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Abstract

Exporters add and drop destination markets in response to a variety of global, national and industry-specific shocks. This paper develops empirical measures of these market changes and documents a set of key stylized facts using the customs databases of China (2000-2006) and the United Kingdom (2010-2016). First, I find within-firm changes in destination markets involve *large* trade values and 30-40% of all market changes involve simultaneously adding and dropping markets. Second, around 20% of within-firm market changes are driven by fluctuations in bilateral exchange rates and local CPI measures. Taken together, these facts suggest that firms face large destination-specific fluctuations in the demand for their products. Third, while adding and dropping markets, firms simultaneously adjust prices and quantities across all other destinations they serve. I build a multi-country general equilibrium model to investigate the channels that can generate the observed data patterns and study the aggregate implications of mutable markets (within-firm market changes) on the distribution of markups, trade volumes, and welfare. Applying the multi-country model to analysis of a bilateral trade war, I find that aggregate productivity for countries directly involved in the trade war drops more (1-2%) and that of countries not involved rises more (8-10%) when firms endogenously vary their markets in response to the new conditions of competition in local markets induced by the bilateral trade war.

Latest Draft

Online Appendices: UK Results; Additional China Results

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1 Introduction

Firms engaged in the global economy face a complex and ever-changing landscape in which demand for a firm's output rises or falls across different countries around the world, often in a seemingly uncorrelated manner. In part, country-specific fluctuations in demand for a firm's product can be explained by country-specific aggregate fluctuations such as movements in bilateral exchange rates or CPIs. However, they also contain a significant idiosyncratic component—e.g., competition by exporters from third countries systematically impinges on the demand for a firm's product. Overall, many things can shift the residual demand facing a firm in each of its foreign markets, motivating active re-optimization of pricing and marketing decisions. These decisions include whether to continue selling in an existing market, and whether to begin selling in a new market.

This paper relates new stylized facts regarding changes in a firm's set of destination markets to the firm's global pricing strategy and fluctuations in the economic environment in foreign markets. It then uses these facts to guide the specification of a multi-country general equilibrium macro model which quantifies the aggregate effects of firms' dynamic pricing and export decisions. Specifically, exploiting detailed information on country-specific product sales by firms from the universe of customs transactions of China (2000-2006) and of the UK (2010-2016)[1], I first document that the set of markets that an exporter serves is highly variable and that the value of these market changes is quantitatively significant at both the level of the firm and at the level of products within a firm. I provide evidence that the geography of trade is highly mutable not only for growing firms, but also for established firms, and is especially pronounced for "the happy few," large multi-product, multi-destination exporters.[2] Second, I build a multi-country general equilibrium model to study the interdependence between a firm's pricing and exporting choices, providing a rigorous general equilibrium analysis of how a firm's response to shocks in a destination market depends on the set of domestic and foreign firms operating in that market as well the nature and intensity of competition among them. Finally, I explore the aggregate and welfare implications of firms' choices by bringing my multi-country model to bear on the international transmission of shocks and, especially, on the global implications of a bilateral trade war between two countries.

Empirically, the micro evidence on within firm (and product) market changes I provide is novel in three dimensions.[3] First, I show changes in destination markets by established

[1]The two time periods were selected based on data availability and a desire to study entry dynamics both before and after the period of the Great Trade Collapse.

[2]International trade is dominated by a relatively small number of large multi-product and multi-destination firms; see Mayer and Ottaviano (2008).

[3]The empirical analysis is conducted separately at firm, firm-sector (2-digit HS) level and firm-product

exporters involve large trade values. While extensive margin adjustments are the subject of vast body of literature,[4] entrants and exitors are typically associated with small trade values.[5] I focus on the selection of export markets by established exporters over time rather than entry and exit decisions by new exporters. At the firm-product level, I estimate the median value of transactions discountinued when a market is dropped or introduced when a market is opened (on a year-to-year) basis is three times as large as the current export value. Moreover, at the firm-product level, between 30 and 40% of the extensive margin adjustments involve simultaneously adding and dropping markets. This can be interpreted as evidence that fluctuations in destination-specific residual demand for a firm's product are actually quite large. By and large, if fluctuations in a firm's own productivity were at the root of its extensive margin adjustment, I would expect a firm that became more (less) productive to only add (drop) markets – adding *and* dropping markets within the same year suggests that other factors, external to the firm, are at play.

Second, in a variance decomposition, I estimate that 20% of the variation in the firm's choice of markets is associated with changes in bilateral exchange rates and local CPI. I document that firms are less likely to discontinue sales in countries whose currency has appreciated vis-a-vis its own currency. Moreover, my measure of market changes yields evidence consistent with a gravity model. The average geographical distance between all of a firm's destinations and the firm's origin declines in the proportion of markets being dropped. Firms are more like to drop markets that are far away: everything else equal, there is 'gravity' not only in the cross section but also in the time variation of a firm's trade pattern.

Third, the proportion of markets being dropped relative to the total number of markets which have been changed in the same period is strongly associated with the extent to which firms decide to adjust their prices and quantities across all markets. A 1% increase in the drop-change ratio is associated with firms setting a higher average price (0.09%) and exporting a lower quantity (-2.49%) at the firm-product level.[6]

(8 digit HS) level. While the exact quantitative estimates may differ, the main qualitative findings of this paper hold at different disaggregation levels.

[4] Dunne, Roberts and Samuelson (1989) show that around one third of US manufacturing plants enter and exit every five years. Using data on French exporters, Eaton, Kortum and Kramarz (2004) document that more than 60% of the difference in export trade flows across market size is explained by the entry and exit of exporting firms. Using data of US exporters, Bernard, Redding and Schott (2011) find that the effect of distance on bilateral trade flows is mainly due to changes in the extensive margins of the number of exporting firms and exported products.

[5] Entrants and exitors are smaller on average than incumbents; see, e.g., Dunne, Roberts and Samuelson (1989), Geroski (1995) and Albornoz, Calvo Pardo, Corcos and Ornelas (2012).

[6] To assess the determinants of these price changes, I construct proxies for fluctuations in the supply conditions of a firm, using information on the prices set and quantities sold in continuing markets. However, even after controlling for supply, the results on the price and quantity responses are largely unchanged,

The evidence on the volume of transactions involved when firms endogenously change their trade patterns, and the potential relevance of these changes for the global pricing and exporting decisions by firms, suggests that market selection could be an important channel in the international transmission of shocks across markets and a key determinant of the co-movement between international prices and trade flows. Empirical measures that abstract away from it may be plagued by substantial selection bias.[7] Models for policy assessment may correspondingly miss a relevant adjustment mechanism.[8]

Theoretically, I build an analytically tractable multi-country general equilibrium model to investigate possible channels that can generate the observed patterns of market changes and their aggregate implications on markup adjustments and welfare. The model draws on seminal papers in the literature, by incorporating competitive interactions across firms as in Atkeson and Burstein (2008), and vertical interactions among producers and distributors as in Corsetti and Dedola (2005).[9] The mechanisms highlighted by these contributions are essential (and realistic) building blocks of the model, but not sufficient for my purposes. I also model the firms' decision to enter into or exit from a market, and, most crucially, multilateral competition by exporters from a third country. The model provides important insight from general equilibrium into the way in which the interdependence between the variable distribution of markups within a country and the endogenous market participation decision of firms impacts aggregate productivity and welfare.

The model allows me to distinguish among the different factors that cause changes in destination-specific demand for a firm's product (that is, firm-product-destination-specific demand), which, in turn, affect a firm's pricing and exporting decisions. The model suggests that two types of firm-product idiosyncratic shocks are important in generating the observed data patterns: (a) changes in tastes or preferences that are firm-destination specific; and (b)

suggesting that changes in the residual demand might be the driver behind these changes.

[7]This problem is discussed in more detail in Corsetti, Crowley, Han and Song (2018) where a trade pattern sequential fixed effect estimator is developed to address the endogenous selection in estimating destination-specific markup adjustments to changes in local market conditions.

[8]Some recent studies have examined within-firm adjustments of products and inputs. Bernard, Redding and Schott (2011) develop a general equilibrium model of multi-product firms and analyze their behavior during a trade liberalization. They find the trade liberalization fosters productivity growth within and across firms, and in the aggregate, by both inducing firms to shed marginally productive products and forcing the lowest-productivity firms to exit. Gopinath and Neiman (2014) characterize the mechanics of trade adjustment during the Argentine crisis and find within-firm churning of imported inputs played a non-negligible role.

[9]A related alternative approach to model the local component of prices includes the idea of a consumer list (Drozd and Nosal 2012), consumption accumulation (Alessandria and Choi 2014), and exporting networks (Chaney 2014). The need for a distributor has been widely recognised in recent trade and macro studies. Recent empirical findings suggest understanding the seller-buyer relationship is the key to explaining the growth path of destination choices of firms [Aeberhardt, Buono and Fadinger (2014) Albornoz, Fanelli and Hallak (2016) and Araujo, Mion and Ornelas (2016)].

shocks to a retail-distribution cost. Changes in tastes in a given destination shift the demand of a firm and make it more (or less) profitable to sell to that destination. It is worth noting that idiosyncratic shocks can have distortionary effects on markups across destinations and welfare. In a model with variable markups, idiosyncratic shocks distort the market shares of firms, change their demand elasticities and lead to a different and, in most cases, suboptimal difference in markups across destinations. Similarly, shocks to the retail-distribution cost in a country alter the proportion of sales received by the firms operating in that country which also affects the distributions of markups.

Large shifts in firm-destination specific demand conditions, however, can also derive from productivity shocks in a third country. Namely, consider a world with three countries, A, B and C. If firms in C become more productive, more firms producing in C will start selling in B and the firms from C that are already exporting to B will charge lower prices. As a result, the residual demand facing exporters from A will atrophy. Since the local market of B becomes less profitable for A firms, some of them will choose to exit. The model can indeed generate trade deflection in line with previous empirical evidence.[10] It is worth stressing an important difference relative to a partial equilibrium model of trade deflection, which typically relies on the maintained assumption of decreasing return to scale of production. This assumption is not needed in a multilateral framework, in which trade deflection results from the general equilibrium equilibrium adjustment in the exchange rate of a third country.[11]

My final contribution is to use the model to study the global effects of a bilateral trade war. As expected, the two countries involved in the trade war suffer a contraction in their imports and aggregate productivity. The effect of introducing endogenous market participation is an additional reduction (1-2%) in the aggregate outputs of the warring countries. Remarkably, however, the model suggests sizeable welfare gains for the third country not involved in the trade war. The third country experiences an export boom as the warring countries increase demand for its goods. At the same time, entry into the third country by the exporters of the warring countries intensifies the competition within the third country, improving efficiency and bringing additional welfare gains (10%).

Literature: My empirical findings offer new insights to the literature on the export dynamics of firms [Chaney (2008), Albornoz, Calvo Pardo, Corcos and Ornelas (2012), Timoshenko (2015), Araujo, Mion and Ornelas (2016), Fitzgerald, Haller and Yedid-Levi

[10] Bown and Crowley (2007) find that import restrictions on Japanese exports over 1992-2001 lead to a 5-7% increase in Japanese exports to third country markets. Similar empirical results are found for China, e.g., Bown and Crowley (2010) and in the case of tariff uncertainty Crowley, Meng and Song (2018).

[11] In my model, firms make entry decisions in each market separately in each period. The model abstracts away from firm level cost interdependence of destinations. An alternative setting would be Antras, Fort and Tintelnot (2017) where they build a quantifiable multi-country sourcing model in which firms self-select into importing based on their productivity and country-specific variables.

