output table, and the survey data, and we end up with 71 sectors.

Following the literature, the upstream tariff is a weighted average of output tariffs:[1]

$$\text{upstream_tariff}_{jt} = \sum_{m \neq j} \delta_{jm} \ \text{output_tariff}_{mt}$$

[1] We take upstream and output tariffs directly from Brandt et al (2017), who study China in the same period with the same data sources.

where $\delta_{jm}$ is the share of sector $m$ in all of sector $j$'s inputs. The downstream tariff is

$$\text{downstream_tariff}_{jt} = \sum_{k \neq j} \alpha_{jk} \text{ output_tariff}_{kt}$$

where $\alpha_{jk}$ is the share of sector $j$'s production supplied to downstream sector $k$. Weights $\delta_{jm}$ and $\alpha_{jk}$, taken from the 2002 Chinese Input-Output table, do not add up to one because inputs include labor and capital, and part of output goes to final consumption. Downstream tariffs are high in sector $j$ if the downstream users in sector $k$ face high tariffs and demand a large share of sector $j$'s output.

### A.1.2 Coefficients on Control Variables

Tables in the main text report only the coefficients of interest, and here we report the coefficients on all control variables. Tables A.1, A.2, and A.3 refer to the basic regressions with the three measures of tariffs as the coefficients of interest. Tables A.4, A.5, and A.6 refer to the regressions where the dependent variable output_tariff is substituted with the interaction between output_tariff and indicator variables of whether the firm is in each of the four quartiles of firm sales.

Table A.1: Basic Regressions of Productivity on Tariffs

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

| measure of TFP ⟶ | All Enterprises Excluding SOEs and Multinationals | | | | Only Non-Exporters | |
|---|---|---|---|---|---|---|
| | OP OLS | FE OLS | OP IV | FE IV | OP IV | FE IV |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| output_tariff | -0.0304*** | -0.0322*** | -0.0505*** | -0.0477*** | -0.0617*** | -0.0580*** |
| | (0.0027) | (0.0028) | (0.0169) | (0.0184) | (0.0158) | (0.0170) |
| downstream_tariff | -0.0179** | -0.0194** | -0.178*** | -0.173*** | -0.421*** | -0.444*** |
| | (0.0070) | (0.0079) | (0.0627) | (0.0641) | (0.0650) | (0.0672) |
| upsrteam_tariff | -0.132*** | -0.141*** | -0.369*** | -0.483*** | -0.227** | -0.323*** |
| | (0.0118) | (0.0130) | (0.0975) | (0.1020) | (0.0907) | (0.0938) |
| index_subsidy | 0.0106*** | 0.0128*** | 0.0100*** | 0.0120*** | 0.00745*** | 0.00875*** |
| | (0.0012) | (0.0012) | (0.0012) | (0.0012) | (0.0015) | (0.0015) |
| index_tax | 0.0216*** | 0.0220*** | 0.0213*** | 0.0217*** | 0.0210*** | 0.0215*** |
| | (0.0009) | (0.0009) | (0.0009) | (0.0010) | (0.0010) | (0.0010) |
| index_interest | -0.0121*** | -0.0133*** | -0.0119*** | -0.0132*** | -0.0133*** | -0.0144*** |
| | (0.0009) | (0.0009) | (0.0009) | (0.0009) | (0.0010) | (0.0010) |
| exportshare_sector | 0.121*** | 0.166*** | 0.398*** | 0.488*** | 0.479*** | 0.578*** |
| | (0.0352) | (0.0357) | (0.0513) | (0.0539) | (0.0582) | (0.0615) |
| State_share | 0.000537 | 0.0012 | 0.000136 | 0.000733 | 0.00176 | 0.00279 |
| | (0.0037) | (0.0037) | (0.0037) | (0.0037) | (0.0042) | (0.0043) |
| Horizontal FDI | 0.145*** | 0.204*** | 0.135*** | 0.187*** | 0.224*** | 0.286*** |
| | (0.0394) | (0.0420) | (0.0412) | (0.0439) | (0.0487) | (0.0513) |
| Downstream FDI | 1.184*** | 1.108*** | 1.718*** | 1.652*** | 2.281*** | 2.262*** |
| | (0.1940) | (0.2060) | (0.2760) | (0.2890) | (0.2960) | (0.3120) |
| Upstream FDI | 0.0926 | 0.1 | 0.156** | 0.185** | 0.042 | 0.0726 |
| | (0.0724) | (0.0736) | (0.0752) | (0.0764) | (0.0786) | (0.0795) |
| Observations | 1,037,738 | 1,037,738 | 1,037,738 | 1,037,738 | 826,072 | 826,072 |
| F statistic, log(output tariff) = log(downstream tariff) | 3.1 | 2.6 | 4.3 | 4.0 | 31.8 | 34.3 |
| First Stage F, output tariff | - | - | 277.6 | 277.6 | 349.8 | 349.8 |
| First Stage F, downstream tariff | - | - | 630.1 | 630.1 | 524.1 | 524.1 |
| First Stage F, upstream tariff | - | - | 142.8 | 142.8 | 161.8 | 161.8 |

Standard errors are clustered by firm and initial sector. 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. 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 A.2: Introduction of New Goods

| dependent variable → | All enterprises, excluding SOEs and Multinationals | | | | Only Non-Exporters | |
|---|---|---|---|---|---|---|
| | new product share | new product share | 0-1 dummy for introducing a new product | 0-1 dummy for introducing a new product | new product share | 0-1 dummy for introducing a new product |
| | OLS | IV | OLS | IV | IV | IV |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| output_tariff | -0.000356 | -0.0157** | -0.000687 | -0.0405** | -0.00976** | -0.0279*** |
| | (0.0012) | (0.0068) | (0.0029) | (0.0168) | (0.0045) | (0.0102) |
| downstream_tariff | -0.00372 | -0.0272 | 0.00777 | -0.0533 | -0.0313** | -0.0423 |
| | (0.0024) | (0.0184) | (0.0078) | (0.0399) | (0.0147) | (0.0266) |
| upsrteam_tariff | 0.00251 | 0.033 | -0.0016 | 0.103* | 0.0404** | 0.0893** |
| | (0.0037) | (0.0274) | (0.0092) | (0.0622) | (0.0186) | (0.0382) |
| index_subsidy | 0.00631*** | 0.00635*** | 0.0170*** | 0.0171*** | 0.00449*** | 0.0116*** |
| | (0.0008) | (0.0008) | (0.0016) | (0.0016) | (0.0008) | (0.0014) |
| index_tax | -0.000694* | -0.000663* | -0.00213** | -0.00204** | -0.000451 | -0.00145** |
| | (0.0004) | (0.0004) | (0.0009) | (0.0009) | (0.0004) | (0.0007) |
| index_interest | -0.00183*** | -0.00177*** | -0.00617*** | -0.00600*** | -0.000943** | -0.00347*** |
| | (0.0004) | (0.0004) | (0.0010) | (0.0010) | (0.0004) | (0.0008) |
| exportshare_sector | -0.0128 | 0.00461 | -0.00328 | 0.0322 | -0.00341 | -0.0189 |
| | (0.010) | (0.013) | (0.025) | (0.029) | (0.011) | (0.023) |
| State_share | 0.000525 | 0.000416 | 0.00616* | 0.00597 | 0.000107 | 0.00287 |
| | (0.0020) | (0.0020) | (0.0037) | (0.0037) | (0.0021) | (0.0036) |
| Horizontal FDI | 0.0314*** | 0.0229* | 0.0249 | -0.00632 | 0.0227** | 0.0237 |
| | (0.011) | (0.014) | (0.027) | (0.034) | (0.011) | (0.023) |
| Downstream FDI | -0.00932 | 0.0266 | -0.0532 | 0.0261 | 0.0454 | 0.0152 |
| | (0.024) | (0.039) | (0.058) | (0.086) | (0.033) | (0.060) |
| Upstream FDI | -0.00705 | -0.0285** | -0.0175 | -0.0706*** | -0.0272*** | -0.0540*** |
| | (0.006) | (0.011) | (0.013) | (0.025) | (0.009) | (0.018) |
| Observations | 1,037,738 | 1,037,738 | 1,037,738 | 1,037,738 | 826,072 | 826,072 |
| F statistic, log(output tariff) = log(downstream tariff) | 1.7 | 0.5 | 1.1 | 0.1 | 2.6 | 0.4 |
| First Stage F, output tariff | - | 340.7 | - | 340.7 | 447.8 | 447.8 |
| First Stage F, downstream tariff | - | 631.1 | - | 631.1 | 469.4 | 469.4 |
| First Stage F, upstream tariff | - | 192.6 | - | 192.6 | 220.3 | 220.3 |

Standard errors are clustered by firm and initial sector. 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 $p < 0.1$.

Table A.3: Movements to Sectors with Higher Skilled Worker Share Based on 2004 survey

**Dependent variable: Ranking of sector according to skill intensity**

| | All Enterprises, Excluding SOEs and Multinationals | | Only Non-Exporters | |
|---|---|---|---|---|
| | OLS | IV | OLS | IV |
| | (1) | (2) | (3) | (4) |
| output_tariff | -17.82*** | -26.20*** | -18.80*** | -19.27*** |
| | (1.00) | (3.81) | (0.89) | (3.14) |
| downstream_tariff | 6.914*** | -33.44*** | 5.907*** | -31.39*** |
| | (1.34) | (7.40) | (1.31) | (7.49) |
| upsrteam_tariff | 34.04*** | 108.5*** | 36.85*** | 93.35*** |
| | (2.79) | (14.39) | (2.75) | (13.07) |
| index_subsidy | 0.630*** | 0.703*** | 0.843*** | 0.877*** |
| | (0.16) | (0.18) | (0.19) | (0.20) |
| index_tax | 0.134 | 0.153 | 0.216** | 0.173* |
| | (0.09) | (0.10) | (0.10) | (0.10) |
| index_interest | -0.390*** | -0.338*** | -0.431*** | -0.428*** |
| | (0.110) | (0.115) | (0.123) | (0.127) |
| exportshare_sector | -194.7*** | -185.5*** | -209.2*** | -202.1*** |
| | (8.64) | (7.80) | (7.81) | (7.98) |
| State_share | -0.194 | -0.0456 | -0.423 | -0.207 |
| | (0.420) | (0.424) | (0.467) | (0.468) |
| Horizontal FDI | 68.07*** | 44.12*** | 73.68*** | 55.40*** |
| | (7.60) | (9.77) | (7.54) | (9.29) |
| Downstream FDI | 539.2*** | 592.5*** | 549.8*** | 593.3*** |
| | (23.83) | (27.49) | (26.15) | (29.35) |
| Upstream FDI | -33.38*** | -46.95*** | -43.23*** | -51.02*** |
| | (5.58) | (6.24) | (5.89) | (6.51) |
| Observations | 1,037,738 | 1,037,738 | 826,072 | 826,072 |
| F statistic log(output tariff) = log(downstream tariff) | 216 | 1 | 228 | 3 |
| First Stage F, output tariff | - | 341 | - | 448 |
| First Stage F, downstream tariff | - | 631 | - | 469 |
| First Stage F, upstream tariff | - | 193 | - | 220 |

Sectors with a higher rank (number) are more skill intensive. Standard errors are clustered by firm and initial sector. All regressions include firm fixed effects and time fixed effects.

