Escaping Import Competition in China

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Abstract

We propose and provide evidence for a new source of gain from trade: 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. It increases with import competition, and it is always smaller than its social welfare gain. We use establishment data from China spanning its WTO accession in 2001. Tariff cuts are associated with the introduction of new goods and with switches to skill-intensive sectors within firms, in line with the prediction that import competition increases product innovation. Variable markups explain why tariff cuts increase the revenue productivity of small firms and decrease that of large firms in the data.

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 the introduction of new goods, and switches to more skill-intensive sectors. They are associated with increases in within-firm revenue productivity for small firms and decreases for large 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. A similar heterogeneous effect of competition on productivity appears 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. Markup responses, in turn, may explain changes in revenue productivity, a measure of the ratio of revenue to cost. 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, each firm chooses whether (1) to exit, (2) to produce a variety in a nest

[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). Our model violates the assumptions used to split revenue productivity into prices and efficiency. See Section **??** for a discussion.

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 in the model is consistent with the link between tariff cuts and the introduction of new products and switches to skill intensive sectors. The heterogeneous effects on markup rationalize the empirical finding that the productivity changes associated with tariff cuts decrease systematically with firm size, while the introduction of new products and switches to skill-intensive sectors is similar across firms of all sizes. 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]

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

We find conditions for a large reduction in foreign costs that affects a large share of 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.[6] 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 differentiated varieties. Our welfare analysis complements Spence (1976a), Spence (1976b), Dixit and Stiglitz (1977) and Dhingra and Morrow (2018).

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.

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.

[6] 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.

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 firms (SOEs), regardless of size, and all non-state-owned firms (non-SOEs) with annual sales of more than 5 million yuan. We use a ten-year unbalanced panel 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 state owned firms. 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.

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 $j(i,t)$ is the sector of firm i at time t, α_i are firm fixed effects, and α_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.[7] 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.[8]

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.

We estimate, separately for each 2-digit sector, the gross-output production function

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

where X is output, L is number of employees, K is capital, M is material inputs, and α_{0j}, α_{Lj}, α_{Kj} and α_{Mj} are sector-specific parameters to be estimated. Output and cost variables are deflated with the sector-specific price indices.[9] Our estimated $\log TFP_{it}$ is

[7] We follow Javorcik (2004) to construct foreign ownership variables, and Amiti and Konings (2007) and Brandt et al. (2017) to construct tariff measures.

[8] 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.

[9] 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 for the 71 sector aggregates. Capital is defined as the net value of fixed assets, which is deflated by a uniform fixed assets investment index, and labor is a physical measure of the total number of employees. Intermediate inputs used for production

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.[10]

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.[11] 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 (β) on tariffs in regression (1). The coefficient is negative in all specifications. It is statistically significant in all IV specifications, and it doesn't change much when we restrict the sample to non-exporting establishments.[12] 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 on tariffs varies very

are deflated by the intermediate-input price index.

[10]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.

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

[12]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 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.

little when we measure TFP following Olley-Pakes or with OLS and time fixed effects. 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×-0.0157), and with an increase of 2 percentage points in the probability of introducing a new product (0.5×-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.

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-year.

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	-0.108***	-0.112***	-0.0975***	-0.0966***	-0.115***	-0.114***
	(0.00279)	(0.00291)	(0.0162)	(0.0174)	(0.0147)	(0.0154)
tariff*q2	-0.0607***	-0.0639***	-0.0408**	-0.0377**	-0.0554***	-0.0515***
	(0.00266)	(0.00278)	(0.0161)	(0.0173)	(0.0146)	(0.0153)
tariff*q3	-0.0159***	-0.0173***	0.0187	0.0245	0.00770	0.0146
	(0.00259)	(0.00271)	(0.0160)	(0.0172)	(0.0145)	(0.0152)
tariff*q4 (largest)	0.0385***	0.0398***	0.0950***	0.105***	0.0871***	0.0982***
	(0.00261)	(0.00273)	(0.0161)	(0.0173)	(0.0145)	(0.0153)
Observations (panels A, B, C)	1,037,738	1,037,738	1,037,738	1,037,738	826,072	826,072