(2016), Ruhl and Willis (2017)]. It is most closely related to contributions from Albornoz, Calvo Pardo, Corcos and Ornelas (2012) and Fitzgerald, Haller and Yedid-Levi (2016) both of which study the determinants of the formulation of a firm's trade pattern over time. Using firm-level data on Argentina, Albornoz, Calvo Pardo, Corcos and Ornelas (2012) document that many new exporters give up exporting immediately after entry while firms that can survive in the initial market expand to new destinations. Fitzgerald, Haller and Yedid-Levi (2016) focus on the growth of trade volumes and prices for successful exporters and find that, conditional on survival, there is an economically significant growth of trade volume within each of a firm's markets, but price growth is flat.[12] My work contributes to this literature by creating new measures which focus on those foreign markets that have been added or dropped and linking these market changes to fluctuations in local market conditions and pricing behaviour.

My new empirical measures are designed to study the relationship between the direction of market changes and changes in relative market conditions, particularly those captured by bilateral exchange rate and local CPI movements. Fitzgerald and Haller (2018) find entry and revenue are very sensitive to tariff changes but not to fluctuations in real exchange rates. My estimates using data on China and the UK suggest fluctuations in bilateral exchange rate and local CPI measures account for 20 percent of the variation in whether a destination will be added or dropped conditional on a market change.[13]

The theoretical model is related to recent works quantifying of aggregate implications of export participation on the transmission of international shocks, trade and welfare.[14] My model provides a natural environment for assessing the pro-competitive gains of trade[15]

[12]Other important contributions include: Ruhl and Willis (2017) who finds that new exporters sell small quantities and are highly likely to exit in the first few years; Timoshenko (2015) who finds new exporters add and drop products with much greater frequency than established exporters; and Araujo, Mion and Ornelas (2016) who finds that exporters start with higher volumes and sell for longer periods in countries with better contracting institutions.

[13]These findings are closely related to the discussion of "product replacement bias" in constructing price indices and calculating exchange rate pass through estimates. For instance, Nakamura and Steinsson (2012) find 40 percent of products are replaced before a single price change is observed and 70 percent are replaced after two price changes or fewer. They find exchange rate pass through is substantially higher than conventional estimates. However, Gagnon, Mandel and Vigfusson (2014) suggest the empirical bias may be small after both entry and exits have been taken into account. My paper investigates this question from the perspective of exporters and finds strong evidence on selection biases in prices.

[14]Recent works integrate the aspects of adjustments in products, inputs and markups [Bernard, Redding and Schott (2011), Bilbiie, Ghironi and Melitz (2012), Gopinath and Neiman (2014) and Impullitti and Licandro (2017)].

[15]Levinsohn (1993) and Harrison (1994) find pro-competitive effects of trade liberalization in reducing markups in Turkey and Cote d'Ivoire respectively. Using disaggregated data for EU manufacturing over the period 1989–1999, Chen, Imbs and Scott (2009) find import penetration in an industry reduces the industry's relative price. Recent findings suggest that the existence of the pro-competitive effect of trade is highly debated, see, e.g., Edmond, Midrigan and Xu (2015), De Loecker, Goldberg, Khandelwal and Pavcnik

in a multi-country setting.[16] In light of Edmond, Midrigan and Xu (2015), I show that idiosyncratic shocks — either directly through changes in tastes and retail distribution costs or indirectly through changes in productivity of firms in the third country — can have distortionary effects on the distribution of markups and thus impact efficiency and welfare. I investigate the aggregate implications of firms' ability to re-optimize their market choices in a bilateral trade war. Although firms' re-optimization of markets has small impacts on aggregate productivities of the two warring countries, it drives a large gain of the aggregate productivity for the third country not involved with the trade war.

A group of works have emphasized the importance of large firms on aggregate fluctuations [Gabaix (2011) and Carvalho and Grassi (2019)]. This paper focuses on established exporters and analyse micro foundations of aggregate fluctuations through the lens of within-firm market changes. My finding on firms simultaneously adding and dropping markets suggests considerable fluctuations in firm-destination-specific demand. Theoretically, the large demand fluctuations can be rationalized and endogenously generated through the transmission of third-country productivity shocks in a multi-country setting. The model predicts international spillovers through changes in competition and thus the relative demand across exporters from different countries can have sizeable aggregate implications. These empirical and theoretical results together highlight the need to take into account the demand aspects of heterogeneity of firms along the lines of recent research by Di Comite, Thisse and Vandenbussche (2014), Hottman, Redding and Weinstein (2016) and Roberts, Xu, Fan and Zhang (2017).[17]

The rest of the paper is organized as follows. Section 2 explains the new empirical measures and key results from applying the measures in the Chinese and British customs dataset. Section 3 introduces the model and discusses the channels that can generate the observed pattern of within-firm market changes. Section 4 discusses the key model implications

(2016), and Arkolakis, Costinot, Donaldson and Rodríguez-Clare (2018).

[16] This paper is closely related to Edmond, Midrigan and Xu (2015), which uses the Atkeson and Burstein (2008) model to study the procompetitive gains from trade. My paper focuses on the mechanisms that can generate large within-firm market changes and study their aggregate implication on the distribution of markups and welfare. The model used in this paper departs from Edmond, Midrigan and Xu (2015) in two important aspects: (i) it incorporates multi-country competition with entry and exit in a general equilibrium framework, which allows for multilateral shock transmissions and generates trade deflection in both intensive and extensive margins through the general equilibrium effect of bilateral exchange rate adjustments; (ii) it incorporates a local retail channel in a general equilibrium setting which has been found as an important determinant of firms' destination choices in recent empirical works and partial equilibrium models [Aeberhardt, Buono and Fadinger (2014), Albornoz, Fanelli and Hallak (2016) and Araujo, Mion and Ornelas (2016)].

[17] Using Nielson HomeScan data, Hottman, Redding and Weinstein (2016) find 50-70% of the variance in firm sales can be attributed to differences in taste or quality. By analysing the footwear industry of Chinese manufacturing firms during 2002-2006, Roberts, Xu, Fan and Zhang (2017) find that firm-specific demand factors account for 30% of sales and price variations among exporters.

through a trade war scenario. Section 6 concludes.

2 Within-firm Market Changes: Measurement and Evidence

Firms engaged in international trade have a "frothy" extensive margin characterized by simultaneous entry and exit. I develop a new set of measures for this froth, which can be used to quantify how market expansion/contraction by firms relates to local market conditions. This section discusses the main empirical findings on changes in the set of export markets served by a firm over time.

Due to the richness of the customs data, the market changes within a firm can happen along different product dimensions. I conduct the analysis separately on changes in trade patterns measured at the firm-product (8-digit HS), firm-sector (2-digit HS) and firm levels. In the following discussions, I focus on the statistics of market changes at the most disaggregated level, i.e., the firm-product level. Online appendices report measures and results at the firm-sector and firm levels, which largely confirm the main results discussed in the text.

2.1 Measuring Changes in Trade Patterns

How can we measure changes in trade patterns? I develop a set of simple measures to capture changes in the set of export markets served by a firm with a particular product over time. To illustrate the properties of the custom datasets and how trade pattern measures are defined and calculated, it is useful to go through the following example. The example, constructed to reflect the actual structure of trading patterns of many firm and product level transactions, conveys the highly unbalanced nature of data.

Consider a firm that sells a product to four countries, A, B, C, D over 4 time periods. The left panel of Figure 1 shows the trading records of this firm-product pair. An empty cell means no trade. The right panel shows the construction of relevant statistics.

					Trade Pattern	Activity	M. Changes/ Markets	Drops/ Changes
$t=1$	A	B			A-B	–	–	–
$t=2$	A		C		A-C	Churn	2/2	1/2
$t=3$	A		C	D	A-C-D	Add	1/3	0/1
$t=4$	A		C		A-C	Drop	1/2	1/1

Figure 1: An Example of Market Switching Measures

A trade pattern is defined as the set of destination markets that a firm-product pair exports to in a given period. The first column in the right hand side panel shows the identified trade patterns. In this example, 3 trade patterns are identified, i.e., A-B, A-C, and A-C-D. The second column in the right hand side panel classifies the activity of market changes into different categories. Market churn happens if the firm-product pair simultaneously adds and drops markets in a given period. In this example, market churn only occurs in period 2. The last two columns of Figure 1 show that changes to the extensive margin can be decomposed into two components: (a) the proportion of markets changed among all active markets and (b) the proportion of markets being dropped/added among the changed markets.

Specifically, I construct 5 measures meant to capture the magnitude, quantitative importance, direction and frequency of changes in the trade patterns of a firm (or firm-product):

Market Changes / Number of Markets: This variable captures the magnitude of market changes.

> Count Measure: the number of markets that have changed from $t-s$ to t divided by the total number of markets operating in period t, where s is the lag between two observed periods.
>
> Value Measure: the total trade value of those markets that have changed from $t-s$ to t divided by the total export value at period t, where s is the lag between two observed periods.

Market Drop / Market Changes (DC Ratio): This variable captures the proportion of markets being dropped among the total number of markets changed.

> Count Measure: the number of markets being dropped from $t-s$ to t divided by the number of market changes from $t-s$ to t, where s is the lag between two observed periods.

Value Measure: the total trade value of markets being dropped from $t-s$ to t divided by the total trade value of markets being added and dropped from $t-s$ to t, where s is the lag between two observed periods.

Note that the drop-to-change ratio is a directional measure. If a firm only adds markets, the drop-to-change ratio will be zero; if a firm only drops markets, the drop-to-change ratio will be 1; If a firm simultaneously adds and drops markets, the drop-to-change ratio will be in between 0 and 1.

Probability of Churn: The number of market churn activities over the total number of trading periods, i.e., the probability that the drop-to-change ratio is neither one nor zero.

2.2 Data

I carry out my analysis on two custom databases: (1) the Chinese Customs Database, i.e., the universe of annual import and export records for China from 2000 to 2006 and (2) administrative data from Her Majesty's Customs and Revenue (HMRC) in the UK from 2010 to 2016.

The Chinese Customs Database reports detailed trade flows (quantities and values) at the firm-product-destination level. In addition to standard variables, such as the firm ID, an 8-digit HS code, the destination country and month, the database contains the Chinese measure word in which quantity is reported, an indicator of the form of commerce for tax and tariff purposes, and a categorization based on the registration type of the exporting firm.[18] The database is available at the monthly frequency during the period 2000-2006. I aggregate trade flows into the annual level in this study. Like other firm-level studies using customs databases, I use unit values as a proxy for prices. A product is defined as a 8-digit Harmonized System (HS) code. An industry in defined as a 2-digit HS code. The database reports transactions denominated in US dollars. I calculate the price in the exporter's currency (renminbi) by multiplying the unit value of dollar transactions with the annual renminbi-dollar rate.

[18]The form of commerce indicator records the commercial purpose of each trade transaction including "general trade," "processing imported materials," and "assembling supplied materials," etc. The registration type variable contains information on the capital formation of the firm by 8 categories: namely state-owned enterprise, Sino-foreign contractual joint venture, Sino-foreign equity joint venture, wholly foreign owned enterprise, collective enterprise, private enterprise, individual business, and other enterprise. In my later analysis, I group three types of foreign-invested firms, namely wholly-foreign-owned enterprise, Sino-foreign contractual joint venture and Sino-foreign equity joint venture, into one category and dub it as "foreign invested enterprises." I group minority categories such collective enterprise, individual business and other enterprise into one category and refer to them as "other enterprises."

The HMRC administrative datasets include transaction level trade flows for non-EU exports and monthly records for EU exports.[19] HMRC reports the value of transactions denominated in sterling and two quantity measures (net mass and quantity). I aggregate trade flows at the firm-product-destination-year level by summing over quantity and value of transactions. The unit value is calculated as the total sterling value divided by the quantity with reported quantities (net mass in kilos, units, pairs, etc) and as the total sterling value divided by the net mass (in kilos) for products for which there is no specific quantity units reported. Firms are identified by a firm-specific anonymised identifier.[20] Products are defined by an 8-digit Combined Nomenclature (CN) code.[21] To create the same time span of Chinese firms, I focus on time period 2010-2016, where 2016 is the latest year of data available at the time when the analysis was performed.