Table A.4: Regressions of Productivity on Tariffs Interacted with Lagged Quartile of Sales

**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 | FE | OP | FE |
| | OLS | OLS | IV | IV | IV | IV |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| output_tariff*q1 | -0.0337*** | -0.0344*** | -0.0334** | -0.0276 | -0.0435*** | -0.0365** |
| | (0.00341) | (0.00350) | (0.0169) | (0.0175) | (0.0167) | (0.0172) |
| output_tariff*q2 | -0.0302*** | -0.0312*** | -0.0277 | -0.0249 | -0.0396** | -0.0353* |
| | (0.00313) | (0.00322) | (0.0179) | (0.0189) | (0.0173) | (0.0181) |
| output_tariff*q3 | -0.0261*** | -0.0273*** | -0.00859 | -0.00510 | -0.0180 | -0.0132 |
| | (0.00314) | (0.00324) | (0.0190) | (0.0198) | (0.0189) | (0.0196) |
| output_tariff*q4 (largest) | -0.0240*** | -0.0253*** | -0.0129 | -0.0118 | -0.0259 | -0.0233 |
| | (0.00327) | (0.00340) | (0.0168) | (0.0178) | (0.0173) | (0.0182) |
| downstream_tariff | -0.0112* | -0.0117 | -0.153** | -0.156** | -0.388*** | -0.404*** |
| | (0.00639) | (0.00719) | (0.0643) | (0.0645) | (0.0714) | (0.0732) |
| upsrteam_tariff | -0.137*** | -0.146*** | -0.445*** | -0.521*** | -0.322*** | -0.389*** |
| | (0.0124) | (0.0133) | (0.0988) | (0.101) | (0.0965) | (0.0984) |
| index_subsidy | 0.00466*** | 0.00617*** | 0.00401*** | 0.00540*** | 0.00206 | 0.00288* |
| | (0.00129) | (0.00130) | (0.00130) | (0.00132) | (0.00170) | (0.00171) |
| index_tax | 0.0188*** | 0.0192*** | 0.0186*** | 0.0189*** | 0.0180*** | 0.0185*** |
| | (0.000989) | (0.000995) | (0.00100) | (0.00101) | (0.00105) | (0.00106) |
| index_interest | -0.00623*** | -0.00718*** | -0.00624*** | -0.00720*** | -0.00684*** | -0.00773*** |
| | (0.000960) | (0.000967) | (0.000972) | (0.000981) | (0.00112) | (0.00114) |
| Export_share | 0.190*** | 0.223*** | 0.450*** | 0.513*** | 0.567*** | 0.632*** |
| | (0.0343) | (0.0354) | (0.0545) | (0.0569) | (0.0601) | (0.0635) |
| State_share | -0.00327 | -0.00319 | -0.00325 | -0.00313 | -0.000174 | 0.000417 |
| | (0.00440) | (0.00435) | (0.00443) | (0.00439) | (0.00490) | (0.00486) |
| Horizontal FDI | 0.192*** | 0.239*** | 0.177*** | 0.218*** | 0.282*** | 0.333*** |
| | (0.0424) | (0.0447) | (0.0457) | (0.0480) | (0.0541) | (0.0563) |
| Downstream FDI | 0.812*** | 0.706*** | 1.599*** | 1.543*** | 2.215*** | 2.171*** |
| | (0.197) | (0.204) | (0.321) | (0.329) | (0.354) | (0.367) |
| Upstream FDI | 0.0527 | 0.0560 | 0.190** | 0.213** | 0.0287 | 0.0504 |
| | (0.0816) | (0.0824) | (0.0901) | (0.0911) | (0.0927) | (0.0937) |
| q1 | -0.0804*** | -0.0909*** | -0.0560** | -0.0756*** | -0.0613** | -0.0801** |
| | (0.00729) | (0.00766) | (0.0275) | (0.0279) | (0.0308) | (0.0313) |
| q2 | -0.0660*** | -0.0738*** | -0.0465** | -0.0573** | -0.0479* | -0.0584** |
| | (0.00626) | (0.00657) | (0.0236) | (0.0238) | (0.0267) | (0.0269) |
| q3 | -0.0435*** | -0.0482*** | -0.0587** | -0.0684** | -0.0645** | -0.0732** |
| | (0.00509) | (0.00524) | (0.0269) | (0.0271) | (0.0314) | (0.0316) |
| Observations | 701,765 | 701,765 | 701,765 | 701,765 | 548,283 | 548,283 |

output_tariff*q# indicates output tariffs interacted with a dummy for whether sales is in the first, second, third or fourth quartile of sales in the lagged year. Standard errors are clustered by firm and initial sector. 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. 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 A.5: Introduction of New Goods on Tariffs Interacted with Lagged Quartile of Sales

| dependent variable → | All Enterprises excluding SOE's and multinationals | | | | Only Non-Exporting Enterprises | |
|---|---|---|---|---|---|---|
| | new product share | 0-1 dummy for introducing a new product | new product share | 0-1 dummy for introducing a new product | new product share | 0-1 dummy for introducing a new product |
| | OLS | OLS | IV | IV | IV | IV |
| | (1) | (2) | (3) | (4) | (6) | (5) |
| output_tariff*q1 | 0.000531 | -0.00138 | -0.0152** | -0.0513*** | -0.0123** | -0.0327*** |
| | (0.00144) | (0.00348) | (0.00746) | (0.0184) | (0.00582) | (0.0124) |
| output_tariff*q2 | 0.000509 | 0.000862 | -0.0169** | -0.0337* | -0.0117** | -0.0252** |
| | (0.00142) | (0.00328) | (0.00747) | (0.0177) | (0.00575) | (0.0120) |
| output_tariff*q3 | 0.000192 | 0.00117 | -0.0148* | -0.0293 | -0.00981 | -0.0168 |
| | (0.00153) | (0.00343) | (0.00786) | (0.0191) | (0.00612) | (0.0134) |
| output_tariff*q4 (largest) | -0.000867 | -0.00185 | -0.0189** | -0.0264 | -0.0131** | -0.0290** |
| | (0.00179) | (0.00377) | (0.00834) | (0.0194) | (0.00628) | (0.0135) |
| downstream_tariff | -0.00253 | 0.0142 | -0.0381* | -0.0742 | -0.0500*** | -0.0725** |
| | (0.00238) | (0.00909) | (0.0224) | (0.0497) | (0.0177) | (0.0351) |
| upsrteam_tariff | 0.00138 | -0.00309 | 0.0440 | 0.137* | 0.0469** | 0.113** |
| | (0.00403) | (0.0103) | (0.0313) | (0.0710) | (0.0231) | (0.0472) |
| index_subsidy | 0.00544*** | 0.0138*** | 0.00547*** | 0.0140*** | 0.00417*** | 0.0100*** |
| | (0.000851) | (0.00171) | (0.000845) | (0.00170) | (0.000885) | (0.00163) |
| index_tax | -0.000130 | -0.00176 | -9.29e-05 | -0.00166 | 0.000277 | -0.000624 |
| | (0.000424) | (0.00108) | (0.000429) | (0.00109) | (0.000421) | (0.000861) |
| index_interest | -0.00249*** | -0.00776*** | -0.00242*** | -0.00763*** | -0.00135*** | -0.00462*** |
| | (0.000514) | (0.00126) | (0.000512) | (0.00126) | (0.000496) | (0.000970) |
| Export_share | -0.0112 | -0.0153 | 0.0107 | 0.0223 | 0.00664 | -0.0147 |
| | (0.00984) | (0.0262) | (0.0143) | (0.0337) | (0.0129) | (0.0277) |
| State_share | -0.00205 | 0.00188 | -0.00207 | 0.00185 | -0.00335 | -0.00108 |
| | (0.00247) | (0.00471) | (0.00247) | (0.00473) | (0.00255) | (0.00473) |
| Horizontal FDI | 0.0173 | 0.0158 | 0.00538 | -0.0249 | 0.0164 | 0.0125 |
| | (0.0113) | (0.0310) | (0.0150) | (0.0392) | (0.0123) | (0.0261) |
| Downstream FDI | -0.0245 | -0.0637 | 0.0334 | 0.0637 | 0.0722* | 0.0682 |
| | (0.0277) | (0.0695) | (0.0498) | (0.111) | (0.0401) | (0.0789) |
| Upstream FDI | -0.00302 | -0.0118 | -0.0283** | -0.0606** | -0.0309*** | -0.0550** |
| | (0.00727) | (0.0151) | (0.0127) | (0.0281) | (0.0110) | (0.0221) |
| q1 | -0.00757* | -0.0104 | -0.0129 | 0.0480* | -0.00451 | -0.00260 |
| | (0.00400) | (0.00893) | (0.0123) | (0.0270) | (0.0115) | (0.0239) |
| q2 | -0.00851** | -0.0186** | -0.00984 | 0.00450 | -0.00623 | -0.0196 |
| | (0.00375) | (0.00789) | (0.0112) | (0.0247) | (0.0113) | (0.0222) |
| q3 | -0.00704** | -0.0187*** | -0.0139 | -0.00515 | -0.00938 | -0.0350 |
| | (0.00337) | (0.00648) | (0.0127) | (0.0284) | (0.0125) | (0.0258) |
| Observations | 701,765 | 701,765 | 701,765 | 701,765 | 548,283 | 548,283 |

output_tariff*q# indicates output tariffs interacted with a dummy for whether sales is in the first, second, third or fourth quartile of sales in the lagged year. Standard errors are clustered by firm and initial sector. 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 $p < 0.1$.