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	-0.000914	-0.00566**	-0.0160**	-0.0438***	-0.0103**	-0.0300***
	(0.00119)	(0.00287)	(0.00679)	(0.0167)	(0.00447)	(0.0102)
tariff*q2	-0.000700	-0.00262	-0.0156**	-0.0396**	-0.00966**	-0.0276***
	(0.00121)	(0.00290)	(0.00677)	(0.0167)	(0.00445)	(0.0101)
tariff*q3	-0.000557	-0.000705	-0.0153**	-0.0369**	-0.00940**	-0.0261***
	(0.00122)	(0.00292)	(0.00675)	(0.0167)	(0.00442)	(0.0101)
tariff*q4 (largest)	0.000522	0.00446	-0.0138**	-0.0301*	-0.00895**	-0.0227**
	(0.00123)	(0.00298)	(0.00672)	(0.0167)	(0.00445)	(0.0101)

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	-7.631***	-12.40***	-8.445***	-10.50***
	(0.854)	(2.532)	(0.778)	(1.970)
tariff*q2	-7.582***	-12.33***	-8.375***	-10.41***
	(0.856)	(2.526)	(0.781)	(1.966)
tariff*q3	-7.650***	-12.29***	-8.435***	-10.39***
	(0.864)	(2.531)	(0.788)	(1.968)
tariff*q4 (largest)	-7.561***	-12.04***	-8.340***	-10.18***
	(0.864)	(2.531)	(0.788)	(1.967)

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-year (q1, q2, q3, q4). 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.

Table 2 reports the coefficients on these 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 increases systematically with quartile of sales, and the differences are statistically significant. Tariff cuts are associated with *increases* in TFP for small firms and *decreases* for large firms.

Discussion 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).[13] In recent models of multiproduct firms such as Bernard et al. (2011) and Mayer et al. (2014), 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.[14] Our empirical results, however, exploit variations in tariffs imposed by China

[13] Appendix A.4 analyzes the relation between revenue and TFP. In Table A.21, TFP and revenue are correlated, even after controlling for time and sector fixed effects. In Table A.22, tariff cuts are associated with decreases in sales. These patterns are consistent with the models above and with previous findings.

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.

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

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 has a single differentiated 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 in sector S. Worker-households inelastically supply their labor endowments in a perfect labor market. Labor is the unique input into production. 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 η, irrespective of whether nests are in the same sector or not for simplicity. The elasticity of substitution between varieties within a nest is σ. 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} to produce. 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 its 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 where 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).[15]

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

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

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

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

The endogenous elasticity of demand ϵ is a weighted average between the elasticity within nest σ and the elasticity across nests η, where the weight s is the firm's market share in revenue. Otherwise, Function (7) implicitly defines prices as a function of costs of all firms in the same nest.

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

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

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 $\mathcal{L}_S = \emptyset = \mathbf{c}$, and define $\epsilon_L(c_i, \mathbf{c}_{-1})$ as the elasticity of demand of a firm

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

with unit cost c_i when the vector of unit costs of the other firms in the same nest is $\mathbf{c}_{-i}$. When firm i does not differentiate and the vector of other firms' unit costs in $\mathcal{L}_S$ is $\mathbf{c}_{-iLS}$, its operating profit is

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

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 set of firms in sector S that differentiate their varieties in the equilibrium path. 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 consumer gets income from wages and profits:

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

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 individual firms' discrete choices. Hence, the integrals exist when all sectors are in SPE.

An equilibrium is a set of strategies, one for each firm, a price $\overline{P}$, and income y such that: Firm strategies are SPE strategies in all sectors $S \in [0, 1]$, and equations (10) and (11) hold.

3.2 Results in the Closed Economy

Exit 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.)[16]