Aggregate time series such as bilateral exchange rates and local CPI rates are taken from International Financial Statistics, International Monetary Fund. Data on geographical distance between countries is taken from the organised dataset of Feenstra, Li and Yu (2014).

In this draft of my paper, I only report the main empirical results on Chinese exporters in the following subsections. Statistics and estimates of UK exporters are reported in Online Appendix: UK Results.[22] The following statistics and estimates are based on exports to the destinations with non-missing bilateral exchange rates and CPI series during the sampling period.[23] Statistics for the full sample including all destinations are available at Online Appendix: Additional China Results.

2.3 Stylized Facts on Within-firm Market Changes

Statistics on market changes at the most refined disaggregation level of my dataset, i.e., firm-product level, are reported below. Results on changes in trade patterns at the firm-sector and firm level are reported in my online appendices.

Table 1 presents the median of market change measures for Chinese exporters during

[19] EU records only contain UK firms whose exports to the EU exceed £250,000 in a given calendar year. The requirement to report exports at the detailed product level applies to firms whose total value of exports exceeds the reporting threshold. A comparison with official statistics indicates that these companies account for around 96-98% of the total value of UK exports to the EU. Details on the data statistics can be find in Online Appendix: UK Results.

[20] The raw data also contains a plant indicator on a firm has multiple production bases. In index of plant numbers are self-reported and may not consistent over time. I aggregate all trade flows into the firm level.

[21] There has been a major revision in the product classification during the year 2012 and many small revisions in other years during my sampling period 2010-2016. I wrote an algorithm to convert all product classifications into the base year (2012) while keeping the maximum number of consistent product definitions based on the official concordance tables.

[22] HMRC requires two months of advance notice before it will permit any changes to documents that report results from its micro data. For expediency, I have placed all UK-based results in a separate document.

[23] In practice, this means I drop 51 (217-166) destinations whose total share of world trade is small.

2000-2006. As shown in the table, around two-thirds of markets have changed between two observed trading years at the firm-product level (row 1). To clarify the economic importance of these market changes, I use the value measure of market changes (row 2). The question is whether market changes are mainly due to frequent changes of fringe markets with small trade values. As shown in the table, the value measure of market changes is actually substantially larger than the count measure, suggesting that market changes involve shifts in trade reflecting more that, say, trial and error with small markets.[24]

With a median value measure of market changes around 2.21, large firms seems to have more stable trade patterns. However, as large firms tend to trade with more markets, the total trade value involved in these changes is still bigger than that of small firms.

Table 1: Statistics on Firm-product Level Trade Patterns (Median)

	All Firms	Large Firms
Markets Changes/ Markets	0.67	0.64
Markets Changes/ Markets (Value Measure)	3.27	2.21
Markets Drop/ Market Changes	0.50	0.50
Markets Drop/ Market Changes (Value Measure)	0.41	0.35
Probability of Churn	0.26	0.33

Note: This table presents the statistics on changes in trade patterns at the firm-product (8-digit HS) level. Statistics are calculated based on year-to-year changes of Chinese exporters during 2000-2006. The median of each measure is presented in the table. Details regarding the distribution of relevant statistics are reported in Appendix A.4.

A key question is whether these market changes are mainly due to product switches/replacement within a firm—a possibility consistent with the empirical evidence documented by Bernard, Redding and Schott (2010). To clarify that the margins of market changes are actually substantially more general, I aggregate trade flows to the firm-destination-year level and repeat all empirical estimates discussed in this section. The degree of market changes are quantitatively smaller at the firm level, but the qualitative pattern remains the same.

In view of the large scale of market changes found in the data, a natural question is whether these changes mainly consists of dropping existing markets or adding new markets. The median value of market drops over market changes (drop-to-change ratio afterwards) is around 0.5. This suggests that firms simultaneously add and drop markets at the same time—a pattern that is difficult to rationalize using trade models that focus exclusively on

[24]It is worth stressing these large changes of trade value measures cannot be explained by the partial year effects as in Bernard et al. (2017) as this effect tend to lower the relative importance of the first year trade values.

supply side (productivity) determinants of trade. Note that the drop-to-change ratio is not very sensitive to the size of firms. The value measure of the drop-to-change ratio is slightly smaller for larger firms, suggesting that large firms are more likely to add markets. In terms of frequency, market churn accounts for around one-third of the trading periods.

Relying on the rich information included in the Chinese Customs Database, I uncover substantial heterogeneity in the degree of the value measure of market changes depending on the capital structure of the firm, the nature of the business and the degree of product differentiation. Table 2 shows results by firm and product types. Market changes are considerable for both private and state-owned enterprises. In contrast, trading patterns seem more stable for foreign invested enterprises, with only very small market changes.

The information on the form of commerce allows me to group transactions into three categories according to the purpose of trade: (a) those firm-product pairs conducting general trade, i.e., those manufacturers selling their own products in the foreign market; (b) firm-product pairs with contracts to process other foreign firms products/materials; and (c) firm-product pairs conducting businesses in both general trade and processing trade.[25] There is a striking difference across these these categories: large market changes are only observed in relation to general trade, but not for firms with contracts to process other firms products.

Finally, I breakdown trade transactions by product differentiation according to Rauch (1999) classification. As shown in the bottom panel of Table 2, firms selling less differentiated products (such as vegetable animal products, and foodstuffs) rarely change their destination markets. In contrast, firms selling more differentiated products, such as machinery and mechanical appliances and optical and photographic products, demonstrate a significantly larger degree of market changes. A breakdown by two-digit industries is presented in Table 12 in the appendix.

The last two columns show the count and value measures of drop-to-change ratio. These statistics are calculated based on those time periods involving market changes. Although the degree of market change differ among firm and product types, drop-to-change ratios are very similar across types.

These three dimensions of heterogeneity all together suggest within-firm-product market changes are far from random and unlikely due to transportation concerns such as infrequent shipments.[26] Instead, these changes seem to be related to the underlying strategic pricing behaviour of exporters. Evidence regarding this aspect is discussed in more detail in the

[25]Firms conducting both general trade and processing trade only account for a very small proportion of transactions and trade vales. More details regarding the number of observations associated with each type of transaction can be found in my online appendix of China results.

[26]All statistics are calculated based on year-to-year changes. This is another reason that the infrequent shipments would not play an important role in generating these results.

next two subsections.

Table 2: Breakdown by Firm and Product Types

	Market Changes / Markets		Market Drops / Market Changes	
		Value Measure		Value Measure
By Firm Ownership				
— Private Enterprises	0.75	4.10	0.50	0.36
— State-owned Enterprises	0.88	5.98	0.50	0.47
— Foreign Invested Enterprises	0.33	0.18	0.33	0.12
By Form of Commerce				
— General Trade	0.79	4.84	0.50	0.42
— Processing Trade	0.40	0.22	0.50	0.37
— Mixture	0.00	0.00	0.50	0.32
By Rauch Classification				
— Differentiated Products	0.71	3.98	0.50	0.41
— Reference Priced	0.50	1.01	0.50	0.42
— Organised Exchange	0.40	0.19	0.50	0.48

Note: This table presents the statistics of firm-product level market change measures. The median of each measure is presented in the table. The distributions of relevant statistics for each type of goods and products are reported in the online appendix of China results. Source: Chinese Customs Database, 2000-2006.

2.3.1 Entropy in Market Changes

In studying these changes, a relevant question concerns the extent to which market changes are synchronized or correlated across firms. Empirically, it has been documented firms tend to learn from the market choices of other firms.[27] The firms' decisions captured by my measures may result in common changes in trade patterns. To get a measure for the degree of heterogeneity in firms' market choices, I calculate deviations from the common trade pattern among firms, where the "Common Trade Pattern" is defined as the set of

[27]Using data on Chinese exporters, Fernandes and Tang (2014) show neighbors' exporting activity affects new exporters' performance as exporters update beliefs about foreign demand, after observing neighbors' exports. Kamal and Sundaram (2016) show the presence of neighboring exporters that previously transacted with a U.S. importer is associated with a greater likelihood of matching with the same U.S. importer for the first time. Moreover, recent findings by Crowley, Meng and Song (2018) suggest that firms learn about foreign trade policy from geographically proximate firms.

markets that occur most often across firms selling the same product in any given period. In most cases, the common trade pattern is the most popular market or a combination of two most popular markets of a product. Specifically, I construct an entropy measure based on the deviations from the common trade pattern. In each time period, I count the number of deviations from the common trade pattern for each firm-product pair. To obtain a compatible measure across firms, I divide the calculated deviation counts by the number of trading markets in period t. Figure 2 illustrates how this measure is calculated.

Trade Pattern	**Common Trade Pattern**	**Deviation / Markets**
A	A	$0/1$
A	$A-C$	$1/1$
$A-B$	A	$1/2$
$A-B$	$A-C$	$2/2$
C	A	$2/1$
C	$A-C$	$1/1$

Figure 2: Examples of How the Entropy Measure Is Calculated

All my measures on market changes can be redefined in terms of deviations from the common trade pattern—as illustrated in the last two columns of Figure 9 in Appendix A. I should also stress that there are different to identify the common trade pattern. For instance, instead of studying the deviation from the common trade pattern among firms, one may be interested in how a firm's trading markets deviate from the firm's own most frequently exported set of destinations. Figure 10 in Appendix A illustrates such a measure. All the steps in the analysis to follow are reproduced for these different measures in the Appendix A.

Table 3: Deviation from the Common Trade Pattern (CTP)

			Distribution (Percentile)				
	Mean	Median	1st	25th	75th	99th	Observations
8-digit level deviation from							
product-time CTP	1.28	1.50	0.00	0.75	2.00	2.00	6,042,761
firm-product CTP	0.64	0.00	0.00	0.00	1.00	5.00	6,042,761
2-digit level deviation from							
product-time CTP	1.23	1.25	0.00	0.83	2.00	2.00	1,927,599
firm-product CTP	0.71	0.00	0.00	0.00	1.00	7.00	1,927,599

Note: This table presents statistics on two entropy measures: the deviation from the product-time common trade pattern and the deviation from the firm-product common trade pattern. For each measure, the deviation is normalized by the number of markets traded to facilitate the comparison across firms. Source: Chinese Customs Database, 2000-2006.

Table 3 shows statistics of the entropy measure designed to capture the degree of heterogeneity of trade patterns across and within firms.[28] The deviation from the product-time common trade patterns captures the degree of heterogeneity in the set of destinations across firms, whereas the deviation from the firm-product common trade pattern captures the degree of heterogeneity of trading countries within a firm over time. Combining these two measures provide useful information to disentangle the change of trade patterns due to global, local and firm idiosyncratic shocks by examining the synchronization of trade patterns across firms (and products).

There are two key findings. First, the level of disaggregation does not exert any significant influence on these measures. This suggests that differences in trade patterns, both across firms and within a firm and product, are not due to differences in product allocations. Second, deviations are substantially larger across firms than within firm (and product) deviations. The mean deviation from the product-time common trade pattern is around 1.25, suggesting substantial heterogeneity in trade patterns across firms. The fact that the deviation statistic is larger than 1 suggests that differences in trade patterns across firms are not primarily driven by large firms selling to more destinations. By way of example, suppose the common trade pattern consists of two destinations $\{A, B\}$. Both small and large firms export to these two destinations. In addition, large firms also export to two additional destinations, C and D. In this case, the deviation measure for small firms will be zero and the deviation measure

[28] Examples on construction of this measure are given by Figure 2 in the previous subsection and Figures 9 and 10 in the appendix.

for large firms is $2/4 = 0.5$, which is smaller than 1. Comparing to deviations across firms, the time deviation from the common trade pattern within firm-product is much smaller, with a mean value of 0.64 for the 8-digit measure and of 0.71 for the 2-digit measure.