Table A.6: Sectoral skill intensity and tariffs interacted with lagged quartiles of firm sales

**Dependent variable: Ranking of sector according to skill intensity**

| | All Enterprises Excluding SOEs and Multinationals | | Only Non-Exporters | |
|---|---|---|---|---|
| | OLS | IV | OLS | IV |
| | (1) | (2) | (3) | (4) |
| output_tariff*q1 | -17.70*** | -21.31*** | -18.51*** | -15.49*** |
| | (1.067) | (3.914) | (1.012) | (3.441) |
| output_tariff*q2 | -17.62*** | -19.51*** | -18.32*** | -13.33*** |
| | (1.070) | (3.662) | (1.015) | (3.283) |
| output_tariff*q3 | -17.41*** | -20.63*** | -18.07*** | -15.17*** |
| | (1.079) | (3.835) | (1.011) | (3.446) |
| output_tariff*q4 (largest) | -16.95*** | -23.32*** | -17.89*** | -17.71*** |
| | (1.105) | (3.890) | (1.078) | (3.499) |
| downstream_tariff | 5.040*** | -40.18*** | 4.296*** | -42.09*** |
| | (1.297) | (8.168) | (1.250) | (8.872) |
| upsrteam_tariff | 33.69*** | 110.0*** | 35.25*** | 94.50*** |
| | (3.102) | (14.99) | (3.153) | (14.23) |
| index_subsidy | 0.557*** | 0.575*** | 0.721*** | 0.694*** |
| | (0.186) | (0.199) | (0.226) | (0.239) |
| index_tax | 0.120 | 0.136 | 0.202* | 0.142 |
| | (0.106) | (0.112) | (0.120) | (0.125) |
| index_interest | -0.327*** | -0.276** | -0.341** | -0.347** |
| | (0.126) | (0.132) | (0.144) | (0.149) |
| exportshare_sector | -189.8*** | -181.7*** | -206.3*** | -198.1*** |
| | (9.236) | (8.140) | (8.927) | (9.022) |
| State_share | -0.147 | 0.287 | -0.311 | 0.104 |
| | (0.526) | (0.529) | (0.594) | (0.600) |
| Horizontal FDI | 65.14*** | 40.52*** | 71.19*** | 52.45*** |
| | (8.281) | (10.34) | (8.537) | (10.07) |
| Downstream FDI | 541.6*** | 606.0*** | 549.6*** | 611.8*** |
| | (26.71) | (30.71) | (29.73) | (34.02) |
| Upstream FDI | -33.28*** | -42.72*** | -42.68*** | -49.50*** |
| | (6.264) | (7.028) | (6.869) | (7.850) |
| q1 | 2.157 | -4.534 | 2.022 | -4.695 |
| | (1.333) | (4.008) | (1.467) | (4.343) |
| q2 | 1.803 | -8.723** | 1.407 | -9.660** |
| | (1.149) | (3.859) | (1.287) | (4.194) |
| q3 | 0.944 | -6.313 | 0.540 | -5.658 |
| | (0.911) | (3.935) | (1.033) | (4.189) |
| Observations | 701,765 | 701,765 | 548,283 | 548,283 |

output_tariff*q# indicates output tariffs interacted with a dummy for whether sales is in the first, second, third or fourth quartile of sales in the lagged year. Sectors with a higher rank (number) are more skill intensive. Standard errors are clustered by firm and initial sector. All regressions include firm fixed effects and time fixed effects.

## A.2 Other Firm Outcomes

We study the relation between tariffs various firm outcomes. Table A.7 runs the main specification with an exit dummy as the dependent variable. The results are consistent with the prediction of the model that import-competing firms are more likely to exit when tariffs fall.

In Table A.8, the dependent variable is a dummy for whether the firm switches sectors. To the extent that product differentiation may be accompanied by sectoral switches, the model predicts the coefficient on downstream and output tariffs should be negative. The coefficient is negative, though statistically insignificant for non-exporting establishments.

Table A.9 repeats the main regression specification with revenue as the dependent variable. In all IV specifications, the coefficient on tariff is positive and statistically significant. Tariff cuts are associated with decreases in sales, especially among non-exporting firms. This result is consistent with most international trade models. The results for OLS specifications is more mixed, many of the coefficients are negative and statistically insignificant.

Table A.10 confirms the well-known positive relationship between revenue and TFP in our data. The table shows the coefficients from regressing TFP on revenue with time fixed effects. The coefficient is around 0.20, and it is statistically significant at a 99% confidence level in all specifications, which vary in their TFP measure and in whether they include sector fixed effects. In the model, the increasing relation between firm size and markup holds within sectors among firms that are less-differentiated. Firms that are differentiated have higher markups and generally vary in size.

Table A.7: Determinants of Exit

| | All enterprises | Non-Exporters | Non-Exporters No Sectoral Changes |
|---|---|---|---|
| | (1) | (2) | (3) |
| output_tariff | -0.0576** | -0.0518** | -0.0866*** |
| | (0.0237) | (0.0241) | (0.0219) |
| downstream_tariff | -0.316*** | -0.346*** | -0.413*** |
| | (0.0737) | (0.0829) | (0.0829) |
| upsrteam_tariff | 0.295*** | 0.313*** | 0.346*** |
| | (0.1060) | (0.1190) | (0.1040) |
| index_subsidy | -0.0306*** | -0.0304*** | -0.0283*** |
| | (0.0017) | (0.0017) | (0.0021) |
| index_tax | -0.00579*** | -0.00605*** | -0.00732*** |
| | (0.0011) | (0.0012) | (0.0013) |
| index_interest | 0.0147*** | 0.0139*** | 0.0143*** |
| | (0.0013) | (0.0014) | (0.0015) |
| exportshare_sector | 0.195*** | 0.232*** | 0.268*** |
| | (0.047) | (0.052) | (0.054) |
| State_share | -0.0011 | -0.00157 | -0.0061 |
| | (0.0052) | (0.0052) | (0.0059) |
| Horizontal FDI | -0.152*** | -0.141*** | -0.167*** |
| | (0.044) | (0.043) | (0.044) |
| Downstream FDI | 0.574*** | 0.518*** | 0.592*** |
| | (0.144) | (0.159) | (0.162) |
| Upstream FDI | -0.141*** | -0.160*** | -0.221*** |
| | (0.036) | (0.036) | (0.042) |
| Observations | 851,742 | 818,699 | 672,222 |

Notes: Standard errors are clustered by firm and initial sector. Linear 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 $p < 0.1$.

Table A.8: Probit Regression of Whether or Not Establishment Switched Sector

| | All enterprises (1) | Non-Exporters (2) | Exporters (3) |
|---|---|---|---|
| output_tariff | -0.0169 | -0.00707 | -0.0773** |
| | (0.0216) | (0.0211) | (0.0365) |
| downstream_tariff | -0.155*** | -0.171*** | -0.0133 |
| | (0.0483) | (0.0464) | (0.0779) |
| upsrteam_tariff | -0.187*** | -0.236*** | -0.067 |
| | (0.0404) | (0.0389) | (0.0805) |
| index_subsidy | 0.130*** | 0.136*** | 0.0775*** |
| | (0.0117) | (0.0137) | (0.0200) |
| index_tax | -0.0166* | -0.0143 | -0.0129 |
| | (0.0085) | (0.0093) | (0.0157) |
| index_interest | -0.0496*** | -0.0411*** | -0.0649*** |
| | (0.0089) | (0.0096) | (0.0158) |
| exportshare_sector | 0.159 | 0.279*** | -0.431*** |
| | (0.105) | (0.107) | (0.166) |
| State_share | -0.165*** | -0.127*** | -0.358*** |
| | (0.0283) | (0.0315) | (0.0619) |
| Horizontal FDI | -0.17 | -0.124 | -0.405 |
| | (0.156) | (0.151) | (0.269) |
| Downstream FDI | 2.254*** | 2.345*** | 2.078*** |
| | (0.381) | (0.367) | (0.587) |
| Upstream FDI | 0.248** | 0.262** | 0.181 |
| | (0.113) | (0.110) | (0.155) |
| Observations | 987,022 | 785,271 | 201,751 |

Dependent variable is a zero-one dummy variable for whether or not the enterprise changed sector. *** indicates $p < 0.01$, ** $p < 0.05$, and * indicates $p < 0.1$.