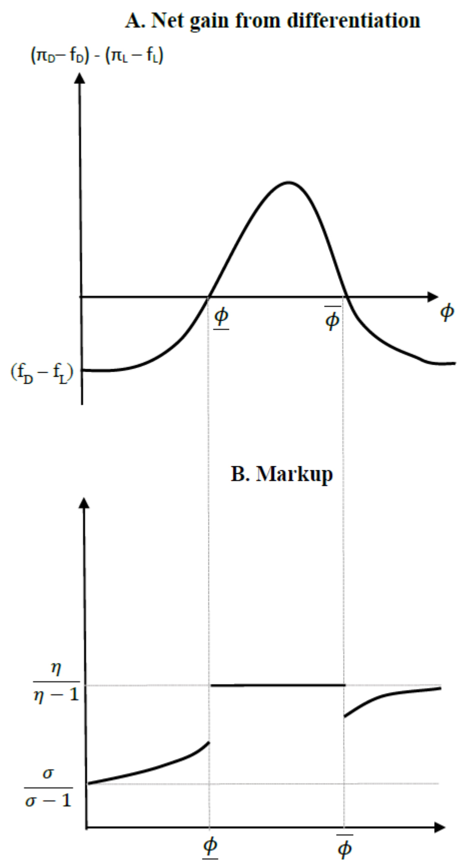
Productivity and a firm's decision to differentiate The effect of changes in unit costs on a firm's decision to differentiate its product is straightforward: An efficient firm disproportionately gains if $c_{iD} < c_{iL}$, and loses from differentiation if $c_{iD} > c_{iL}$.[17] So to isolate the novel mechanism, assume $c_{iD} = c_{iL} \equiv c_i$ 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

[16] Although this exit pattern seems standard, the result depends on more productive firms making their discrete choices first. Otherwise, the entry of a less-productive firm could drive down the price index in $\mathcal{L}_S$ sufficiently to prevent the entry of a more productive firm.

[17] 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 $c_{iL} \gtreqless c_{iD}$ in Appendix B.

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



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

The limit $c_i \to 0$ is more didactic. Let $p_{iD} = \eta c_i/(\eta - 1)$ be the price under differentiation, and P_{-iLS} be the CES price index in nest $\mathcal{L}_S$ excluding firm i from the sum, where we omit its argument $(c_i, \mathbf{c}_{-iL})$.[18] Then

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

The second line is the operating profit of a hypothetical, differentiated firm that charges $\left[P_{-iLS}^{1-\sigma} + p_{iD}^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \leq p_{iD}$ 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 $P_{-iLS} < \infty$. Rearranging and taking limits,

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

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.[19]

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[18]

$$P_{-iLS} = \left(\sum_{i' \in \mathcal{L}, i' \neq i} p_{i'}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$$

where prices $p_{i'}$ are implicitly defined in (7) when the productivity vector in $\mathcal{L}_S$ is $(c_i, \mathbf{c}_{-iL})$.

[19] 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

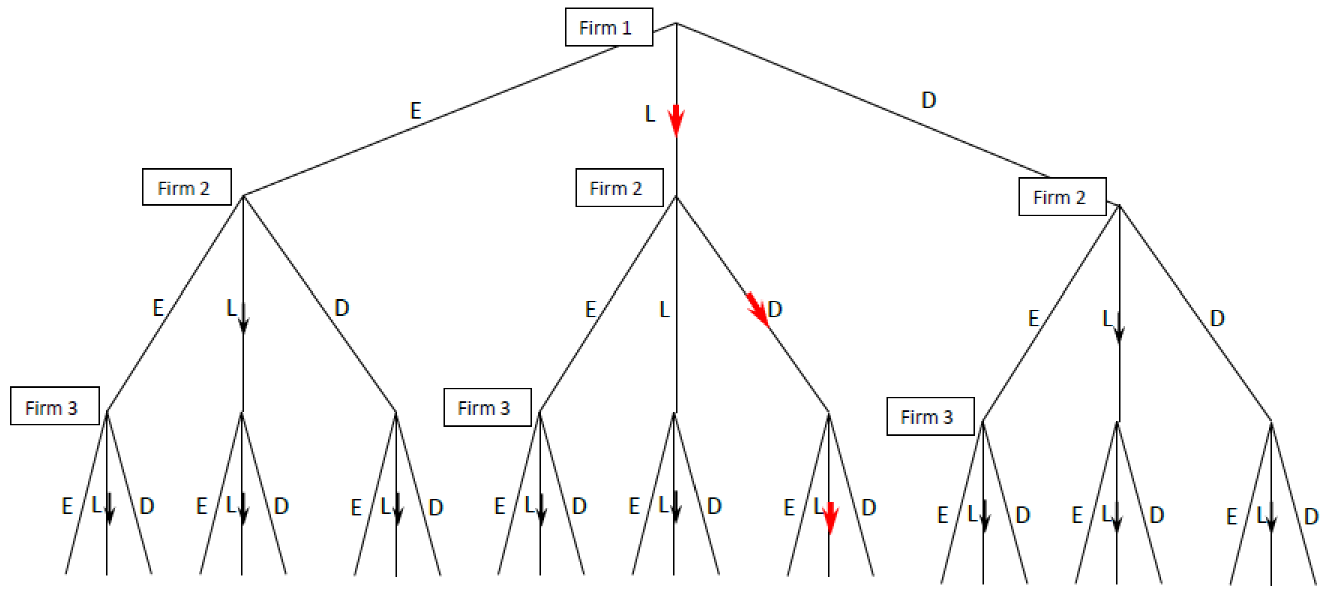
Small Shocks to Competition in Sector S. Sector S is in SPE. The unit cost c_{iL} decreases for some firm $i \in S$. All firms adjust their strategies to a new SPE. We show that the effect of this shock on the discrete choices of other firms $i' \in S$ is ambiguous. In (9), the operating profit under less differentiation $\pi_L(c_{i'L}, \mathbf{c}_{-i'LS})$ is decreasing in any element of $\mathbf{c}_{-i'LS}$, 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).