2.4 Market changes and local market conditions

What are the sources of these market changes? I next investigate the relationship between changes in local market conditions and within-firm market changes. In particular, I use fluctuations of bilateral exchange rates and changes in local CPI as proxies for changes in destination-specific demand. Intuitively, an appreciation of the currency of the destination country makes the product of foreign exporters relatively cheaper and thus makes it more profitable to sell to the destination country. All else equal, the firm is less likely to drop (more likely to add) a market whose currency has appreciated. Similarly, a rise in the average price of the consumption basket in a destination makes the price of the exporter relatively cheap and the exporter is less likely to drop (more likely to add) a market.

Table 4: Regressing Drop-to-Change Ratio on Changes in Relative Market Conditions

	Exchange Rate	Destination CPI	Within R^2	Observations
Count Measure				
Firm-product (8-digit) level	-0.22***	-0.81***	0.23	1,791,353
Firm-sector (2-digit) level	-0.14***	-0.59***	0.21	875,096
Firm level	-0.12***	-0.45***	0.20	301,455
Value Measure				
Firm-product (8-digit) level	-0.21***	-0.83***	0.17	1,791,353
Firm-sector (2-digit) level	-0.14***	-0.61***	0.16	875,095
Firm level	-0.11***	-0.46***	0.16	301,455

Note: This table shows estimates from regressing drop-change ratio on relative exchange rates and destination CPI measures. The upper and bottom panel present results using the count and value measures of drop-change ratio respectively. Each row represents a separate regression with the different levels of disaggregation at which the trade pattern measures are constructed. Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. Source: Chinese Customs Database, 2000-2006.

I estimate the following equation:

$$DC_{f,i,t} = \widetilde{e}_{f,i,t} + \widetilde{P}_{f,i,t} + \delta_{f,i} + \delta_t + \epsilon_{f,i,t}$$

where DC is the drop-to-change ratio; $\widetilde{e}_{f,i,t}$ is a measure of relative exchange rates; $\widetilde{P}_{f,i,t}$ is the

relative local CPI rate; and $\delta_{f,i}$ and δ_t are firm-product and time fixed effects, respectively. f, i, t represent firm, product, and time respectively. Details on construction of the relevant measures are discussed in Appendix A.1.

As shown in Table 4, a 1% increase in the relative exchange rate lowers the drop-to-change ratio by 0.2%, suggesting that those markets whose exchange rates have appreciated are more likely to be dropped conditional on a market change. Similarly, a 1% increase in local market CPI lowers the drop-to-change ratio by 45-83%. The magnitude of the estimates differs slightly between estimates of Chinese and British exporters. British exporters are less sensitive to changes in bilateral exchange rates and more sensitive to changes in destination CPI. Analysis of variance suggests that around 20% of the variation of the drop-to-change rate is explained by changes in the relative exchange rate and local market CPI measures.

In addition to changes in measures of local market conditions, I find the probability of market being dropped is negatively correlated with the geographical distance between the origin of the exporter and the destination country, suggesting that markets with longer distance are more likely to be dropped. The relevant results are presented in Appendix A.3 and discussed in more detail in the online appendix of UK results.

2.5 Market Changes, Prices and Quantities

A final question to be addressed is whether market changes are related to firms' pricing and the quantity sold in different markets. Market changes reflecting endogenous selection by firms may have a much larger aggregate impact if they are correlated with changes in prices and quantities of firms across all markets. In fact the empirical evidence shows that market changes are related to global firms' price and quantity decisions. Specifically, I regress changes in prices and quantities at the firm-product level on the drop-to-change ratio, which measures the direction of the market changes, i.e., proportion of markets being dropped.

Table 5 presents a summary of the estimation results. The upper panel represents estimates from regressing changes in unit value, mean quantity or the total quantity on the drop-to-change ratio. An illustration of the estimation equation is given by Figure 7 in the appendix. Each cell represents an estimate from a separate estimation equation: the header of each column indicate the dependent variable of the estimation equation and the rows presents the level of disaggregation at which the trade pattern measures are constructed. Firm-product and time fixed effects have been added to all specifications.[29]

As shown in the table, the drop-to-change ratio is closely related to firm's price and quantity decisions: (a) the drop-to-change ratio is positively correlated with the average

[29] Alternative empirical specifications, such as adding firm-time and product fixed effects, are reported in the online appendices.

price — the unit value is higher if more markets are dropped; (b) the drop-to-change ratio is negatively correlated with the mean quantity and total quantity — less units being sold per market if more markets are dropped; and (c) the drop-to-change ratio is highly correlated with the mean quantity of continuing markets and is only weakly correlated with the unit value of continuing markets.

While firm-product and time fixed effects have been added to all specifications. I construct proxies of changes in supply conditions using changes in unit values or mean quantities of continuing markets at firm or firm-product level. The construction of related measures are detailed in Appendix A.2.

Table 5: Elasticity of Prices and Quantities to Drop-to-Change Ratio
(Summary of Key Estimates)

	(1) Unit Value	(2) Mean Quantity	(3) Total Quantity	Observations
Firm-product (8-digit) level	0.08***	-0.52***	-2.49***	1,788,094
Firm-sector (2-digit) level	0.15***	-0.57***	-2.49***	873,994
Firm level	0.16***	-0.06***	-1.82***	314,537
After Controlling for Unit Values or Quantities of Continuing Markets				
Firm-product (8-digit) level	0.06***	0.18***†	-1.59***	1,244,580
Firm-sector (2-digit) level	0.11***	0.10***†	-1.68***	731,199
Firm level	0.10***	0.58***	-1.05***	281,564

Note: This table presents a summary of estimates regressing price or quantity measures on the drop-change ratio. *Each cell presents a parameter estimate from a separate estimation.* The detailed regression statistics are reported in my online appendix. The header of each column indicates the dependent variable of the corresponding estimation equation. The bottom and top panel present estimates with and without controlling changes in supply side factors respectively. Each row indicates the level of disaggregation at which the trade pattern measures are constructed. Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% level respectively. † indicates the magnitude and statistical significance of the estimates are sensitive to alternative samples and measures. Source: Chinese Customs Database, 2000-2006.

The bottom panel shows the results after controlling for firm and product specific changes in supply conditions. Column (1) of the bottom panel shows results controlling changes in unit values of the continuing market. Although the magnitude of the coefficients is smaller, the changes in unit values are still positively correlated with the drop-to-change ratio even

after controlling for the unit value in those continuing markets. Column (2) of the bottom panel shows estimates controlling the mean quantity of continuing markets. Interestingly, the mean quantity changed the sign and become positively correlated with the drop-to-change ratio after controlling the mean quantity of continuing markets. These estimates suggest that, controlling the supply side changes of the firm and product, destinations with smaller demand are dropped from the set of the markets.

Column (3) of the bottom panel differs from the specification of column (2) in that the total quantity of the continuing markets are used as the control variable and the total quantity of all markets exported are used as the dependent variable. These coefficients suggest 1% increase in the drop-to-change ratio is associated with 105-168% drop in exported quantities.

3 A Global Macro Model with Variable Markups and Variable Markets

This section introduces a multi-country model with variable markups and variable markets. The model integrates two fundamental sources of markup variability, i.e., competition across producers as in Atkeson and Burstein (2008) (henceforth AB) and vertical interactions of producers and distributors as in Corsetti and Dedola (2005) (henceforth CD), drawing upon a multi-country model ($ABCD^H$) developed in my previous work in Corsetti, Crowley and Han (2018). I model variable markets by adding firm participation to the multi-country framework developed in Corsetti, Crowley and Han (2018), such that the set of markets that a firm serves varies endogenously with the demand conditions and the degree of competitiveness in each market. Specifically, I focus on the *per period* exporting decision of firms and discuss firms' optimal prices and markups under various demand assumptions and market structures. I use the model to explore the mechanisms behind the observed data patterns and their aggregate implications on the distribution of markups, trade volumes, and welfare.

3.1 Market Structure

The world consists of H countries, where countries are indexed by destination d. In each country, there are two sectors, one selling goods that can be traded across countries and the other selling non-tradable goods such as services. There is a continuum of unit mass of industries within the tradable goods sector. The nontradable goods sector provides services for retail distribution. The levels of aggregation of variables in the model are indicated by their subscripts. The most disaggregated variables have five dimensions with f, i, o, d, t

standing for firm, industry, origin, destination, and time respectively.

The final consumption $C_{d,t}$ and the price of the final consumption good $P_{d,t}$ in each country d in period t are aggregated over industries i:

$$C_{d,t} = \left[\int_i (C_{i,d,t})^{\frac{\eta-1}{\eta}} di\right]^{\frac{\eta}{\eta-1}}, \quad P_{d,t} = \left[\int_i (P_{i,d,t})^{1-\eta} di\right]^{\frac{1}{1-\eta}} \tag{1}$$

where $\eta > 1$ is the constant elasticity of substitution across industries. Within each industry, there are a finite number of domestic and foreign firms, each producing a differentiated variety. Each industry i produces by costlessly combining all the different varieties of goods characterized by the within-industry elasticity of substitution ρ across varieties, where ρ is strictly higher than cross-industry elasticity of substitution η.

In each period, the exporter from origin o meets a local retailer in country d and negotiates a price $\chi_{f,i,o,d,t}$ for distributing its product. As a result, the consumer price $p_{f,i,o,d,t}$ is equal to the sum of the border/producer price denominated in the local currency $p^b_{f,i,o,d,t}$ and the retail distribution cost $\chi_{f,i,o,d,t}$:

$$p_{f,i,o,d,t} = p^b_{f,i,o,d,t} + \chi_{f,i,o,d,t} \tag{2}$$

As in CD, I assume the distribution service is produced by the non-tradable goods sector.[30] Let $\theta_{f,i,o,d,t}$ denote the bargaining power of exporter f in destination d.[31] The retail distribution cost $\chi_{f,i,o,d,t}$ can be written as:

$$\chi_{f,i,o,d,t} = \theta_{f,i,o,d,t} mc_{N,d,t} \tag{3}$$

where $mc_{N,d,t}$ is the marginal cost of producing nontradable goods.

As shown in CD, the presence of a local cost component $\chi_{f,i,o,d,t}$ results in variable markups of border/producer prices since the demand elasticity with respect to the border/producer price, defined as $-\frac{\partial q_{f,i,o,d,t}}{\partial p^b_{f,i,o,d,t}} \frac{p^b_{f,i,o,d,t}}{q_{f,i,o,d,t}}$, is a decreasing function of the retail distribution margin:

$$dm_{f,i,o,d,t} \equiv \frac{\chi_{f,i,o,d,t}}{p^b_{f,i,o,d,t} + \chi_{f,i,o,d,t}} \tag{4}$$

$$-\frac{\partial q_{f,i,o,d,t}}{\partial p^b_{f,i,o,d,t}} \frac{p^b_{f,i,o,d,t}}{q_{f,i,o,d,t}} = \rho\left(1 - dm_{f,i,o,d,t}\right) \tag{5}$$

[30] Vertical interactions between producers and distributors are also emphasized by Burstein, Eichenbaum and Rebelo (2005) and Burstein, Eichenbaum and Rebelo (2007) in relation to the transmission of large devaluations into local prices.

[31] This paper abstracts away from the specific negotiation process. This result can be derived through a Nash bargaining process between producers and local retailers as in Drozd and Nosal (2012).

Intuitively, a larger distribution margin means a smaller weight on the producer price in the final consumer price, as can be seen from (2). Therefore, the change in the producer price has a smaller impact on demand.

The industry-level consumption $C_{i,d,t}$ and price $P_{i,d,t}$ are aggregated over firms from different origins:

$$C_{i,d,t} = \left[\sum_f \sum_o \left(\alpha_{f,i,o,d,t}\right)^{\frac{1}{\rho}} \left(q_{f,i,o,d,t}\right)^{\frac{\rho-1}{\rho}} \phi_{f,i,o,d,t}\right]^{\frac{\rho}{\rho-1}}$$
$$P_{i,d,t} = \left[\sum_f \sum_o \alpha_{f,i,o,d,t} (p_{f,i,o,d,t})^{1-\rho} \phi_{f,i,o,d,t}\right]^{\frac{1}{1-\rho}} \tag{6}$$

where $\alpha_{f,i,o,d,t} > 0$ is a taste/preference shifter[32] and $\phi_{f,i,o,d,t} \in \{0,1\}$ is a binary indicator of whether firm f in industry i from origin o chooses to sell in destination d at time t.