Table A.9: Basic Regressions of Revenue on Tariffs

**The dependent variable is log of revenue**

| | All enterprises | | Non-Exporters Only | | All enterprises | | Non-Exporters Only | |
|---|---|---|---|---|---|---|---|---|
| | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| output_tariff | -0.0275** | 0.0549* | -0.0336*** | 0.0556* | -0.0182 | 0.0533 | -0.0260* | 0.0697** |
| | (0.0118) | (0.0309) | (0.0115) | (0.0306) | (0.0119) | (0.0344) | (0.0130) | (0.0337) |
| downstream_tariff | 0.0411 | 0.534*** | 0.0116 | 0.383*** | 0.0814** | 1.110*** | 0.0439 | 0.756*** |
| | (0.0253) | (0.0728) | (0.0236) | (0.0865) | (0.0372) | (0.1180) | (0.0364) | (0.1390) |
| upstream_tariff | 0.0142 | -0.131 | 0.0129 | -0.223* | -0.103 | -0.678*** | -0.122 | -0.580*** |
| | (0.0391) | (0.1100) | (0.0412) | (0.1160) | (0.0741) | (0.1830) | (0.0819) | (0.1850) |
| index_subsidy | 0.0972*** | 0.0976*** | 0.0828*** | 0.0829*** | 0.0933*** | 0.0939*** | 0.0792*** | 0.0796*** |
| | (0.0063) | (0.0029) | (0.0071) | (0.0036) | (0.0064) | (0.0029) | (0.0071) | (0.0036) |
| index_tax | 0.0660*** | 0.0662*** | 0.0685*** | 0.0688*** | 0.0658*** | 0.0663*** | 0.0679*** | 0.0687*** |
| | (0.0025) | (0.0018) | (0.0029) | (0.0021) | (0.0024) | (0.0018) | (0.0029) | (0.0021) |
| index_interest | -0.0995*** | -0.0998*** | -0.110*** | -0.110*** | -0.0966*** | -0.0969*** | -0.106*** | -0.106*** |
| | (0.0034) | (0.0022) | (0.0033) | (0.0026) | (0.0033) | (0.0022) | (0.0033) | (0.0025) |
| exportshare_sector | 0.014 | -0.375*** | -0.139 | -0.393*** | 0.471*** | -0.216** | -0.129 | -0.520*** |
| | (0.0829) | (0.0545) | (0.0981) | (0.0672) | (0.1490) | (0.0895) | (0.1910) | (0.1070) |
| state_share | 0.0422*** | 0.0428*** | 0.0391*** | 0.0394*** | 0.0433*** | 0.0422*** | 0.0402*** | 0.0397*** |
| | (0.0097) | (0.0090) | (0.0106) | (0.0102) | (0.0097) | (0.0090) | (0.0109) | (0.0101) |
| Horizontal FDI | -0.0287 | -0.0106 | 0.0292 | 0.0635 | -0.1 | -0.239*** | -0.0147 | -0.0984 |
| | (0.1750) | (0.0543) | (0.1860) | (0.0596) | (0.2840) | (0.0642) | (0.3140) | (0.0758) |
| Downstream FDI | 0.758* | -0.395** | 0.828* | 0.144 | 0.215 | -3.035*** | -0.184 | -2.218*** |
| | (0.4070) | (0.1880) | (0.4350) | (0.2160) | (1.0560) | (0.4540) | (1.0790) | (0.5320) |
| Upstream FDI | 0.222** | 0.433*** | 0.208** | 0.416*** | 0.672*** | 0.501*** | 0.481** | 0.457*** |
| | (0.0972) | (0.0478) | (0.1030) | (0.0570) | (0.1960) | (0.0960) | (0.2350) | (0.1030) |
| Sector Fixed Effects | no | no | no | no | yes | yes | yes | yes |
| Observations | 982,142 | 982,142 | 777,739 | 777,739 | 982,142 | 982,142 | 777,739 | 777,739 |

Standard errors are clustered. Tariffs and revenue are in logs. All specifications include fixed effects for the firm and time. 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 A.10: Cross-sectional relation between revenue and TFP
**Dependent variable is log TFP, measured à la Olley-Pakes (OP) or OLS with fixed effects (FE)**

| | OP | FE | OP | FE |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| log revenue | 0.191*** | 0.204*** | 0.188*** | 0.197*** |
| | (0.0074) | (0.0062) | (0.0077) | (0.0061) |
| Time Fixed Effects | Yes | Yes | Yes | Yes |
| Sector Fixed Effects | No | No | Yes | Yes |
| Observations | 1,012,444 | 1,012,444 | 1,012,444 | 1,012,444 |
| R-squared | 0.279 | 0.319 | 0.453 | 0.455 |
| Number of firm ID's | 327,924 | 327,924 | 327,924 | 327,924 |

Robust standard errors in parenthesis. *** indicates p-values less than 1%.

## A.3 Robustness of Empirical Results

### A.3.1 Basic Regression Specification

We conduct robustness checks on the main regression specification, Table 1 in the main text:

$$y_{it} = \beta \ln \text{Tariff}_{j(i,t)t} + \gamma_1 X_{j(i,t)t} + \gamma_2 X_{i,t} + \alpha_i + \alpha_t + \varepsilon$$

Tables A.11, A.12 and A.13 show the coefficient on output tariff $\beta$ for each robustness check. The dependent variable is revenue TFP measured à la Olley Pakes in Table, the two measures of introduction of new goods in Table A.12, and the ranking of sector skill intensity in Table A.13. All specifications include time and firm fixed effects and control variables described in Appendix A.1. When the dependent variable is TFP, we also include sector fixed effects and a dummy for when the firm switches sectors.

In row 1, we include all multinationals and state-owned enterprises (SOE's) excluded from the main specification. In rows 2-4 we check if the results are affected by the collinearity among tariff measures. We drop upstream tariffs in row 2, downstream tariffs in row 3 and both upstream and downstream tariffs in row 4. We do two exercises to address the concern that selection drives our results. Row 5 keeps only a balanced panel of establishments that survived all ten years of our data.

For our second test, we follow Wooldridge (2002) 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. We use the establishment's profitability in the previous period as the determinant of survival that does not appear in the estimating equation.

Rows 7 and 8 drop key sectors from the data. Row 7 drops textiles and apparel. There were

Table A.11: Robustness checks on TFP

**Dependent variable is TFP measured à la Olley-Pakes (except in row 10)**

| | all establishments excluding SOEs and multinationals | | | non-exporters | |
|---|---|---|---|---|---|
| | coefficient on tariffs | | number of | coeff. on tariffs | number of |
| | OLS | IV | observations | IV | observations |
| **Baseline specification (main text)** | **-0.0304*** ** | **-0.0505*** ** | **1,037,738** | **-0.0617*** ** | **826,072** |
| | (0.0027) | (0.0169) | | (0.0158) | |
| 1. including SOE's and multinationals | -0.0271*** | -0.0123 | 1,495,411 | -0.0294** | 1,047,907 |
| | (0.00228) | (0.0168) | | (0.0142) | |
| 2. drop upstream tariffs | -0.0406*** | -0.0912*** | 1,037,738 | -0.0872*** | 826,072 |
| | (0.0026) | (0.0131) | | (0.0120) | |
| 3. drop downstream tariffs | -0.0301*** | -0.0722*** | 1,037,738 | -0.0876*** | 826,072 |
| | (0.00266) | (0.0202) | | (0.0173) | |
| 4. drop upstream and downstream tariffs | -0.0417*** | -0.173*** | 1,037,738 | -0.166*** | 826,072 |
| | (0.00262) | (0.0179) | | (0.0156) | |
| 5. balanced panel | -0.0536*** | -0.0373* | 65,809 | -0.0659*** | 47,128 |
| | (0.0070) | (0.0218) | | (0.0224) | |
| 6. Include Mills ratio | -0.0326*** | -0.0272* | 850,582 | -0.0386*** | 671,237 |
| | (0.0027) | (0.0162) | | (0.0032) | |
| 7. Excluding textiles and apparel | -0.0322*** | -0.0727*** | 849,870 | -0.103*** | 706,931 |
| | (0.00273) | (0.0192) | | (0.0179) | |
| 8. Excluding computers and peripherals | -0.0307*** | -0.0504*** | 1,037,243 | -0.0616*** | 825,647 |
| | (0.00268) | (0.0169) | | (0.0158) | |
| 9. Including tariffs in estimating TFP | -0.0323*** | -0.0492*** | 1,004,678 | -0.0383*** | 797,937 |
| | (0.00280) | (0.0174) | | (0.00319) | |
| 10. TFP estimated à la Ackerberg, Caves, Frazer (2015) | -0.0619*** | -0.120** | 1,036,517 | -0.169*** | 825,221 |
| | (0.0057) | (0.0549) | | (0.0513) | |

Table A.12: Robustness checks on the introduction of new goods

| | all establishments excluding SOEs and multinationals | | | non-exporters | |
|---|---|---|---|---|---|
| | coefficient on tariffs | | number of | coeff. on tariffs | number of |
| | OLS | IV | observations | IV | observations |
| **Dependent variable is the share of new products in sales** | | | | | |
| **Baseline specification (main text)** | **-0.000356** | **-0.0157**** | **1,037,738** | **-0.00976**** | **826,072** |
| | **(0.0012)** | **(0.0068)** | | **(0.0045)** | |
| 1. including SOE's and multinationals | 0.00141 | -0.0122 | 1,495,411 | -0.00703* | 1,047,907 |
| | (0.000968) | (0.00845) | | (0.00395) | |
| 2. drop upstream tariffs | -4.27e-05 | -0.0104** | 1,037,738 | -0.00351 | 826,072 |
| | (0.00117) | (0.00481) | | (0.00336) | |
| 3. drop downstream tariffs | -0.000277 | -0.0186** | 1,037,738 | -0.0110** | 826,072 |
| | (0.00120) | (0.00794) | | (0.00471) | |
| 4. drop upstream and downstream tariffs | -0.000155 | -0.0156** | 1,037,738 | -0.00757* | 826,072 |
| | (0.00118) | (0.00619) | | (0.00399) | |
| 5. balanced panel | -0.000430 | -0.0192 | 65,809 | -0.0110 | 47,128 |
| | (0.00343) | (0.0138) | | (0.00869) | |
| 6. Include Mills ratio | 0.000606 | -0.0129** | 850,582 | -0.0100** | 671,237 |
| | (0.00118) | (0.00625) | | (0.00428) | |
| 7. Excluding textiles and apparel | -0.000361 | -0.0169** | 849,870 | -0.00999** | 706,931 |
| | (0.00124) | (0.00750) | | (0.00479) | |
| 8. Excluding computers and peripherals | -0.000474 | -0.0157** | 1,037,243 | -0.00978** | 825,647 |
| | (0.00121) | (0.00678) | | (0.00445) | |
| **Dependent variable is a 0-1 dummy of whether the firm introduced a new product in the year** | | | | | |
| **Baseline specification (main text)** | **-0.000687** | **-0.0405**** | **1,037,738** | **-0.0279***** | **826,072** |
| | **(0.0029)** | **(0.0168)** | | **(0.0102)** | |
| 1. including SOE's and multinationals | 0.00134 | -0.0446*** | 1,495,411 | -0.0195** | 1,047,907 |
| | (0.00207) | (0.0172) | | (0.00838) | |
| 2. drop upstream tariffs | -0.000887 | -0.0237* | 1,037,738 | -0.0141* | 826,072 |
| | (0.00283) | (0.0133) | | (0.00764) | |
| 3. drop downstream tariffs | -0.000852 | -0.0461** | 1,037,738 | -0.0295*** | 826,072 |
| | (0.00290) | (0.0188) | | (0.0106) | |
| 4. drop upstream and downstream tariffs | -0.000630 | -0.0310** | 1,037,738 | -0.0184** | 826,072 |
| | (0.00284) | (0.0150) | | (0.00882) | |
| 5. balanced panel | 0.00317 | -0.0650** | 65,809 | -0.0409** | 47,128 |
| | (0.00713) | (0.0272) | | (0.0186) | |
| 6. Include Mills ratio | 0.00140 | -0.0292* | 850,582 | -0.0282*** | 671,237 |
| | (0.00328) | (0.0159) | | (0.00943) | |
| 7. Excluding textiles and apparel | -0.000124 | -0.0412** | 849,870 | -0.0269** | 706,931 |
| | (0.00298) | (0.0184) | | (0.0109) | |
| 8. Excluding computers and peripherals | -0.000784 | -0.0405** | 1,037,243 | -0.0279*** | 825,647 |
| | (0.00292) | (0.0168) | | (0.0102) | |