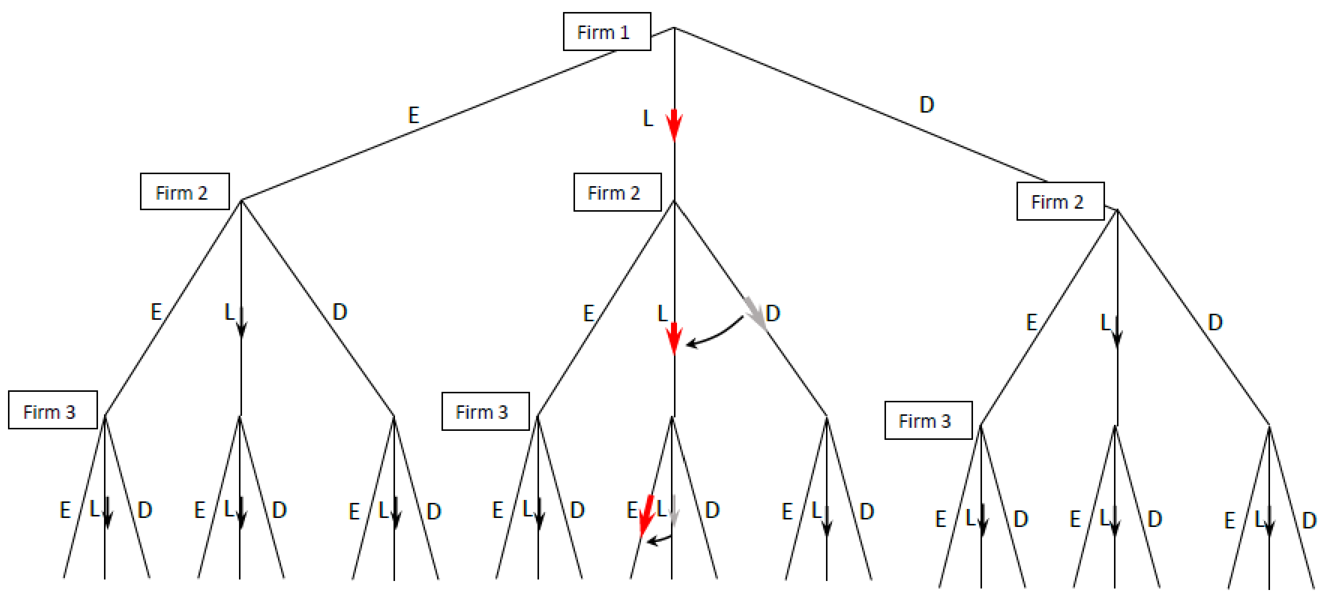
Figure 2(b) illustrates the effects of this SPE of a decrease in firm 1's cost from $c_1 = 1$ to $c_1 = 0.9$. Now, $\pi_L(c_3, \{c_1, c_2\}) = 0.041 < f_L$. Then, firm 3 exits in the subgame following actions (L, L) by firms 1 and 2. The gross gain from product differentiation for firm 2 becomes $\pi_D(c_2)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

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.