As I will discuss in more detail in section 4, I explore two types of exogenous idiosyncratic shocks that can generate within-firm market changes: (a) changes in preferences $\alpha_{f,i,o,d,t}$ and (b) changes in retail bargaining power $\theta_{f,i,o,d,t}$.

3.1.1 Price and Export Decisions

Firms compete by simultaneously choosing whether to enter a market, indicated by $\phi_{f,i,o,d,t}$ and if enter, the price[33] $p_{f,i,o,d,t}$ internalizing (i) their impact on the industry level price index $P_{i,d,t}$ and (ii) the retail distribution cost $\chi_{f,i,o,d,t}$ shown in (2). The production function is assumed to be constant returns to scale and hence firms make decisions for each destination separately. The profit maximization problem of firm f in industry i from origin o in destination d is given by:

$$\pi_{f,i,o,d,t} = \max_{p_{f,i,o,d,t}, \phi_{f,i,o,d,t}} \left[q_{f,i,o,d,t}(\mu^b_{f,i,o,d,t} - 1) mc_{f,i,o,t} - W_{o,t} F_x\right] \phi_{f,i,o,d,t}$$

[32] Bastos, Silva and Verhoogen (2018) find selling to richer destinations leads firms to raise the average quality of goods they produce and to purchase higher-quality inputs using detailed customs and firm-product-level data from Portugal. My model is currently absent from endogenous quality choices of firms.

[33] In this nested CES structure, the main theoretical result is not sensitive to whether firms compete in prices or quantities. AB show that similar expressions can be derived if firms are competing in quantities.

subject to

$$q_{f,i,o,d,t} = \alpha_{f,i,o,d,t} \left(\frac{p_{f,i,o,d,t}}{P_{i,d,t}} \right)^{-\rho} \left(\frac{P_{i,d,t}}{P_{d,t}} \right)^{-\eta} C_{d,t} \tag{7}$$

$$\mu^{b}_{f,i,o,d,t} = \frac{(p_{f,i,o,d,t} - \chi_{f,i,o,d,t}) e_{o,d,t}}{mc_{f,i,o,t} \tau_{o,d,t}} \tag{8}$$

where $\mu^{b}_{f,i,o,d,t}$ denotes the markup denominated in the exporter's currency, $W_{o,t}$ is the nominal wage in origin o at time t and F_x is a constant per-period export cost in terms of labor units. $W_{o,t}F_x$ is the per-period export cost in nominal terms. The firm will enter a market if the potential operating profit $q_{f,i,o,d,t}(\mu_{f,i,o,d,t} - 1)mc_{f,i,o,t}$ is larger than the fixed export cost $W_{o,t}F_x$. As shown in (8), the markup denominated in the exporter's currency equals the price denominated in the destination currency $p_{f,i,o,d,t}$ net of the distribution cost $\chi_{f,i,o,d,t}$, which is converted into exporter's currency and divided by the marginal cost $mc_{f,i,o,t}$ denominated in the exporter's currency taking into account the trade cost and tariffs $\tau_{o,d,t}$.[34] The nominal bilateral exchange rate $e_{o,d,t}$ is defined as units of currency of country o per unit of currency of country d at time t. An increase in $e_{o,d,t}$ means an appreciation of the destination country's currency.

Upon entry, the optimal consumer price $p_{k,i,o,d,t}$ for an exporter k from origin o to destination d denominated in the destination currency can be derived as:

$$p_{k,i,o,d,t} = \frac{\varepsilon_{k,i,o,d,t}(ms_{k,i,o,d,t})}{\varepsilon_{k,i,o,d,t}(ms_{k,i,o,d,t}) - 1} \left[\frac{mc_{k,i,o,t}\tau_{o,d,t}}{e_{o,d,t}} + \chi_{k,i,o,d,t} \right] \tag{9}$$

where $\varepsilon_{k,i,o,d,t}$ is the elasticity of demand with respect to the consumer price; and $ms_{k,i,o,d,t}$ is the market share of the exporter k in industry i of destination market d:

$$ms_{k,i,o,d,t} \equiv \frac{p_{k,i,o,d,t} q_{k,i,o,d,t}}{\sum_f \sum_o \phi_{f,i,o,d,t} p_{f,i,o,d,t} q_{f,i,o,d,t}} = \frac{\alpha_{k,i,o,d,t} p^{1-\rho}_{k,i,o,d,t}}{\sum_f \sum_o \phi_{f,i,o,d,t} \alpha_{f,i,o,d,t} (p_{f,i,o,d,t})^{1-\rho}}.$$

Note that $\varepsilon_{k,i,o,d,t}$ is not a constant but varies with the exporter's market share. Under the assumption that the elasticity of substitution is higher within an industry than cross industries ($\rho > \eta$), $\varepsilon_{k,i,o,d,t}$ is a strictly decreasing function of market share, i.e., bigger firms

[34] Note that the presence of local retail-distribution cost creates a wedge between border/producer price and the final consumer price. The markup thus can be defined in terms of the consumer price $p_{f,i,o,d,t}$, i.e., $\mu_{f,i,o,d,t} = \frac{p_{f,i,o,d,t} e_{o,d,t}}{mc_{f,i,o,t}\tau_{o,d,t}}$, or in terms of the border/producer price $p^{b}_{f,i,o,d,t}$ as shown in (8). Also note that all prices are defined in terms of the destination currency and all markups are defined as the producer's currency.

face a less elastic demand and charge a higher markup.

$$\varepsilon_{k,i,o,d,t} = (1 - ms_{k,i,o,d,t})\rho + ms_{k,i,o,d,t}\eta$$

The production and price decisions in the domestic market are symmetrically defined with a smaller fixed cost of operating in the domestic market, $F_h < F_x$.

3.1.2 Production

Labor is inelastically supplied and immobile across countries. Wages are assumed to be identical across sectors and industries in a given country. The production function is assumed to be linear in labour L and productivity Ω, i.e., $Y = F(\Omega, L) \equiv \Omega L$. The marginal cost of a firm in tradable sector $mc_{f,i,o,t}$ and nontradable sector $mc_{N,d,t}$ are:

$$mc_{f,i,o,t} = \frac{W_{o,t}}{\Omega_{f,i,o,t}}, \quad mc_{N,d,t} = \frac{W_{d,t}}{\Omega_{N,d,t}} \tag{10}$$

where $W_{o,t}$ and $W_{d,t}$ denote the nominal wage of the origin country and the destination country respectively. Similarly, $\Omega_{f,i,o,t}$ and $\Omega_{N,d,t}$ are firm's productivity in the tradable and nontradable sector respectively.

3.2 Variable Markets and Profit Heterogeneity

Let $\pi^*_{k,i,o,d,t+1}$ denote the potential profit of firm k in market d. The empirical measure, drop-to-change ratio, can be defined in the model as:

$$\text{DC Ratio} = \frac{\mathbb{1}(\pi^*_{k,i,o,d,t+1} < 0 \bigcap \pi^*_{k,i,o,d,t} > 0)}{\mathbb{1}(\pi^*_{k,i,o,d,t+1} < 0 \bigcap \pi^*_{k,i,o,d,t} > 0) + \mathbb{1}(\pi^*_{k,i,o,d,t+1} > 0 \bigcap \pi^*_{k,i,o,d,t} < 0)}$$

where the numerator represents the *ex ante* probability of market drop, i.e., the probability that market d was profitable in period t but no longer profitable in the period $t+1$; the denominator represents the probability of the market change, i.e., the probability of a market being dropped plus the probability of a market being added.

Note that the *ex ante* probability of a market being dropped can be approximated as:

$$\mathbb{1}(\pi^*_{k,i,o,d,t+1} < 0 \bigcap \pi^*_{k,i,o,d,t} > 0) \approx \mathbb{1}((1 + \widehat{\pi}^*_{k,i,o,d,t})\pi^*_{k,i,o,d,t} < 0 | \pi^*_{k,i,o,d,t} > 0)\mathbb{1}(\pi^*_{k,i,o,d,t} > 0)$$

where $\widehat{\pi}^*_{k,i,o,d,t} \approx \frac{\pi^*_{k,i,o,d,t+1} - \pi^*_{k,i,o,d,t}}{\pi^*_{k,i,o,d,t}}$ is the first order approximation of profit changes from t to $t+1$. A similar expression can be derived for the probability of a market being added in the denominator. As shown from the ex ante probability of dropping a market, for a given

distribution of period-t profits across destinations $\pi^*_{k,i,o,d,t}$, the key to understand market changes and the drop-to-change ratio is the change in potential profit $\widehat{\pi}^*_{k,i,o,d,t}$ and the factors behind it.

Let $\widehat{X}_t$ denote the first order approximation of changes in variable X from t to $t+1$, it is shown in Appendix B.3 that changes in the potential profit $\widehat{\pi}^*_{k,i,o,d,t}$ can be decomposed into:

$$\begin{aligned}\widehat{\pi}^*_{k,i,o,d,t} \propto \underbrace{\widehat{\alpha}_{k,i,o,d,t}}_{\text{taste}} - [\varepsilon_{k,i,o,d,t}(1-dm_{k,i,o,d,t})-1]\underbrace{\widehat{mc}_{k,o,d,t}}_{\text{marginal cost}} - \varepsilon_{k,i,o,d,t}dm_{k,i,o,d,t}\underbrace{\widehat{\chi}_{k,i,o,d,t}}_{\text{retail cost}} \\ - \frac{\rho-\eta}{\rho-1}\underbrace{\widehat{CE}_{k,i,o,d,t}}_{\text{competitors' effect}} + \underbrace{\varepsilon_{k,i,o,d,t}(1-dm_{k,i,o,d,t})\widehat{e}_{o,d,t} + \eta\widehat{P}_{d,t} + \widehat{C}_{d,t}}_{\text{local market conditions}} \end{aligned} \tag{11}$$

Equation (11) states that changes in the potential profit $\widehat{\pi}^*_{k,i,o,d,t}$ are proportional to changes in tastes, marginal cost, retail cost, industry level competition ($\widehat{CE}_{k,i,o,d,t}$), and local market conditions (i.e., changes in the bilateral exchange rates $\widehat{e}_{o,d,t}$, aggregate consumer price index $\widehat{P}_{d,t}$ and aggregate demand $\widehat{C}_{d,t}$). Among these factors, taste shocks transmit one-to-one into changes in potential profits, while shocks to marginal cost, retail cost and changes in bilateral exchange rates can have an elasticity bigger than one depending on the elasticity of demand with respect to the consumer price $\varepsilon_{k,i,o,d,t}$ and the distribution margin $dm_{k,i,o,d,t}$. In addition, the relative importance among changes in marginal cost, retail cost and bilateral exchange rate in affecting the change in potential profit depends on the distribution margin $dm_{k,i,o,d,t}$. As can be seen from the coefficients in equation (11), a larger distribution margin amplifies the effect of shocks to retail costs and dampens the effect of changing marginal costs and bilateral exchange rates.