Table A.13: Robustness checks on switches to skill-intensive sectors

**Dependent variable is the ranking of skill intensity of the sector**

| | all establishments excluding SOEs and multinationals | | | non-exporters | |
|---|---|---|---|---|---|
| | coefficient on tariffs | | number of | coeff. on tariffs | number of |
| | OLS | IV | observations | IV | observations |
| **Baseline specification (main text)** | **-17.82*** ** | **-26.20*** ** | **1,037,738** | **-19.27*** ** | **826,072** |
| | (1.00) | (3.81) | | (3.14) | |
| 1. including SOE's and multinationals | -15.83*** | -40.10*** | 1,495,411 | -18.70*** | 1,047,907 |
| | (0.970) | (4.997) | | (2.743) | |
| 2. drop upstream tariffs | -13.56*** | -8.540*** | 1,037,738 | -4.837*** | 826,072 |
| | (0.890) | (2.125) | | (1.726) | |
| 3. drop downstream tariffs | -17.96*** | -29.69*** | 1,037,738 | -20.47*** | 826,072 |
| | (0.996) | (4.287) | | (3.278) | |
| 4. drop upstream and downstream tariffs | -13.12*** | -9.612*** | 1,037,738 | -7.073*** | 826,072 |
| | (0.876) | (2.345) | | (1.941) | |
| 5. balanced panel | -14.49*** | -23.15*** | 65,809 | -16.50*** | 47,128 |
| | (1.957) | (4.897) | | (4.469) | |
| 6. Include Mills ratio | -17.73*** | -26.09*** | 850,582 | -19.10*** | 671,237 |
| | (1.053) | (3.760) | | (3.097) | |
| 7. Excluding textiles and apparel | -17.87*** | -29.36*** | 849,870 | -21.73*** | 706,931 |
| | (1.027) | (4.141) | | (3.349) | |
| 8. Excluding computers and peripherals | -17.86*** | -26.19*** | 1,037,243 | -19.25*** | 825,647 |
| | (1.004) | (3.822) | | (3.150) | |

major liberalizations in textiles and apparel during this period, such as the phasing out of the Multi-fibre Agreement (MFA). Row 8 drops the computer and computer peripherals sector. These sectors experienced large growth due to offshoring. For the TFP regressions, row 9 includes tariffs in the first stage of the TFP estimate, and row 10 measures TFP following Caves, Fraser, and Ackerberg (2015).

When the dependent variable is sectoral skill intensity in Table A.13, the results hold in all specifications, OLS and IV, including all firms and only non-exporting firms. The coefficient only decreases from 19 to 7 when we drop upstream tariffs, indicating that collinearity may influence the results, but not eliminate them.

The results are also very robust when the dependent variable is TFP or it is a 0-1 dummy for whether or not the firm introduces a new product. It is large, negative and statistically significant in all specifications especially when we include only non-exporting firms.

When we include all multinationals, SOE's and exporters, the coefficient on tariffs is insignificant when the dependent variable is TFP or it is the share of new goods in sales. Multinationals are generally more engaged in offshoring and exporting and may be less influenced by the domestic market. They also may have more difficulty tailoring their products to domestic tastes or coupling their products with non-tradable services. Reassuringly, the results hold when we exclude exporting firms, even when we include SOE's and multinationals.

The results are also weaker when the dependent variable is the share of new goods in sales, and we include only a balanced panel. Firms that survive through the ten years or our sample are more likely to have introduced successful products that hold a large share of sales. Our preferred specification i

To summarize, the results are somewhat less robust when the dependent variable is the share of new goods in sales. But even then, in all specifications when we include only non-exporting firms, tariff cuts are associated with increases in TFP, the introduction of new goods, and shifts to more skill-intensive sectors. Since import competition drives our results, we expect them to be stronger for this subsample of non-exporters.

# B Proofs of Basic Model

We prove Propositions 1, 2 and 3. We also show that the set of differentiated firms is not convex in productivity even when unit costs do not change with differentiation.

## B.1 Exit

*Suppose that firms can be ranked in terms of costs, $c_{iD} < c_{i'D}$ if and only if $c_{iL} < c_{i'L}$. Then, there exists $\tilde{c} > 0$ such that firms produce if and only if $c_{iL} \leq \tilde{c}$. Cutoff $\tilde{c}$ is increasing in $\overline{P}$.*

**Claim 1.** Suppose by contradiction that $i$ firm with costs $(c_{iL}, c_{iD})$ enters and a firm $j$ with $(c_{jL}, c_{jD}) \ll (c_{iL}, c_{iD})$ does not enter. If firm $i$ differentiates its product, then trivially, firm $j$ would make positive profits from entering and differentiating. Let firm $j$ be the highest-cost firm that

Table B.1: Operating profits (before fixed costs) in the numerical example

| **Panel A: Initial** | | | |
|---|---|---|---|
| | firm 1 | firm 2 | firm 3 |
| cost $c_{iL} = c_{iD}$ | **1.0** | 1.1 | 1.2 |
| $\pi_D$ | 0.148 | 0.122 | 0.103 |
| $\mathcal{L}_S \downarrow$ | | $\pi_L$ | |
| $\{1,2,3\}$ | 0.092 | 0.064 | 0.045 |
| $\{1,2\}$ | 0.107 | 0.075 | |
| $\{1,3\}$ | 0.114 | | 0.058 |
| $\{2,3\}$ | | 0.088 | 0.064 |

| **Panel B: After decrease in** $c_1$ | | | |
|---|---|---|---|
| | firm 1 | firm 2 | firm 3 |
| cost $c_{iL} = c_{iD}$ | **0.9** | 1.1 | 1.2 |
| $\pi_D$ | 0.183 | 0.122 | 0.103 |
| $\mathcal{L}_S \downarrow$ | | $\pi_L$ | |
| {1,2,3} | 0.126 | 0.058 | 0.041 |
| {1,2} | 0.143 | 0.067 | |
| {1,3} | 0.150 | | 0.051 |
| {2,3} | | 0.088 | 0.064 |

does not enter and that has some firms with costs higher than it enter. Consider the subgame perfect equilibrium where firm $j$ enters and does not differentiate. If any of the subsequent firms remain in the market, then firm $j$ must make positive profits in this subgame, since other firms have costs higher than $j$. So, the entry of firm $j$ must induce exit from all subsequent firms. This is a contradiction because firm $j$'s profits in this subgame equilibrium must be strictly higher than firm $i$' profit, $\pi_i \geq 0$. ■

## B.2 Numerical Example

The operating profits in the numerical example are in Table B.1.

## B.3 Product Differentiation and Productivity

*Fix $\hat{\mathbf{c}}_{-iL}$ and the ratio of unit costs $c_{iD}/c_{iL}$. If the set of firm productivity parameters $\phi_i \equiv (c_{iL})^{-1}$ such that firm $i$ differentiates its product is non-empty, then (i) it is a line segment $[\underline{\phi}, \overline{\phi}]$ if differentiation increases unit costs $c_{Di}/c_{Li} \geq 1$, and (ii) it is unbounded if differentiation decreases unit costs $c_{Di}/c_{Li} < 1$. The net gain from product differentiation $\pi_D(c_{iD}) - \pi_L(c_{iL}, \hat{\mathbf{c}}_{-iL})$ strictly increases if $\hat{\mathbf{c}}_{-iL}$ decreases or if $\hat{\mathbf{c}}_{-iL}$ is augmented with new elements (competitors).*

*Proof.* We omit the firm's subscript $i$, and without loss of generality, write its costs as $c_{iL} = c_L/\phi$ and $c_{iD} = c_D/\phi$ where $\phi$ is the firm's productivity. (Obviously, nothing changes if we set $c_L = 1$.)

**Step 1: Limits of profits.** For a less-differentiated firm, $\lim_{\phi\to\infty} s = 1$, $\lim_{\phi\to\infty} \epsilon = \eta$ and $\lim_{\phi\to\infty} P_L = \frac{\eta c_L}{(\eta-1)\phi}$. We use these limits below,

$$\begin{aligned}
\lim_{\phi\to\infty}(\pi_D - \pi_L) &= \lim_{\phi\to\infty} \overline{P}^{\eta-1}\left[\frac{1}{\eta}\left(\frac{\eta c_D}{(\eta-1)\phi}\right)^{1-\eta} - \frac{P_L^{\sigma-\eta}}{\epsilon_L}\left(\frac{\epsilon_L c_L}{(\epsilon_L-1)\phi}\right)^{1-\sigma}\right] \\
&= \overline{P}^{\eta-1}\left[\frac{1}{\eta}\left(\frac{\eta c_D}{(\eta-1)\phi}\right)^{1-\eta} - \frac{1}{\eta}\left(\frac{\eta c_L}{(\eta-1)\phi}\right)^{1-\eta}\right] \\
&= \overline{P}^{\eta-1}\frac{1}{\eta}\left(\frac{\eta}{(\eta-1)\phi}\right)^{1-\eta}\left[c_D^{1-\eta} - c_L^{1-\eta}\right]
\end{aligned}$$

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

$$\begin{aligned}
\left[c_D^{1-\eta} - c_L^{1-\eta}\right] &< 0 \qquad \text{if } c_D > c_L \\
\left[c_D^{1-\eta} - c_L^{1-\eta}\right] &= 0 \qquad \text{if } c_D = c_L \\
\left[c_D^{1-\eta} - c_L^{1-\eta}\right] &> 0 \qquad \text{if } c_D < c_L
\end{aligned}$$

This completes the case $c_D < c_L$ for which convexity does not necessarily hold.