(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 L, E, 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. We picked fixed costs so that firm 2 is close to indifference between the payoff under actions (L,L,L) and (L,D,L), and firm 3 is close to exiting if firms 1 and 2 play (L,L). 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 decrease in c_1 on the SPE strategies

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

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

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 profit in (6) depends on $\mathbf{c}_{-iL}$ only through $P_{-\bullet LS}(c_{iL}, \mathbf{c}_{-iL})$. In the example above, $P_{-\bullet LS}(c_{2L}, \mathbf{c}_{-2L})$ 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 $P_{-\bullet LS}(c_{i'L}, \mathbf{c}_{-i'LS})$ 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 $P_{-\bullet LS}(c_{i'L}, \mathbf{c}_{-i'LS}) < \eta c_{iL}/(\eta - 1)$ for all $i' \neq i$, when firm i chooses less-differentiation in all subgames (which occurs if c_{iL} is small enough). Then if the shock is sufficiently large, all other firms in sector S, if they switch actions, they switch from less-differentiation to differentiation or exit.

Among surviving firms in sector S, 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 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 $P_{-\bullet LS}(c_{iL}, c_{-iL})$ 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 in $[1/\sigma, 1/\eta]$, and the effect of the shock in decreasing $\overline{P}$ may be made arbitrarily large. 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 $P_{-\bullet LS}(c_{iL}, c_{-iL}) > \underline{p}$ 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.[20]

The shock only affects firms in a sector $S \notin \mathcal{S}$, through its decrease in $\overline{P}^{\eta-1}y$. If the decrease is small, then it has an ambiguous effect on firms' discrete choices due to strategic interactions between firms, as in the example of Figure 2. But if $\overline{P}^{\eta-1}y$ declines sufficiently, then it increases exit. Among surviving firms, it decreases differentiation if $f_D > f_L$ and increases differentiation if $f_D < f_L$ (and $c_{iD} > c_{iL}$). As in standard models, tighter competition decreases firm sales and incentives to incur costly investments.

For firms in a sector $S \in \mathcal{S}$, but not in $\mathcal{I}$, the general equilibrium effect is combined with the decrease in $P_{-\bullet LS}(c_{iL}, \mathbf{c}_{-iL})$. The ratio $\pi_D(c_{iD})/\pi_L(c_{iL}, c_{-iL})$ is not affected by $\overline{P}^{\eta-1}y$ except through $\mathbf{c}_{-iL}$. Then, from the analysis of the large shock to a single sector above, a sufficiently large shock increases exit, and it increases differentiation among surviving firms if $f_D \leq f_L$.

In sum, we have derived conditions for a shock to competition in the less-differentiated

[20] It is possible that a large shock drives all firms out of the market in some sectors, including firms directly hit with the shock due to $\overline{P}^{\eta-1}y$. This possibility does not affect any of the claims below.

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. Home is a small country that trades with large Foreign. There is an exogenous set of sectors $[0, 1]$ that are split into nests according to the outcome of the game below. Worker-households inelastically sell their one-unit of labor in a perfect labor market. Labor is the only input into production, and Home wages are set to one. Consumer demand in (3) and the technologies of Home firms are as in Section 3. Relative to the closed economy, the only two differences are the existence of a finite set of Foreign firms in each sector, and that Home firms may export.

Foreign technologies Each Foreign firm i chooses among *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 Home, it gets zero profits. Otherwise, it pays a fixed cost $w^* f_L^*$ and a per-unit cost $c_{iL} = w^* c_{iL}^*$ to deliver each unit of its variety in Home, where w^* is the equilibrium real exchange rate (wages in foreign relative to Home). 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 firm in sector S. Assume costs $(c_{i^*(1,S)L}, ..., c_{i^*(m_S^*,S)L})$ 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 where m_S^* may change.

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 whether to exit or sell a less-differentiated variety. Once all discrete choices are made, firms simultaneously set prices.