A crucial component for understanding the firm's change in potential profit is how the degree of competition changes within an industry, which can be derived as

$$\begin{aligned}\widehat{CE}_{k,i,o,d,t} \equiv \sum_{o'}\sum_{f\neq k}\phi_{f,i,o',d,t+1}\phi_{f,i,o',d,t}ms_{f,i,o',d,t}(1-\rho)\left[\begin{array}{c}(1-\omega_{f,i,o',d,t})(\widehat{mc}_{f,i,o',t}-\widehat{e}_{o',d,t})+ \\ \omega_{f,i,o',d,t}\widehat{\chi}_{f,i,o',d,t}+\kappa_{f,i,o',d,t}\widehat{ms}_{f,i,o',d,t}\end{array}\right] \\ + \sum_{o'}\sum_{f\neq k}\phi_{f,i,o',d,t+1}(1-\phi_{f,i,o',d,t})ms_{f,i,o',d,t+1} \\ - \sum_{o'}\sum_{f\neq k}(1-\phi_{f,i,o',d,t+1})\phi_{f,i,o',d,t}ms_{f,i,o',d,t}\end{aligned} \tag{12}$$

where $\omega_{k,i,o,d,t} \in [0,1)$ is the cost share of retail distribution and captures the degree of local integration; $\kappa_{k,i,o,d,t} > 0$ is the price elasticity with respect to a firm's own market share, which strictly decreases in the demand elasticity, $\varepsilon_{k,i,o,d,t}$, and strictly increases in the

exporter's market share, $ms_{k,i,o,d,t}$.[35]

The first line of expression (12) shows changes in the continuning exporters govened by not only of direct factors such as the marginal cost and retail cost, but also of indirect factors such as bilateral exchange rate movements as well as the productivity changes of all other trade partners, weighted by a non-linear function of competitors' market share. The second and third lines represent the effect of new entrants and exitors respectively. The relative importance of each competitor is determined by the its market share.

It is worth noting that the channel of multilateral shock transmissions is typically neglected by open macro theory, as the vast majority of models assume a two-country framework. In principle, firms' responses to shocks and the resulting distribution of variables (e.g., markups and market share) could be quantitatively very different in a two-country versus three-country model with variable markups. As recent studies (e.g., De Blas and Russ (2015)) start quantifying this changes, this paper provides a full analysis of how intensive and extensive margins contribute to this difference.

The channel of competition among firms partly operates via the changes in the desired markups. The markup change in the exporter's currency $\widehat{\mu}^{b*}_{k,i,o,d,t}$ is determined by both direct and indirect factors. Direct factors impact upon the production, retail and economic condition of the producer from the origin country o, while indirect factors capture the changes in the production, retail and economic condition of the competitors of the firm $\widehat{CE}_{k,i,o,d,t}$. More specifically, direct factors include changes in the bilateral exchange rate $\widehat{e}_{o,d,t}$, firm's own margin cost $\widehat{mc}_{k,i,o,t}$, and retail distribution cost $\widehat{\chi}_{k,i,o,d,t}$.

$$\widehat{\mu}^{b*}_{k,i,o,d,t} = \frac{1}{1-dm_{k,i,o,d,t}} \left\{ \begin{array}{l} (1-\lambda_{k,i,o,d,t})\kappa_{k,i,o,d,t}(1-ms_{k,i,o,d,t})\widehat{\alpha}_{k,i,o,d,t} \\ -(1-\lambda_{k,i,o,d,t})\kappa_{k,i,o,d,t}\widehat{CE}_{k,i,o,d,t} \\ +[(1-\lambda_{k,i,o,d,t})\omega_{k,i,o,d,t} - dm_{k,i,o,d,t}]\widehat{\chi}_{k,i,o,d,t} \\ +\left[1-(1-\lambda_{k,i,o,d,t})(1-\omega_{k,i,o,d,t}) - dm_{k,i,o,d,t}\right](\widehat{e}_{o,d,t} - \widehat{mc}_{k,i,o,t}) \end{array} \right\} \tag{13}$$

where $\lambda_{k,i,o,d,t} \equiv 1 - \frac{1}{1-(1-ms_{k,i,o,d,t})(1-\rho)\kappa_{k,i,o,d,t}} \in [0,1)$ captures the degree of competition among firms. According to (13), a larger retail distribution margin $dm_{k,i,o,d,t}$ amplifies the effect of taste and competitors' shocks. However, a larger retail distribution margin attenu-

[35] Defination of these two terms are given below:

$$\text{degree of local integration} \quad \omega_{k,i,o,d,t} \equiv \frac{\chi_{f,i,o,d,t}e_{o,d,t}}{mc_{k,i,o,t} + \chi_{f,i,o,d,t}e_{o,d,t}}$$

$$\text{price elasticity to market share} \quad \kappa_{k,i,o,d,t} \equiv \frac{\partial p_{k,i,o,d,t}}{\partial ms_{k,i,o,d,t}} \frac{ms_{k,i,o,d,t}}{p_{k,i,o,d,t}} = \frac{\rho - \varepsilon_{k,i,o,d,t}}{(\varepsilon_{k,i,o,d,t})^2 - \varepsilon_{k,i,o,d,t}}$$

ates the effect of direct shocks (i.e., $\widehat{e}_{o,d,t}, \widehat{mc}_{k,i,o,t}, \widehat{\chi}_{f,i,o,d,t}$) and even reserves the sign if the distribution margin is big enough.[36] As can be seen from the last term in the bracket of (13), the pass through of exchange rate fluctuations $\widehat{e}_{o,d,t}$ and marginal cost shocks $\widehat{mc}_{k,i,o,t}$ is incomplete if $dm_{k,i,o,d,t} \neq 0$ or $\lambda_{k,i,o,d,t} \neq 0$.

4 The Model at Work: Global Implications of Productivity Shocks and a Bilateral Trade War

The $ABCD^H$ model with endogenous entry can be used to gain key insights into firms' exporting and pricing decisions in the face of multilateral competition, and their implications for the welfare allocations.[37] To illustrate the main mechanisms and features of the model, I focus on extensive and intensive margin adjustments in two scenarios: (i) aggregate productivity shocks to firms in the third country that both impinge on the equilibrium currency rates and generate changes in the residual demand for the products of competitors around the world; and (ii) a bilateral trade war where there is a sudden increase in bilateral tariff rates.

Calibration of the model is discussed in Appendix B.1. Throughout the analyses that follow, I assume financial autarky, hence bilateral exchange rates are determined by the balance of trade condition.

4.1 Third-country Productivity Shocks

I first describe the transmission of country-specific productivity shocks. In a three-country framework, this implies variation in the residual demand for the products of foreign firms in all markets. Specifically, I simulate the $ABCD^H$ model for three symmetric countries (A, B, C) and two time periods. In the first period, the model is at its competitive equilibrium. In the second period, there is a 10% positive aggregate productivity shock to country B, i.e., the productivity of all firms in country B rises by 10%.

Table 6 shows the market change measures and intensive and extensive margin adjustments for firms from all three countries. Countries are symmetric *ex ante*, and therefore country C and country A have very similar responses. I focus on the responses of country B

[36] Note that $\frac{a-x}{1-x}$ is strictly decreasing in $x \in [0,1)$ for $a \in [0,1)$. For example, for $\widehat{e}_{o,d,t}$, $a = [1-(1-\lambda_{k,i,o,d,t})(1-\omega_{k,i,o,d,t})]$ and $x = dm_{k,i,o,d,t}$

[37] In related work, Corsetti, Crowley and Han (2018), we show that the $ABCD^H$ model provides a superior fit to the intensive margin pricing and quantity behaviour of multi-country exporters that is captured by the destination-specific markup elasticity (DSME) and cross-market supply elasticity (CMSE) developed in Corsetti, Crowley, Han and Song (2018) relative to the three alternatives AB, CD, and CES. In this paper, I focus the mechanisms of endogenous entry and exit by firms.

and C. After the shock, firms in B become more competitive, so more of them find it optimal to export to A and C, resulting in a higher value of total exports that adds appreciatory pressure to country B's currency. To keep trade balanced, the currency of country B appreciates against the other two countries. Exporters from A and C face a cost advantage in B due to the appreciation despite the fact that B's domestic firms are more productive. As a result, more firms from A and C start selling to B. At the same time, exporters from A selling in C (and exporters from C selling in A) face more competitive pressure from B's exporters. Due to more intense competition in countries A and C, some of A's exporters selling in C (and some of C's exporters selling in A) become less profitable and exit the market. As shown in Table 6, on average, A and C import more, whereas country B imports less.

Table 6: In response to a 10% increase in aggregate productivity in country B
Model: $ABCD^H$ with variable markets

	A or C	B
Market Change Measures		
Market Changes / Markets * 100	8.7	6.9
Market Drop / Market Changes * 100	9.4	0.0
Probability of Churn	3.1	0.0
Percentage Changes in Intensive and Extensive Margins		
Import Share	1.0	-0.6
Number of Exporters (Destination 1)	-0.7	3.5
Number of Exporters (Destination 2)	8.2	3.6

Note: This table presents responses of variables to a 10% increase in aggregate productivity in country B under the calibration for the benchmark model. Destination 1 of exporters from A and C refers to C and A respectively. Destination 2 of exporters from A and C refers to B.

The discussion of this section has not touched upon the interesting markup adjustments that take place in response to third country productivity shocks. In the following subsection, I use a bilateral trade war scenario to provide a more in-depth discussion focusing on the interdependence among firms' exporting choices and the distribution of markups.

4.2 Bilateral Trade War

In this section, I investigate a bilateral trade war and quantify the importance of market changes on price setting and trade flows in a multi-country framework. Specifically, I compare the responses of a number of variables across four different models: (i) variable markups and variable markets; (ii) variable markups and fixed markets, (iii) constant markups and variable markets and (iv) constant markups and fixed markets.

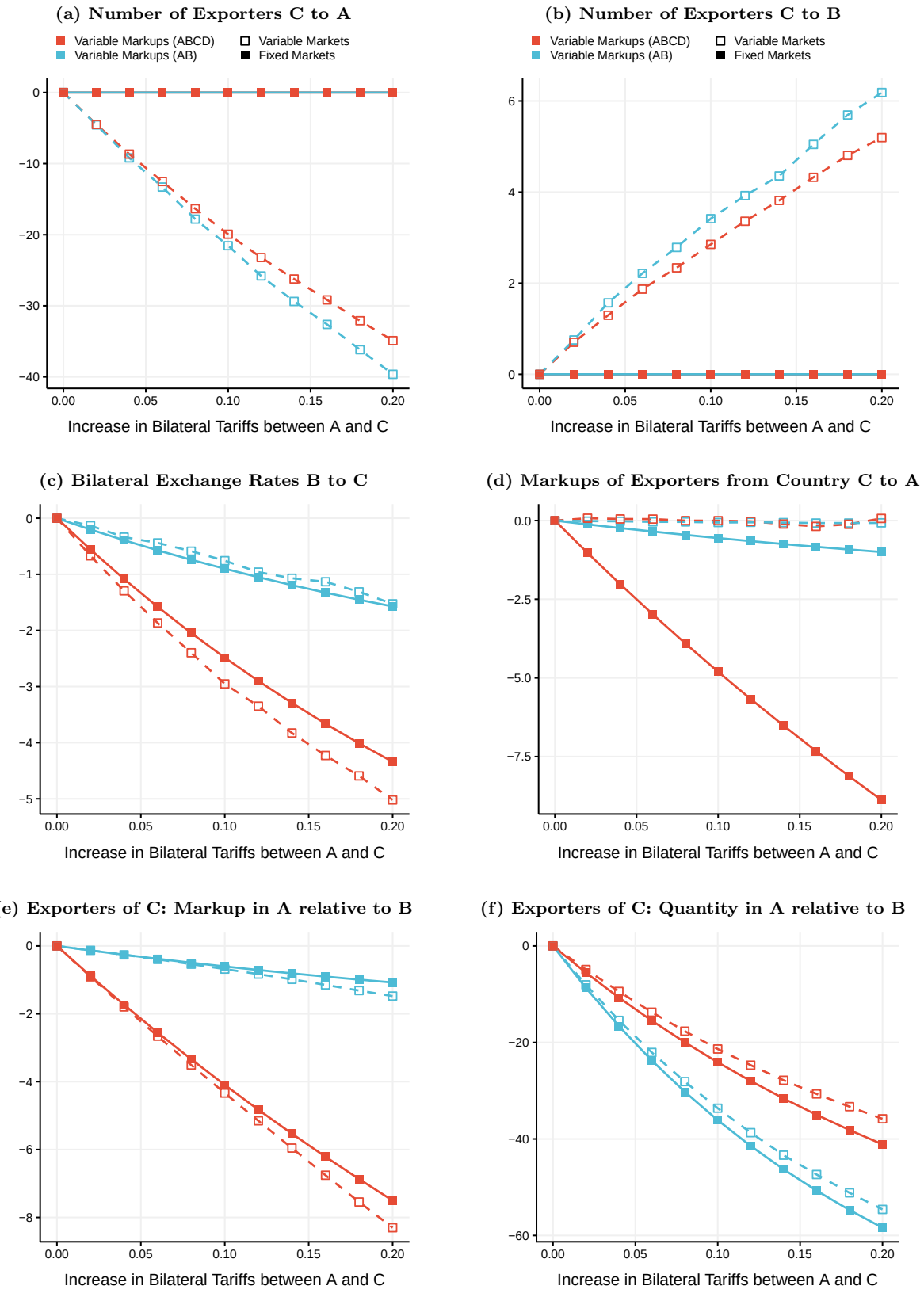
I use the $ABCD^H$ model as the benchmark model of variable markups. For comparison, I simulate a simpler CES version of model in which firms facing a nested CES demand compete monopolistically in the absence of any distribution sector (i.e., the distribution margin is set to zero). Firms in this model charge a constant markup and hence the model abstracts away from pro-competitive effects of trade policy changes. For each model, two versions are compared. In the first version with fixed markets, the set of firms in each market is determined before the trade war begins and firms remain stuck in these markets after any trade policy changes are introduced. In the second version with variable markets, firms can optimally enter and exit to different markets.