**Step 2: Convexity when $c_D \geq c_L$.**

**Step 2.1.** Get $\frac{d\pi}{d\phi}$. The profit of a downstream firm is

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

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

$$\begin{aligned}
\frac{\partial\pi}{\partial\phi} &= \overline{P}^{\eta-1} P_n^{\sigma-\eta} p^{-\sigma}\frac{c_n}{\phi^2} \\
&= \frac{\pi}{\phi}\left(\frac{c_n/\phi}{p - c_n/\phi}\right) \\
&= (\epsilon-1)\frac{\pi}{\phi} \qquad \text{(B.1)}
\end{aligned}$$

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

**Step 2.2.** Define $G = \pi_D - \pi_L$ as the gain from differentiation gross of fixed costs. A necessary condition for a maximum of the gross gain from differentiating $G(\phi)$ is

$$G'(\phi) = 0 \quad \Rightarrow \quad (\eta-1)\pi_D = (\epsilon-1)\pi_L. \qquad \text{(B.2)}$$

**Step 2.3.** Let $s$ be the market share of the firm in $\mathcal{L}$ when it does not differentiate its product.

Clearly, $s$ is strictly increasing in $\phi$. To prove that there a unique $s$ satisfying equation (B.2), we rewrite the condition above as a function of $s$. Denote the markup of the firm with $\mu_D$ if it is differentiated, and $\mu_L$ otherwise. Substituting the expression for profit in (B.2), we have:

$$\frac{\eta-1}{\eta}p_D^{1-\eta} = \frac{\epsilon-1}{\epsilon}P_L^{1-\eta}\left(\frac{p_L}{P_L}\right)^{1-\sigma} \tag{B.3}$$

$$\frac{(\mu_D c_D/\phi)^{1-\eta}}{\mu_D} = \frac{P_L^{1-\eta}}{\mu_L}s$$

$$\equiv \quad \left(\frac{\mu_D c_D}{\mu_L c_L}\frac{\mu_L c_L/\phi}{P_L}\right)^{1-\eta} = \frac{\mu_D}{\mu_L}s$$

$$\equiv \quad s^{\frac{\eta-1}{\sigma-1}} = s\left(\frac{\mu_D}{\mu_L}\right)^{\eta}\left(\frac{c_D}{c_L}\right)^{(\eta-1)}$$

$$\equiv \quad s = \left(\frac{\mu_L}{\mu_D}\right)^{\eta\frac{\sigma-1}{\sigma-\eta}}\left(\frac{c_L}{c_D}\right)^{(\eta-1)\frac{\sigma-1}{\sigma-\eta}} \tag{B.4}$$

When $s=1$, then the right-hand-side is $(c_L/c_D)^{(\eta-1)\frac{\sigma-1}{\sigma-\eta}}$, less than or equal to one since $c_L \leq c_D$. When $s=0$, then $\mu_L = \sigma/(\sigma-1)$ and the right-hand-side is strictly larger than one. Next, we prove that $\mu_L$ is a convex function of $s$. Then these two limits will be enough to prove that the left- and right-hand-sides of (B.4) cross at most once.

**Step 2.4.** The pricing rule is

$$\mu_L = \frac{\sigma+(\eta-\sigma)s}{\sigma+(\eta-\sigma)s-1}$$

We must show that $\frac{\partial^2(\mu_L)^a}{\partial s^2} > 0$ where $a>1$ is a constant.

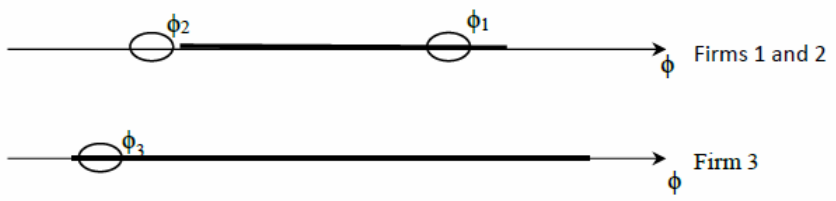
$$\frac{\partial(\mu_L)^a}{\partial s} = a\mu_L^{a-1}\frac{\sigma-\eta}{(\sigma+(\eta-\sigma)s-1)^2}$$

It is a positive constant $a$ times the product of two positive and increasing functions of $s$, $\mu_L^{a-1}$ and $(\sigma+(\eta-\sigma)s-1)^{-2}$. Hence, $\frac{\partial^2(\mu_L)^a}{\partial s^2} > 0$ as we wanted to prove. ■

Two notes on convexity are in order. First, convexity generally does not hold when $c_L > c_D$. By the arguments in steps 2.3 and 2.4, the gain from differentiation, $\pi_D - \pi_L$ has either zero or two critical points when $c_L > c_D$ satisfying equation (B.4). When there are no critical points, then the set of productivity $\phi$ for which the firm differentiates its product is convex $(\underline{\phi}, \infty)$. When there are two critical points, the first is local maximum and the second is a local minimum. Convexity holds only if the gain from differentiating is strictly larger than the fixed cost $\pi_D - \pi_L - (f_D - f_L) > 0$ at the second critical point.

Second, even when the ratio of unit costs $c_{iL}/c_{iD}$ is the same for all firms, the set of differentiated firms is not necessarily convex in costs $c_{iL}$ in a given equilibrium because firms face different levels of competition in the less-differentiated nest $c_{-iL}$. We sketch an example where the equilibrium set

Figure B.1: Set of productivities $\phi$ where differentiation is profitable, given $P_{-1L} = P_{-2L} > P_{-3L}$




of differentiated firms is not necessarily convex in productivity.

When $c_{iL}/c_{iD}$ is the same for all firms, we can write firms' units costs as functions of firm-specific productivity $\phi_i$: Let $c_{iL} = c_L/\phi_i$ and $c_iD = c_D/\phi_i$ for all $i$ where $c_L$ and $c_D$ are common parameters. Consider an economy with Foreign competition and three domestic firms with productivity parameters $\phi_1 > \phi_2 > \phi_3$. Let $c_D = c_L$ so that the set of differentiated firms is a bounded interval $(\underline{\phi}, \overline{\phi})$ for any given $P_{-iL}$. We claim that for some parameter values, it is possible to construct a subgame perfect equilibrium with actions in the equilibrium path {*differentiate, not differentiate, differentiate*}. Suppose that in the subgame where firm 1 does not differentiate, then the two other firms differentiate. Then, the level of competition faced by the three firms in the less-differentiated nest is $P_{LF} = P_{-1L} = P_{-2L} > P_{-3L}$. Then, the set of productivity $\phi$ that makes differentiation profitable is illustrated in Figure B.1 in bold. The set is larger for firm 3 because $P_{-1L} = P_{-2L} > P_{-3L}$, and so it is possible to judiciously pick productivity levels in the regions indicated with an oval such that the proposed equilibrium holds.

## B.4 Markup Responses of Firms of Different Sizes

*Consider the effect of a sufficiently large decrease in the cost of foreign varieties on two domestic firms, a and b, originally producing less-differentiated varieties with $c_{aL} < c_{bL}$. If both firms a and b differentiate their products or if both firms remain less-differentiated, the markup of firm b increases relative to firm a, i.e., $\mu_b/\mu_a$ increases, where $\mu_i$ is the markup of firm i.*

*Proof.* The case where both firms differentiate is in the main text. If both firm remain less-differentiated, they decrease their markups. We must prove that the markup response is greater for firm $a$ than for firm $b$:

$$\left|\frac{d\mu_a}{\mu_a}\right| > \left|\frac{d\mu_b}{\mu_b}\right|$$

where $\mu_i$ is the markup of firm $i$ and $d\mu_b$ is the change given the shock.

In setting prices in the less-differentiated nest, firm $i$ best responds to the other firm's prices. Define

$$P_{-iL}^{1-\sigma} = \sum_{i' \in \mathcal{L}, i' \neq i} p_{i'}^{1-\sigma}.$$

The shock decreases the price of firms in $\mathcal{L}$, excluding firm $a$ and $b$. Since both $a$ and $b$ respond to it, the shock to $P_{-aL}$ and $P_{-bL}$ is different. We first consider each firm's response to an increase in $P_{-iL}^{1-\sigma}$. For ease of notation, we drop the firm's subscript and define $A = P_{-iL}^{1-\sigma}$. Denote the markup

with $\mu$ and without loss of generality, we set $c_L = 1$.

**Step 1: Derive an expression for $\frac{P_L^{1-\sigma}}{\mu}\frac{d\mu}{dA}$** Using the pricing rule, the markup $\mu$ of a less-differentiated firm with unit cost $c$ is implicitly defined as a function of $A$ as

$$\Psi(\mu, A) \quad \equiv \quad \frac{\sigma + (\eta - \sigma)\left(\frac{(\mu c)^{1-\sigma}}{(\mu c)^{1-\sigma}+A}\right)}{\sigma + (\eta - \sigma)\left(\frac{(\mu c)^{1-\sigma}}{(\mu c)^{1-\sigma}+A}\right) - 1} \quad - \quad \mu = 0$$

By the Implicit Function Theorem, $\frac{d\mu}{dA} = -\frac{\Psi_A}{\Psi_\mu}$ where $\Psi_x$ refers to derivative of $\Psi$ with respect to $x$, following standard notation. Taking derivatives,

$$\Psi_A = \frac{(\eta - \sigma)\left(\frac{(\mu c)^{1-\sigma}}{[(\mu c)^{1-\sigma}+A]^2}\right)}{\left[\sigma + (\eta - \sigma)\left(\frac{(\mu c)^{1-\sigma}}{(\mu c)^{1-\sigma}+A}\right) - 1\right]^2}$$

$$\Psi_\mu = -1 - \frac{\frac{(\sigma-\eta)(\sigma-1)}{\mu}\left(\frac{A(\mu c)^{1-\sigma}}{[(\mu c)^{1-\sigma}+A]^2}\right)}{\left[\sigma + (\eta - \sigma)\left(\frac{(\mu c)^{1-\sigma}}{(\mu c)^{1-\sigma}+A}\right) - 1\right]^2}$$

Since $\eta < \sigma$, $(\Psi_A, \Psi_\mu) \ll 0$ so that $\frac{d\mu}{dA} = -\frac{\Psi_A}{\Psi_\mu} < 0$, confirming that firms decrease markups in response to tighter competition.

$$\frac{d\mu}{dA} = \frac{(\eta - \sigma)\left(\frac{(\mu c)^{1-\sigma}}{[(\mu c)^{1-\sigma}+A]^2}\right)}{\left[\sigma + (\eta - \sigma)\left(\frac{(\mu c)^{1-\sigma}}{(\mu c)^{1-\sigma}+A}\right) - 1\right]^2 + \frac{(\sigma-\eta)(\sigma-1)}{\mu}\left(\frac{A(\mu c)^{1-\sigma}}{[(\mu c)^{1-\sigma}+A]^2}\right)}$$