The solution to the subgame perfect equilibrium (SPE) in this open economy game is similar to the closed economy. 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, $g_i = \mathit{exit}, \mathit{less\ differentiation}, \mathit{differentiation}$, and for Foreign firms, $g_i = \mathit{exit}, \mathit{less\ differentiation}$. 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

$$X^*(c_{iL}, w^*) = (c_{iL}/w^*)^{1-\sigma} w^* Y^*, \qquad (13)$$
$$\pi^*(c_{iL}, w^*) = \frac{X^*(c_{iL}, w^*)}{\sigma} - f^*$$

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 vector of less-differentiated unit costs $\mathbf{c}_L$ includes Home and Foreign firms. Let $\mathcal{L}_{HS}$ be the set of less-differentiated Home firms in sector S and $\mathcal{L}_{FS}$ be the set of Foreign firms produce in sector S, $\mathcal{L}_{HS} \cup \mathcal{L}_{FS} = \mathcal{L}_S$. Let also S_H be the set of Home firms in sector S.

The representative household gets income from labor and profits:

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

Trade is balanced if

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

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, and a vector of real exchange rates, price index, and income $(w^*, \overline{P}, y)$. The strategies are SPE in all sectors and equations (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 $\bar{c}_{FS}$ such that Foreign firms in sector S enter only if $c_{iL} < \bar{c}_{FS}$. For Home firms, the exit threshold $\bar{c}_{HS}$ exists when firms can be ranked in their costs, i.e., $c_{iD} < c_{i'D}$ if and only if $c_{iL} < c_{i'L}$ for all i in sector S. (Proof is in Appendix B.)

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 sufficiently large to decrease $P_{-\bullet LS}(c_{iL}, \mathbf{c}_{-iL})$ decreases for all $i \in S_H$, then Home firms in sector S increase exit and differentiation. Among surviving firms, the markups decrease 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 $\mathcal{S} \subset [0,1]$, decreases $\overline{P}^{\eta-1}y$ and increases the exit of Home firms. For Home firms not in sectors $S \notin \mathcal{S}$, differentiation decreases if differentiation involves a costly investment $f_D > f_0$, and it increases if $f_D < f_0$. Among surviving Home firms in sectors $S \in \mathcal{S}$, differentiation increases if $f_D \leq f_0$.

4.3 Empirical Results through the Lenses of the Model

As in the examples of Xiaomi cell phones and Chery Automobiles in the introduction, domestic firms differentiate their products from foreign competition by 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.[21] The key assumption is that an increase in import competition disproportionately decreases the profits from producing more standardized, tradable varieties for domestic firms.

Since strategies to escape import competition are not directly observed, we take the

[21] 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 $\mathcal{L}_S$.

introduction of new goods and shifts to skill-intensive four-digit sectors as proxies for product differentiation in the model. 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. Given the magnitude of tariff cuts during China's accession to the WTO, it is plausible to assume that these cuts were large enough to tighten competition for domestic firms in the most affected sectors.

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 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, precisely the pattern in Panel A of Table 2.

Revenue productivity is the standard measure of firm performance in the literature, and its interpretation above is valid is valid as long as revenue TFP is correlated with the true unobserved revenue to cost ratio in the data. But revenue productivity is inadequate to evaluate firms in the current model for two reasons. First, the model violates the assumptions underlying the estimates of TFP. A Markov path for

productivity, Hicks neutrality, and product homogeneity 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.[22] The usual decomposition of revenue TFP into quantity TFP and prices is not applicable because varieties in the model are differentiated and costs c_{iL} and c_{iD} are quality-adjusted like in Melitz (2003).[23]

Second, even if revenue productivity were perfectly measured the ratio of revenue to cost in the data, it would still be a poor proxy for product differentiation. It confounds the positive effect of differentiation on markups with the negative effect of greater competition on firms that do not differentiated. These opposing effects may explain the mixed findings linking tariff cuts to firm productivity in the empirical literature.[24]

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 widespread decreases in foreign costs 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 generally increased product differentiation in China, not just in some sectors relative to others. Next, we investigate the welfare effects of such differentiation.

[22]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.

[23]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.

[24]See references in footnote 1.

5 Differentiation and Welfare

It is well-known in the literature 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 any set of discrete choices with the corresponding profit-maximizing prices and market-clearing quantities. A planner can reallocate labor used for domestic production but cannot change discrete choices or the quantities imported and exported. Appendix C proves that, compared to the market, the planner allocates relatively more labor to differentiated than to less-differentiated varieties. And within a less-differentiated nest, the planner allocates more labor to more productive varieties.[25]

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 μ_{iL} if $i \in \mathcal{L}_S$ and with $\mu_D = \eta/(\eta - 1)$ if $i \in \mathcal{D}_S$. Markup μ_{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.