To study a bilateral trade war in a multi-country world, I simulate models of three symmetric countries for two periods. In the first time period, firms in each model reach their competitive equilibrium. In the second period, there is a sudden increase in bilateral tariffs between A and C: $\Delta\tau_{A,C} = \Delta\tau_{C,A}$. I study the percentage changes of variables between these two time periods. I focus on the responses of exporters from country C, noting the responses of exporters from country A are symmetric to C. Figure 3 shows the percentage change in the number of exporters, the bilateral exchange rates, the average markup and quantities of exporters from country C.

Subfigures (a) and (b) show adjustments along two extensive margins. The sudden increase in bilateral tariffs has two effects on the international trade flows: a direct trade destruction effect where the number of exporters from C to A decreases and an indirect trade deflection effect where the number of exporters from C to B increases. The trade destruction result is intuitive. As a result of the increase in bilateral tariffs, the costs for exporters from C selling in A are higher, thus these exporters are less profitable and the least competitive exporters exit.

The trade deflection results are less straightforward and are generated through general equilibrium effects in a multi-country framework. As shown in subfigure (c), the currency of B appreciates against C (and also A). This is due to the increase in bilateral tariffs between A and C reducing the demand for each others' goods (as their products are relatively more expensive) and increasing the demand of firms from country B. The currency of B appreciates to keep trade balanced.

Figure 3: In response to a sudden increase in bilateral tariffs between A and C



Note: The y axis indicates the percentage changes of variables between two time periods.

Both trade destruction and trade deflection effects are stronger in a model with constant markups. In a model with only monopolistic competition among firms and no distribution margin, the increase in the tariffs are fully passed through to the price of consumers. As a result, the demand for the product drops more compared to the case where producers optimally adjust their markups. A lower quantity is sold and exporters selling from A into C make lower profits; the least efficient firms stop exporting along their bilateral route.

To summarize the contribution of the $ABCD^H$ model to understanding the extensive margin, the loss of profit is smaller and therefore the drop in the number of exporters from A to C is smaller. Therefore, the number of exporters from C to A decreases more with constant markups. Statistics on these adjustments are given by Table 15 in the appendix.

I now turn to the intensive margin, focusing on the differences in markup changes between the variable and fixed market models. Subfigure (d) shows the average markups for exporters selling from C into A. If the set of firms serving each market does not change, exporters of C optimally reduce markups in A to minimise losses. Allowing firms to enter and exit brings in two additional effects. (i) A selection effect: only very productive firms continues exporting to A after the increase in tariff. These firms are larger and charge higher markups. Therefore, the average markup goes up. (ii) A competition effect: the surviving exporters that continue selling from C into A will have a different markup adjustment through a combination of the following channels: (a) less competition due to exits of less productive exporters from C and (b) more competition due to entry by exporters from B into A. In equilibrium, channels (i) and (ii a) outweigh (ii b), and the average markup increases.

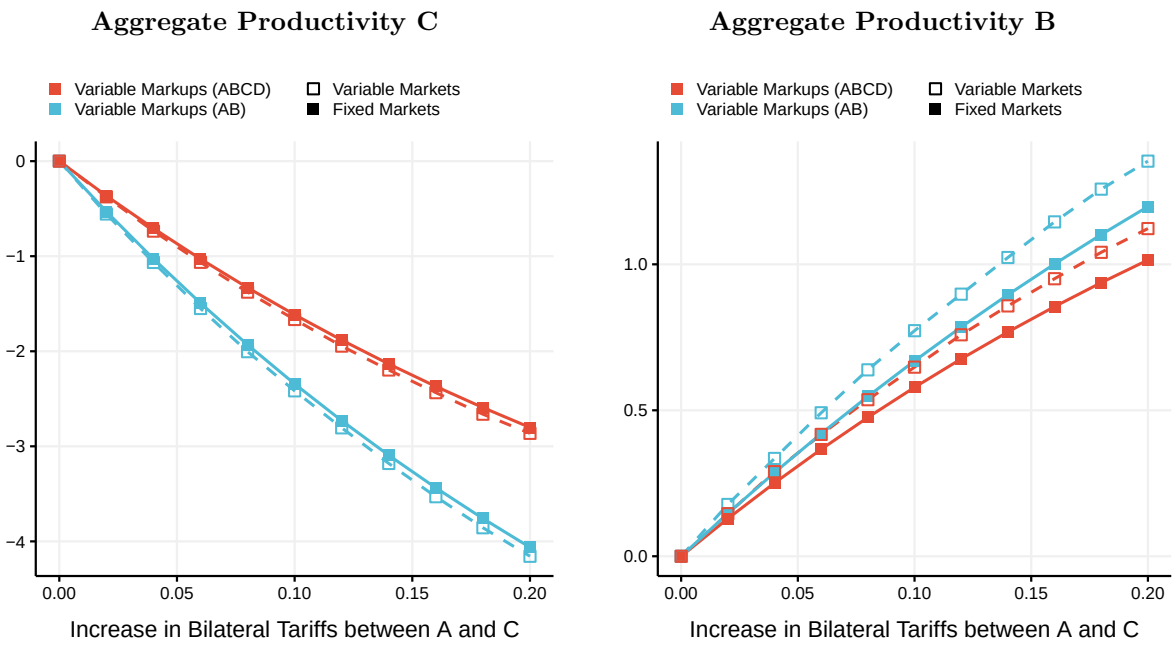
The last two subfigures (e) and (f) present changes in relative markups and quantities for exporters of C selling to both A and B. The relative markup (A relative B) drops as the bilateral tariff increases. The tariff pass through rate into (relative) markups is around 55%. The pass through rate is larger with variable markets. The quantity sold to A decreases relative to B in all models. The decrease is smallest when firms optimally adjust their markups and reallocate their outputs.

Figure 4 shows the impact of the bilateral war on aggregate productivity.[38] The aggregate productivity of country C drops as a consequence of less trade between C and B. Consistent to responses of intensive and extensive margins, the model with variable markups are less affected by the trade war. The models with variable markets predict a much smaller decrease — market A is more competitive if less productive exporters from B cannot exit. Notably, the aggregate productivity of B unambiguously increases. The increase in larger with constant markups and variable markets — more firms from A and C choose to export to B if firms

[38]Following Edmond, Midrigan and Xu (2015), the aggregate productivity is quantity weighted productivity of individual firms; see Appendix B.2 for more details.

are free to enter and exit. Although allowing firms to change their markets only has small impacts on aggregate productivity for countries involved in the trade war, the model predicts sizeable differences in aggregate productivity gains of the countries not involved in the trade war. The differences in responses between fixed markets and variable markets are given by Table 7.

Figure 4: Changes in Aggregate Productivity



Note: The y axis indicates the percentage changes of variables between two time periods.

Table 7: Percentage Differences in Responses between Fixed and Variable Markets

Model	Aggregate Productivity C	Aggregate Productivity B
$ABCD^3$	1-2%	10-13%
AB^3	2-3%	5-9%

Note: Calculation based on the average of 10 simulations under the benchmark calibration.

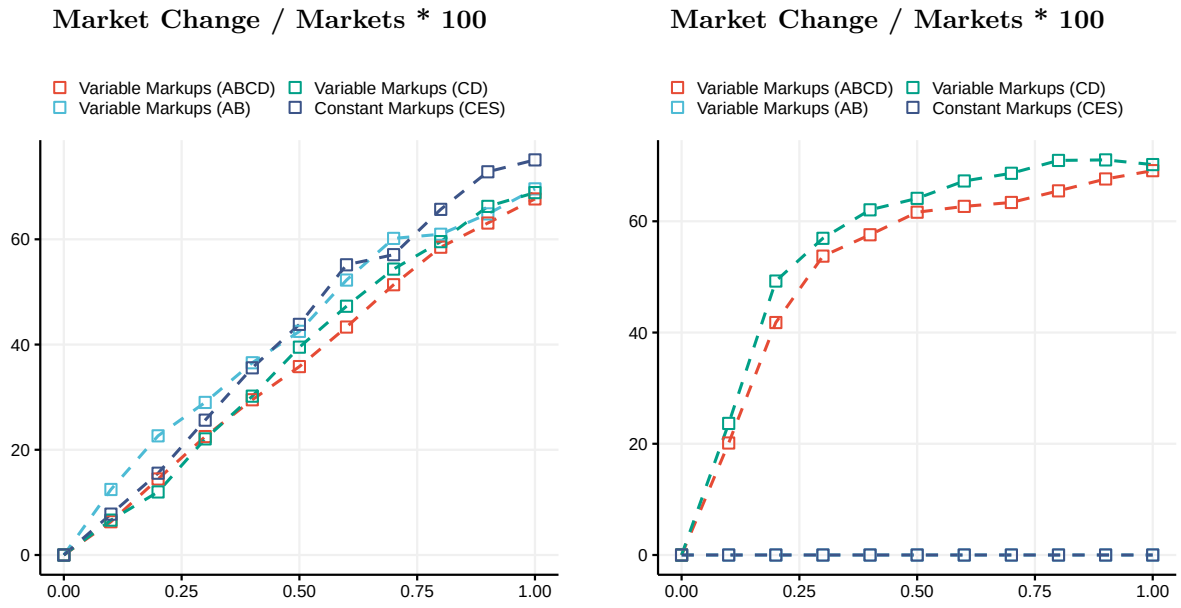
5 A Better Fit: Idiosyncratic Shocks and Aggregate Implications

I investigate the role of idiosyncratic taste shocks and retail-distribution cost shocks in driving large within-firm market changes. I compare results from a three-country $ABCD^H$ model

with variable markets to results obtained from three alternative models with endogenous entry, i.e., AB model, CD model and CES model. Notably, this is the first paper to extend these modelling frameworks to three countries with endogenous entry and exit.

Specifically, I simulate all four models for two periods over a range of dispersions for the tastes and firms' retail bargaining power.[39] For each firm, product, destination and time, I draw taste shocks $\alpha_{f,i,o,d,t}$ from a lognormal distribution $Lognormal(-\mu_\alpha, 2\mu_\alpha)$. The mean of the taste shocks is one and the dispersion of taste shocks is governed by the variance $2\mu_\alpha$. In my experiments, I gradually increase the dispersion of the taste shocks, which in turn raises the dispersion of the distribution of firm profits across destinations. Similarly, I model retail cost heterogeneity by drawing the retail bargaining parameter from a lognormal distribution, i.e., $\theta_{f,i,o,d,t} \sim 2 * Lognormal(-\mu_\theta, 2\mu_\theta)$, for each firm, product, destination and time. An increase in $\theta_{f,i,o,d,t}$ leads to a higher distribution margin and therefore lowers the profitability of the exporter. As a result, a larger dispersion of retail bargaining power will increase the dispersion of exporters' profits across destinations.