Using the firm's market share $s = (\mu c)^{1-\sigma} / \left[(\mu c)^{1-\sigma} + A\right]$

$$-\frac{P_L^{1-\sigma}}{\mu}\frac{d\mu}{dA} = \frac{(\sigma - \eta)s}{\mu\left[(\sigma - 1) - (\sigma - \eta)s\right]^2 + (\sigma - \eta)(\sigma - 1)s(1 - s)} \tag{B.5}$$

**Step 2.** We now return to the original shock that decreases the price of the competitors of firms $a$ and $b$ in the less-differentiated nest. Note first that since firm $a$ and $b$ are in the same nest, price index $P_L$ is the same for both firms. Define $P_{-abL}$ as the component of the shock that is common to $a$ and $b$,

$$P_{-abL}^{1-\sigma} = \sum_{i \in \mathcal{L}, i \neq a,b} p_i^{1-\sigma}.$$

The price index of all firm $a$'s competitors is

$$P_{-aL}^{1-\sigma} = P_{-abL}^{1-\sigma} + (\mu_b c_b)^{1-\sigma} \tag{B.6}$$

Totally differentiating $\mu_a$ with respect to $P_{-abL}^{1-\sigma}$, we get:

$$\frac{d\mu_a}{dP_{-abL}^{1-\sigma}} = \frac{\partial \mu_a}{\partial P_{-abL}^{1-\sigma}} + (1-\sigma)\frac{p_b^{1-\sigma}}{\mu_b}\frac{\partial \mu_b}{\partial P_{-abL}^{1-\sigma}}\frac{\partial \mu_a}{\partial p_b^{1-\sigma}} \tag{B.7}$$

The equivalent expression for $b$ is

$$\frac{d\mu_b}{dP_{-abL}^{1-\sigma}} = \frac{\partial \mu_b}{\partial P_{-abL}^{1-\sigma}} + (1-\sigma)\frac{p_a^{1-\sigma}}{\mu_a}\frac{\partial \mu_a}{\partial P_{-abL}^{1-\sigma}}\frac{\partial \mu_b}{\partial p_a^{1-\sigma}} \tag{B.8}$$

Note that the partial derivatives $\frac{\partial \mu}{\partial P_{-abL}^{1-\sigma}}$ and $\frac{\partial \mu}{\partial p_i^{1-\sigma}}$ with respect to the price of any competitor $i$ is given by (B.5) because of the linearity of (B.6). Then, combining (B.7) and (B.8), we then have

$$\frac{P_L^{1-\sigma}}{\mu_a}\frac{d\mu_a}{dP_{-abL}^{1-\sigma}} - \frac{P_L^{1-\sigma}}{\mu_b}\frac{d\mu_b}{dP_{-abL}^{1-\sigma}} = \frac{P_L^{1-\sigma}}{\mu_a}\frac{\partial \mu_a}{\partial P_{-abL}^{1-\sigma}} - \frac{P_L^{1-\sigma}}{\mu_b}\frac{\partial \mu_b}{\partial P_{-abL}^{1-\sigma}} + (1-\sigma)(s_b - s_a)\frac{(P_L^{1-\sigma})^2}{\mu_b \mu_a}\frac{\partial \mu_b}{\partial P_{-abL}^{1-\sigma}}\frac{\partial \mu_a}{\partial P_{-abL}^{1-\sigma}}$$

Substituting (B.5),

$$\begin{aligned}
&\frac{P_L^{1-\sigma}}{\mu_a}\frac{d\mu_a}{dP_{-abL}^{1-\sigma}} - \frac{P_L^{1-\sigma}}{\mu_b}\frac{d\mu_b}{dP_{-abL}^{1-\sigma}} \\
=&\frac{(\eta-\sigma)s_a}{\mu_a\left[(\sigma-1)-(\sigma-\eta)s_a\right]^2 + (\sigma-\eta)(\sigma-1)s_a(1-s_a)} - \\
&\frac{(\eta-\sigma)s_b}{\mu_b\left[(\sigma-1)-(\sigma-\eta)s_b\right]^2 + (\sigma-\eta)(\sigma-1)s_b(1-s_b)} + \\
&\frac{(1-\sigma)(\sigma-\eta)^2 s_a s_b (s_a - s_b)}{\left\{\mu_a\left[(\sigma-1)-(\sigma-\eta)s_a\right]^2 + (\sigma-\eta)(\sigma-1)s_a(1-s_a)\right\}\left\{\mu_b\left[(\sigma-1)(\sigma-\eta)s_b\right]^2 + (\sigma-\eta)(\sigma-1)s_b(1-s_b)\right\}} \\
=&\frac{(\sigma-\eta)\left\{\mu_a\left[(\sigma-1)-(\sigma-\eta)s_a\right]^2 s_b - \mu_b\left[(\sigma-1)-(\sigma-\eta)s_b\right]^2 s_a\right\}}{\left\{\left[(\sigma-1)-(\sigma-\eta)s_a\right]^2 + (\sigma-\eta)(\sigma-1)s_a(1-s_a)\right\}\left\{\left[(\sigma-1)(\sigma-\eta)s_b\right]^2 + (\sigma-\eta)(\sigma-1)s_b(1-s_b)\right\}}
\end{aligned}$$

Since the denominator is positive, we must prove that the numerator is negative so that in absolute value, $\left|\frac{1}{\mu_a}\frac{d\mu_a}{dP_{-abL}^{1-\sigma}}\right| > \left|\frac{1}{\mu_b}\frac{d\mu_b}{dP_{-abL}^{1-\sigma}}\right|$. That is, the following function must be increasing in $s$:

$$\frac{(\sigma-\eta)s}{\mu[(\sigma-1)-(\sigma-\eta)s]^2} = \frac{\sigma-\epsilon}{\epsilon(\epsilon-1)}$$

We have rewritten the expression as a function of the elasticity of demand that the firm faces $\epsilon$ which is strictly decreasing in $s$. Clearly, the function is decreasing in $\epsilon > 1$ since the numerator is

decreasing and the denominator is increasing. ■

# C Miss-allocation of Labor

*Consider any set of discrete choices with the corresponding profit-maximizing prices and market-clearing quantities. Suppose a planner can reallocate labor but not change discrete choices. For any two less-differentiated firms, the planner allocates relatively more labor to the more productive firm compared to the market. The planner also allocates more labor to differentiated varieties relative to less-differentiated varieties.*

*Proof.* The planner cannot change sets $\mathcal{L}$ and $\mathcal{D}$, but he can reallocate labor to maximize welfare. His problem is to choose quantities $q_i$ for Home varieties to maximize

$$\begin{aligned} \max Q &= \left[ (Q_L)^{\frac{\eta-1}{\eta}} + \sum_{i\in\mathcal{D}} q_i^{\frac{\eta-1}{\eta}} + (Q_D^*)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\ \text{subject to} \quad Q_L &= \left( \sum_{i\in\mathcal{L}_H} q_i^{\frac{\sigma-1}{\sigma}} + (Q_L^*)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \\ L &= \sum_{i\in\mathcal{L}_H} (c_{iL} q_i) + \sum_{i\in\mathcal{D}_H} (c_{iD} q_i) \,. \end{aligned} \tag{C.1}$$

where $Q_D^*$ and $Q_L^*$ are the aggregate quantities consumed of Foreign goods, which the planner takes as given. The first order conditions with respect to quantity $q_L$ for a less-differentiated firm and quantity $q_D$ for a differentiated firm, where

$$\begin{aligned} q_L &= \lambda^{-\sigma} (c_{iL})^{-\sigma} Q^{\sigma/\eta} (Q_L)^{(\eta-\sigma)/\eta} \\ q_D &= \lambda^{-\eta} (c_{iD})^{-\eta} Q \end{aligned}$$

$\lambda$ is the Lagrange multiplier for constraint (C.1). Define the aggregate quantities of Home less-differentiated and differentiated goods are respectively,

$$\begin{aligned} Q_{LH} &= \left( \sum_{i\in\mathcal{L}_H} q_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \\ Q_{DH} &= \left( \sum_{i\in\mathcal{D}_H} q_i^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \end{aligned}$$

Substituting the first order conditions,

$$\begin{aligned}
\frac{Q_{LH}}{Q_L} &= \lambda^{-\sigma}\left(\frac{Q_L}{Q}\right)^{-\sigma/\eta} C_{LH}^{-\sigma} \\
\frac{Q_{DH}}{Q} &= \lambda^{-\eta} C_{DH}^{-\eta} \qquad \text{(C.2)} \\
\text{where} \quad C_{LH} &= \left(\sum_{i\in\mathcal{L}\cap\mathcal{H}} (c_{iL})^{1-\sigma}\right)^{1/(1-\sigma)} \\
C_{DH} &= \mu_D \left(\sum_{i\in\mathcal{D}} (c_{iD})^{1-\eta}\right)^{1/(1-\eta)}
\end{aligned}$$

Note that $C_{LH}$ and $C_{LH}$ are not nominal costs, but labor requirements for production of aggregate quantities since there are no prices in the planner's problem. Rearranging the first equation,

$$\frac{Q_L}{Q}\left(\frac{Q_{LH}}{Q_L}\right)^{\eta/\sigma} = \lambda^{-\eta} C_{LH}^{-\eta}$$

Dividing it by (C.2),

$$\frac{Q_L^W}{Q_D^W}\left(\frac{Q_{LH}^W}{Q_L^W}\right)^{\eta/\sigma} = \left(\frac{C_{LH}}{C_{DH}}\right)^{-\eta} \qquad \text{(C.3)}$$

where the superscript $W$ indicates the planner's solution. Following the same steps, the equivalent expression for the market (superscript $M$) is

$$\begin{aligned}
\frac{Q_L^M}{Q_D^M}\left(\frac{Q_{LH}^M}{Q_L^M}\right)^{\eta/\sigma} &= \left(\frac{P_{LH}}{P_{DH}}\right)^{-\eta} \\
\text{where} \quad P_{LH} &= w\left(\sum_{i\in\mathcal{L}\cap\mathcal{H}} (c_{iL})^{1-\sigma}\right)^{1/(1-\sigma)} \\
P_{DH} &= w\mu_D \left(\sum_{i\in\mathcal{L}\cap\mathcal{H}} (c_{iD})^{1-\sigma}\right)^{1/(1-\sigma)}
\end{aligned}$$

Dividing these market quantities by the planner's (C.3), we have

$$\frac{Q_L^M/Q_D^M(Q_{LH}^M/Q_L^M)^{\eta/\sigma}}{Q_L^W/Q_D^W(Q_{LH}^W/Q_L^W)^{\eta/\sigma}} = \left(\frac{P_{LH}/P_{DH}}{C_{LH}/C_{DH}}\right)^{-\eta} > 1$$

where the inequality holds because markups are smaller for the less-differentiated nest, $\mu_{Li} < \mu_D$ for all $i \in \mathcal{L}_H$ since these less-differentiated firms have at least one (Foreign) competitor within $\mathcal{L}$. The consumption of Foreign goods $Q_L^*$ and $Q_D^*$ and the total quantity of labor are the same for the market and the planner by construction of the problem. So, the only way for the right-hand side to be greater than 1 is for $Q_L^M/Q_D^M > Q_L^W/Q_D^W$ and $Q_{LH}^M/Q_L^M > Q_{LH}^W/Q_L^W$. That is, for the

market to allocate more labor to the production of less-differentiated goods than to the production of differentiated goods. ■

# D Robustness of the Theory

Appendix D.1 introduces free entry and discusses multiplicity of equilibria. Appendix D.2 revisits the results in a model with two symmetric countries, instead of the small open economy in the main text.