5.1 Marginal Welfare Effects of Discrete Choices

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

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

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

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

aggregate quantity, $Q = y/\overline{P}$, and K is labor allocated for production[26]

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

where $\big|\cdot\big|$ denotes the number of elements in a set. 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:

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

where $\overline{P}^{-1}$ is the marginal utility of income, $\mu_D c_{iDS}$ 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 equation (3), the integral equals $\mu_D \pi_D(c_{iDS})$, and (16) becomes

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

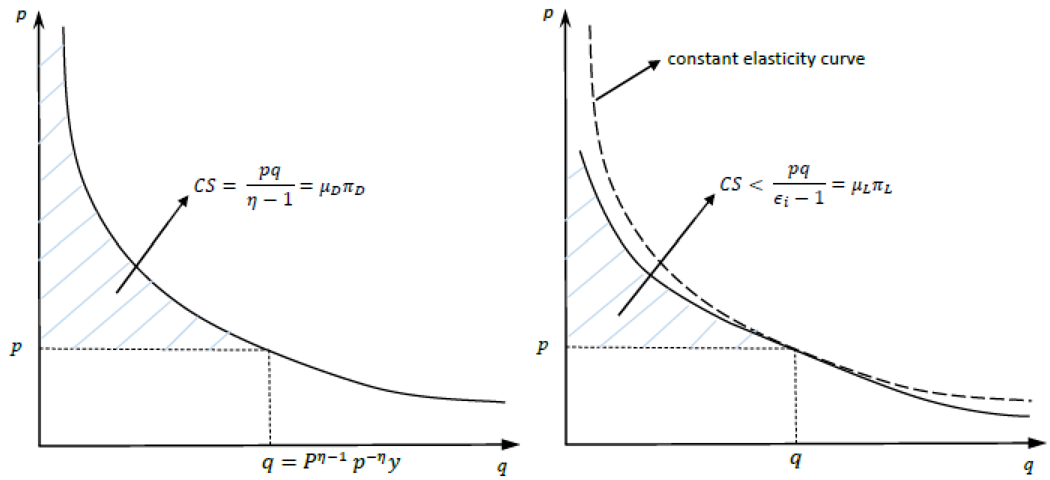
because $\mu_D \geq \overline{\mu}$. Figure 3(a) illustrates the consumer surplus.

For a less-differentiated domestic variety i, define $q_L(p', \mathbf{p}_{-iL})$ as its residual demand

[26] 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 is:

$$Q = \left[\int_{\mathcal{N}} Q_n^{(\eta-1)/\eta} dn \right]^{\eta/(\eta-1)}$$

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



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

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

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),

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

Define $\tilde{q}_i(p) = Ap^{-\epsilon}$ as a hypothetical demand function where ϵ 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.

Since both of these demand functions are functions of unit costs in $\mathcal{L}_S$, $(c_{iL}, \mathbf{c}_{-iL})$, we

write the contribution of variety i to welfare also as a function of these costs:

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

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

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

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.[27] The second inequality is the difference between the areas delineated by q_L and $\tilde{q}$ in Figure 3(b).[28] 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 Differentiation in General Equilibrium

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 differentiate their products, or it may decrease the sales of less-differentiated Foreign firms. To avoid such scenarios, the counterfactual below

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

[28] The area under this dashed line is

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

restricts the discrete choices of firms not undergoing the shock and precludes a large shift of labor from exports to differentiated varieties.

The economy is in equilibrium. A planner selects a non-zero set of differentiated firms $\mathcal{I}$ in a subset of sectors $\mathcal{S}$ 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 on discrete choices.All other firms are forced to maintain their original discrete choices. All firms then set prices and general equilibrium variables $(w^*, \overline{P}, y)$ adjust so that (i) new prices maximize profits given new discrete actions and new values of $(w^*, \overline{P}, y)$ as given, and (ii) new $(w^*, \overline{P}, y)$ satisfy (10), (14) and (15) for the new set of prices and market clearing quantities. Assume also that in the counterfactual, the overall level of differentiation in the economy decreases in the sense the profit share in the economy decreases (y decreases). We prove that the welfare is lower in the counterfactual than in the original equilibrium.