## D.1 Free Entry

We add a free-entry condition to the general equilibrium model. A large mass of entrepreneurs may pay a fixed cost of $f_E$ units of labor to enter the market. Upon entry, a firm is assigned its own variety, a sector, and a productivity. This condition adds an equilibrium mass of firms $M$ and a corresponding condition that expected profits must equal $wf_E$:

$$Mf_E = \int_0^1 \left[ \sum_{i \in S_H} \mathbf{1}\{c_{iL} \leq c^*(w)\} \pi^*(c_{iL}) + \sum_{i \in \mathcal{D}_H} \pi_D(c_{iD}) + \sum_{i \in \mathcal{L}_S} \pi_L(c_{iL}, \hat{\mathbf{c}}_{-iL}) \right] dS \tag{D.1}$$

Since entry is not directed toward specific sectors, then shocks to a single sector does not affect entry. The results on shocks to a zero-measure firms hold for any fixed set of firms, in particular, the one where the free entry condition is met.

The analysis of a shock to a non-zero mass of firms requires a small modification. A sufficiently large decrease in foreign costs decreases the mass of firms. The shock drives to zero the profit of selling in the domestic market, and so the only remaining term in equation (D.1) would be $\pi^*$ and the mass of domestic firms together with other equilibrium variables would be determined by domestic productivity relative to foreign demand function. The rest of the proof remains unchanged.

There are a few practical difficulties with free entry. First is in the interpretation of existing firms' responses to decreases in foreign prices. Free entry must not completely reshuffle firms assigning new productivity parameters and eliminating the concept of an existing firm. One way around this issue is to introduce dynamics and allow firms to choose to exit and subject them to random exit shocks. Then in any period and given any shock, expected profits must be less than or equal to $wf_E$, with equality if entry is positive. Second is that for any measure of entrants, the productivity distributions must be defined so that the assumptions on continuity across sectors in the general equilibrium model hold.

## D.2 Two Symmetric Countries

**Set up** There are two symmetric countries, each with an inelastic supply of labor, with measure one. Labor is the only input in production. It can move freely across firms within countries, but not across countries. The set of sectors is $[0, 1]$. Each country and sector has a finite and exogenous set

of firms. The two countries are symmetric in the sense that the vectors of Home and Foreign labor requirements in sectors [0,0.5) is the same as the vectors of labor requirements in (0.5,1], except that Foreign is switched with Home. We describe the economy from Home's perspective.

For simplicity, we maintain the assumption that firms can only export their less-differentiated varieties.[2] Denote firm $i$'s per unit labor requirement with $\tilde{c}_{iL}$ if we the firm is less-differentiated and $\tilde{c}_{iD}$ if it is differentiated. Normalizing wages in both countries to one, the per unit cost of a variety in Home is $c_{iL} = \tilde{c}_{iL}$ and $c_{iD} = \tilde{c}_{iD}$. The unit cost of delivering of delivering each unit of their variety in Foreign is $c_{iL} = \tau\tilde{c}_{iL}$ where $\tau > 1$ is an iceberg cost. We maintain the same assumptions that the number of firms is bounded and that the vector of labor requirements is bounded from below, and it is continuous in all but a finite set of sectors where the number of firms in Home or Foreign changes.

**Sectoral Game** The game in each sector and market (Home and Foreign) has the following timing. (1) In ascending order of unit cost $c_{iL}$ all firms make their discrete choices. Foreign firms decide whether to sell in Home or not. If they export, they pay a fixed cost $f^*$ units of labor. Home firms decide on whether to (i) exit, (ii) produce a less-differentiated variety, or (iii) produce a differentiated variety. (3) All firms, Home and Foreign, simultaneously set prices.

We consider the subgame perfect equilibrium within a sector-market. The equilibrium is also symmetric in that both countries have wage set to one and the same income and price-index pair $(y, \overline{P})$. We write the general equilibrium conditions when all firms in all sectors play the subgame perfect equilibrium. The pricing rule is the same as in the main text. The price $p_L$, elasticity of demand $\epsilon_L$, market share $s_L$, sales $x$, and profit $\pi_L$ of a firm $i$, domestic or foreign, with unit cost $c_{iL}$ selling in the less differentiated nest $\mathcal{L}_S$ in Home are

$$
\begin{aligned}
p_L(c_{iL}, \mathbf{c}_{-iL}) &= \frac{\epsilon_L(c_{iL}, \mathbf{c}_{-iL})c_{iL}}{(\epsilon_L(c_{iL}, \mathbf{c}_{-iL}) - 1)} \\
\epsilon_L(c_{iL}, \mathbf{c}_{-iL}) &= \sigma s_L(c_{iL}, \mathbf{c}_{-iL}) + \eta(1 - s_L(c_{iL}, \mathbf{c}_{-iL})) \\
s_L(c_{iL}, \mathbf{c}_{-iL}) &= \left(\frac{p_L(c_{iL}, \mathbf{c}_{-iL})}{P_{LS}}\right)^{1-\sigma} \\
x_L(c_{iL}, \mathbf{c}_{-iL}) &= \overline{P}^{\eta-1} P_{LS}^{\sigma-\eta} [p_L(c_{iL}, \mathbf{c}_{-iL})]^{1-\sigma} y \\
\pi_L(c_{iL}, \mathbf{c}_{-iL}) &= \frac{x_L(c_{iL}, \mathbf{c}_{-iL})}{\epsilon_L(c_{iL}, \mathbf{c}_{-iL})}
\end{aligned}
$$

where $P_{LS}$ is the equilibrium price index of nest $\mathcal{L}_S$, the less-differentiated nest of sector $S$, and $\mathbf{c}_{-iL}$ is the vector of unit costs of firm $i$'s competitors in nest $\mathcal{L}$ in the subgame in which firm $i$ does not differentiate and all other firms play their subgame perfect equilibrium strategies. A Foreign firm in sector $S$ exports if $\pi_L(\mathbf{c}_{-iL}, \tau c_{iL}) - f^* \geq 0$. Let the set of firms satisfying this condition in

[2] As in the small open-economy model, nothing changes if foreign firms sell also in nests $\mathcal{D}^*$ in which Home firms cannot sell.

sector $S$ be $\mathcal{L}^*_{FS}$. Foreign total exports to Home are

$$\int_0^1 \sum_{i \in \mathcal{L}^*_{FS}} x_L(c_{iL}, \mathbf{c}_{-iL}) dS$$

The discontinuities in set $\mathcal{L}^*_{FS}$ have zero measure since profits are continuous for any set of discrete choices. Then, the integral exists because labor requirements are continuous almost everywhere and bounded away from zero in $S$.

The set of less differentiated firms in sector $S$ is $\mathcal{L}_S = (\mathcal{L}_{HS} \cup \mathcal{L}^*_{FS})$ where the set of foreign firms exporting $\mathcal{L}^*_{FS}$ is now endogenous. the set of differentiated firms $\mathcal{D}_S$ contains only Home firms by assumption. The set of all nests in the definition of the price index is $\mathcal{N} = \{\mathcal{L}_{SH} \cup \mathcal{D}_S\}_{S \in [0,1]}$ and the price index is

$$\overline{P} = \left\{ \int_0^1 \left[ [P_L(\mathbf{c}_{LS})]^{1-\eta} + \sum_{i \in \mathcal{D}_S} \left( \frac{\eta c_{iD}}{\eta - 1} \right)^{1-\eta} \right] dS \right\}^{1/(1-\eta)} \tag{D.2}$$

The representative household gets income from labor and profits:

$$y = w + \int_0^1 \left[ \sum_{i \in \mathcal{L}^*_{FS}} \pi_L(\tau \tilde{c}_{iL}, \mathbf{c}_{-iL}) + \sum_{i \in \mathcal{D}_S} \pi_D(\tilde{c}_{iD}) + \sum_{i \in \mathcal{L}_{HS}} \pi_L(\tilde{c}_{iL}, \mathbf{c}_{-iL}) \right] dS \tag{D.3}$$

The first term, summing over set $\mathcal{L}^*_{FS}$, enters Home household income because, by symmetry, the sum of all profits of Foreign firms selling in Home is the same as the profits of Home firms selling in Foreign. A general equilibrium is a set of strategies and a vector $(y, \overline{P})$ such that the strategies are subgame perfect equilibrium strategies in all sectors and equations (D.2) and (D.3) hold.

**Welfare.** The welfare results remain unchanged since they pertain to the allocation of labor to variable costs and fixed costs (discrete choices) in the domestic market only.

**Trade barriers and product differentiation.** As in the small open economy, a sufficiently large decrease in foreign prices generally (i) decreases the relative price of less-differentiated varieties, (ii) decreases the overall price index $\overline{P}$. Both of these effects increase differentiation whenever $f_D \leq f_L$. The only issue is that here, foreign prices are endogenous and we cannot directly shock them. A decrease in $f^*$ and $\tau$ may not be sufficient to tighten competition in the less-differentiated nets in all sectors due to strategic interactions between firms. In our empirical application, import penetration in China increased substantially, from 14% of GDP in 1998 to 28% in 2006. It is likely to have tightened competition in tradable market segments.