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 $i \in \mathcal{I}$,

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

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. But 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.[29] So, the only way for the planner to benefit from transferring firms in $\mathcal{I}$ 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 $i \in \mathcal{I}$.

Using the model to interpret the empirical results, we argued in Section 4.3 that differentiation is likely to have increased among surviving Chinese firms during China's accession to the WTO. Combined with the welfare results above, the welfare gains from the trade shock were likely larger than in a counterfactual 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.[30]

[29] Another way of seeing the proof is to observe that the market share of all firms decrease relative to firms in $\mathcal{I}$. But for $\pi_L(c_{iL}, \mathbf{c}_{-iL}) - \pi_D(c_{iD})$ to increase for a non-zero subset of $mathcalI$, the firm sales in the counterfactual must increase from revenue of firms not in $\mathcal{I}$ since the term in square brackets always decreases.

[30] 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.

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 latter result is indicative that the firm changes its output in response to tariff cuts, as predicted by the model.

Appendix A.3 checks for robustness. Appendix A.3.1 repeats the TFP regression in Panel A of Table 1 for various specifications. Table A.9 uses lagged tariffs and includes SOE's and multinationals with minority foreign ownership, in a specification close to Brandt et al. (2017).[31] Table A.10 drops sector fixed effects. To check if collinearity between tariff measures is driving the results, Table A.11 confirms that the coefficients do not change when we drop one tariff measure at a time from the regressions. To check for selection, Table A.12 repeats the regression using a balanced panel of the firms that are in the sample during all ten years of data. We also follow Wooldridge (2010) in estimating a selection equation using a probit, and then including the estimated Mills ratio in the main specification (Table A.13). In Table A.14, we exclude from the regression data on key sectors like textiles and apparel, and the computer industry. Table A.14 includes tariffs in the first stage of the TFP estimation, and Table A.15 estimates TFP following Ackerberg et al. (2015).

Appendix A.3.2 tests the robustness of the results on new goods and sectoral skill intensity in Table 1, Panels B and C. We (i) include SOE's and multinationals with minority foreign ownership, (ii) include only a balanced panel of firms, (iii) exclude textiles and apparel, and (iv) exclude computers and peripherals.In all these specifications, Tables A.18 and A.19 confirm that output tariff cuts shift firms toward

[31] In principle, our mechanism applies to multinationals operating in China. A difference arises if (i) domestic firms have better information about the Chinese market and an edge at tailoring their goods to domestic tastes, or (ii) if multinational affiliates are oriented towards global production chains and foreign markets and are not as affected by import-competition in China.

skill-intensive sectors. In the IV regressions, the coefficients on downstream tariffs are also negative, suggesting a similar response from input suppliers. The results on the introduction of new goods in Table 1 Panel C are all robust to dropping key sectors in Table A.17. The coefficients become small and insignificant when we include multinationals (Table A.16, Panel A) or when we include only a balanced panel of firms (Table A.16, Panel B). But reassuringly even in these specifications, the results hold in the subsample of non-exporting firms.[32]

In the TFP regressions of Table 2 Panel A, the coefficient on output tariffs increases systematically with quartile of firm sales. Appendix Table A.20 confirms these results when we (i) include SOE's and multinationals, (ii) use only a balanced panel of firms, (iii) measure TFP à la Ackerberg et al. (2015), (iv) exclude textiles and apparel, and (v) exclude computers and peripherals.

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 simple extension of Atkeson and Burstein (2008), where import-competing firms escape foreign competition by specializing in new market niches (nests). In practice, firms differentiate their products by complementing them with non-tradable services, offering greater customization, and catering to domestic tastes. Since the increase in product differentiation spurred by import competition improves welfare in the model, it provides a rationale for policy makers' view above. Using data on Chinese firms during China's accession to the WTO, we provide evidence that import-competing firms respond to tariff cuts by introducing new goods, and

[32]Multinationals may be disadvantaged in tailoring their goods to local tastes and offering non-tradable services. They may also be more influenced by offshoring than import competition. The results on new goods may be weaker in the balanced panel if older firms have had successful products and are less prone to introduce new varieties.

switching to skill-intensive sectors. These findings suggest that import-competition encourages product innovation, in line with the escaping-competition mechanism above. Through variable markups, the model also explains the why the effects of tariff cuts on revenue productivity increase in firm size.

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.

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