Figure 5: Exogenous Shocks that Lead to Market Changes



(a) Size of Preference Shock, μ_α

(b) Size of Retail Shock, μ_θ

Note: This figure presents simulation results from four different 3-country models with endogneous entry and exit, namely $ABCD^H$, AB, CD and CES. The y axis indicates the percentage changes of variables between two time periods.

Figure 5 shows the simulation results for the four distinct models under the benchmark calibration. The left panel shows how the ratio of a firm's market changes to the total

[39] Dispersion refers to the variance of the distribution for taste or firms' retail bargaining power.

number of market served increases with the size of the preference shock. All four models yield increases in the share of market changes as the dispersion of idiosyncratic shocks to taste increase. Somewhat surprisingly, although the responses of individual firms to taste shocks very considerably across the four models (in three of which firms have variable markups and a fourth in which markups are constant), the patterns of entry and exit are remarkably similar under full general equilibrium. This is somewhat counter-intuitive when we consider the experiment in a partial equilibrium model of variable markups. For example, in the partial equilibrium analysis of horizontal competition (AB channel), the effect of an idiosyncratic taste shock on firms' profits should be smaller than that in a CES model as firms optimally adjust their markups.[40] However, this is not the case in a general equilibrium environment where the taste shocks are given to all firms in the economy.

A more dispersed distribution of taste shocks implies that many firms simultaneously face large idiosyncratic taste changes. In equilibrium, the market share effects that exist in a partial equilibrium setting are largely cancelled out among firms and there is no substantial difference in entry and exit ratios. For instance, a positive taste shock to a large firm in an AB world creates two effects: first, a taste shock leads the firm to increase its markup; second, this taste shock leads the firm's smaller competitors to reduce their output and market share.

By the same token, as shown in (b), shocks to retail bargaining power drive market changes. A higher retail bargaining power increases the total cost of delivering a product to the consumer and changes the competitiveness of a firm in a market. These firms optimally further adjust their markups to remain competitive and avoid big losses in demand. Comparing to the CD model, the $ABCD^H$ model also takes into account the effect of the horizontal competition among firms (AB channel). The effect of the retail shock is slightly smaller when taking into account this horizontal competition among firms.[41] Both types of shocks are able to generate substantial market changes.

While the difference in the magnitude of generated the market changes is small across the four models, welfare implications can be quite different, especially when compared to the model with constant markups. As a result of competition among firms, the optimal markup is a function of market shares. Idiosyncratic taste shocks changing the distribution of market shares across firms inevitably affecting the distribution of markups. Similarly, shocks to local

[40] A larger positive taste shock increases the market share of the firm, lowers its price elasticity of demand so that it increases its desired markup, which in turn lowers demand for its output. At the same time, the market share of its competitors declines, they lower their markups, which in turn, further lowers the firm's demand. Therefore, horizontal competition à la Atkeson and Burstein (2008) should attenuate the effect of an idiosyncratic taste shock.

[41] The difference is small because the effect of retail shocks largely cancel out with each other.

retail bargaining power affect the relative markups of foreign producers and local firms, and alter the distribution of markups (in terms of producer prices). Despite the idiosyncratic nature of the shocks, and their distortionary effects, on average a country can either benefit or lose ex post, depending on the realized values of the disturbances. Simulation results are shown in Figure 12 in Appendix B.5.

6 Conclusions

Firms frequently change the set of destinations to which they export their products—their international trade is characterized by what I call a 'mutable geography.' This dynamism of market changes observed is not merely an artefact of early stages in a firm's growth in global markets. It is actually detectable among established exporters. A substantial proportion of market changes involves simultaneously adding and dropping export markets. By creating new empirical measures on changes in trade patterns, I find 20% of within-firm market changes are driven by fluctuations in local market conditions, proxied by movements of bilateral exchange rates and local CPI changes. These market changes are important in understanding international prices and aggregate trade patterns since the direction of market changes — the number of markets dropped over the number of markets changed — are highly correlated with firms' price and quantity decisions across destinations.

I find incorporating multi-country competition is the key to understanding these within-firm market changes. I build a multi-country general equilibrium model where firms optimally choose which destinations to sell to and adjust their markups according to the degree of competition in the destination market. The model shows that large fluctuations in a third country, such as productivity shocks, are an important source of fluctuations of a firm's destination-specific residual demand and can generate substantial within-firm market changes. To illustrate the mechanisms of the model, I apply the model to a bilateral trade war: aggregate productivity for countries directly involved in the trade war drops more (1-2%) and that of countries not involved rises more (8-10%) when firms endogenously vary their markets in response to the new conditions of competition in local markets induced by the direct and indirect consequences of the bilateral trade war. While the current model is abstracted away from the currency of invoicing, monetary policies and their spillover effects,[42] a multi-country model with variable markets and variable markups potentially provides new perspectives in analyzing classic questions.[43]

[42] Burstein and Gopinath (2014) and Corsetti, Dedola and Leduc (2010) provide a recent review of the empirical and policy literature.

[43] Related questions range from imported inflation and the consequences of large depreciations to efficiency losses from currency misalignments to the design of stabilization policy in an open economy (see, e.g.,

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A Empirical Measures and Robustness Checks

A.1 Constructing measures of relative changes in local market conditions

To understand whether market changes are related to changes in relative market conditions, I construct the following relative market condition measures focusing on the markets that has changed as illustrated in Figure 6.

Figure 6: Constructing firm-product level measures of changes in local market conditions (focusing on those markets changed)

					Continuing Markets	**Markets Changed**	**Changes in Relative Exchange Rates**
$t=1$	A	$\boxed{B}$	$\boxed{C}$		$-$	$-$	$-$
$t=2$	A	$\boxed{B}$	$\boxed{C}$	$\boxed{D}$	A	B, C	$log(e_{C,2}/e_{C,1}) - log(e_{B,2}/e_{B,1})$
$t=3$	A		C	$\boxed{D}$	A, C	D	$log(e_{D,3}/e_{D,2})$
$t=4$	A		C	$\boxed{D}$	A, C	D	$-log(e_{D,4}/e_{D,3})$

Note: Circled cells mark the variation used to construct the augmented exchange rate variable. Dashed circles indicate auxiliary cells with no transaction observed. The same method is used to construct relative changes in destination CPI.

The relative change in bilateral exchange rates are constructed by taking the relative changes in exchange rates for those markets have been added relative to those markets have been dropped. Specifically, to construct a compatible measure that can be used for both market entry and exit, I multiply $+1$ for exchange rate changes associated with those market being added and -1 for exchange rate changes associated with those markets being dropped. Relative local CPI changes are constructed in the same way as the relative bilateral exchange rates.

A.2 Characterizing Market Changes and Pricing

This subsection introduces the measures that have been used to characterize the relationship among firm's pricing and switching decisions. Regarding measures of pricing strategies, I focus on changes in unit value, mean quantity and total quantity over time. The main switching measure is the drop-to-change ratio (DC ratio). The main estimation equation

is illustrated in Figure 7. The estimation equation captures the relationship between time variations of changes in unit value and quantity measures and the drop-to-change ratio. Note that the drop-to-change ratio is already a change measure and therefore no further time differences need to be taken.

					Changes in Unit Value	**Drops/Changes (DC ratio)**
$t=1$	A	B			$-$	$-$
$t=2$	A		C		$p_{AC,2} - p_{AB,1}$	$1/2$
$t=3$	A		C	D	$p_{ACD,3} - p_{AC,2}$	$0/1$
$t=4$	A		C		$p_{AC,4} - p_{ACD,3}$	$1/1$

Figure 7: Illustration of the Estimation Equation

Note: $p_{TP,t}$ represents the logged unit value for the set of countries TP in period t.

Unit Value: the total trade value divided by the total quantity across all destinations at the firm-product level in period t. Mean Quantity: the total quantity sold at time t divided by the number of destinations at time t. Total Quantity: the total quantity sold at the firm-product level in period t. Drop-to-Change (DC) Ratio: Main variable of interest. The number of markets dropped over the number of market changes from $t-1$ to t at the firm-product level.

One concern of the previous specification is that the change of unit values or quantities could be mainly driven by the changes in continuing markets rather than the switching markets. To address this concern, I construct controls for continuing market variables as illustrated in Figure 8.

					Changes in the Unit Value of Continuing Markets
$t=1$	A	B			$-$
$t=2$	A		C		$\log(V_{A,2}/Q_{A,2}) - \log(V_{A,1}/Q_{A,1})$
$t=3$	A		C	D	$\log[(V_{A,3}+V_{C,3})/(Q_{A,3}+Q_{C,3})]$ $-\log[(V_{A,2}+V_{C,2})/(Q_{A,2}+Q_{C,2})]$
$t=4$	A		C		$\log[(V_{A,4}+V_{C,4})/(Q_{A,4}+Q_{C,4})]$ $-\log[(V_{A,3}+V_{C,3})/(Q_{A,3}+Q_{C,3})]$

Figure 8: Construction of Controls of Continuing Markets

Note: V and Q represent the trade value denominated in sterling and the quantity traded respectively.

Mean Quantity of Continuing Markets (MQCM): the total quantity sold at continuing markets divided by the number of continuing markets in period t. Unit Value of Continuing Markets (UVCM): the total trade value divided by the total quantity among continuing markets in period t.

Results of table 8 characterises the relationship between the proportion of markets being dropped and the unit value and mean quantity of continuing markets. As shown from the table, quantity of the continuing markets is significantly lower if more markets are dropped conditional on a market change. However, the changes in unit value of these markets is only weekly related to the proportion of markets being dropped. The statistical significance of unit value coefficients sensitive to the estimation sample. The magnitude of unit value changes is small.

Table 8: Price and Quantity of Continuing Markets to DC Ratio
(Summary of Key Estimates, China Results)

	Unit Value	Mean Quantity	Observations
Firm-product (8-digit) level	0.01***†	-0.65***	1,244,580
Firm-sector (2-digit) level	0.03***†	-0.73***	731,199
Firm level	0.05***†	-0.73***	281,564

Note: This table shows estimates from regressing changes in the unit value or mean quantity of continuing markets on the drop-to-change ratio. The upper and lower panel shows results using count and value measure of drop-change ratio respectively. The subsections of the first column indicate the level of disaggregation at which the trade pattern measures are constructed. Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. † indicates the estimate is sensitive to alternative samples and measurements.

A.3 Market Changes and Distance

Table 9 shows that the drop-to-change ratio is negatively correlated to the mean distance of trading markets, suggesting longer distance markets are more likely to be dropped.

Mean distance refers to the geographical distance between China and its trade partners. It is calculated as the total distance of all trade partners divided by the total number of markets at the firm-product level in period t.

Table 9: Regressing Mean Distance on DC Ratio

	Mean Distance	Within R^2	Observations
Count Measure			
Firm-product (8-digit) level	-0.16***	0.01	1,791,353
Firm-sector (2-digit) level	-0.13***	0.01	875,096
Firm level	-0.20***	0.04	301,455
Value Measure			
Firm-product (8-digit) level	-0.13***	0.01	1,791,353
Firm-sector (2-digit) level	-0.13***	0.01	875,095
Firm level	-0.15***	0.03	301,455

Note: This table shows estimates from regressing changes in average distance of trading markets on the drop-to-change ratio. The upper panel shows results using non-weighted drop-change ratio as the dependent variable and the bottom panels shows results using trade weighted drop-change ratio as the dependent variable. The subsections of the first column indicate the level of disaggregation at which the trade pattern measures are constructed. Firm-product and year fixed effects are added for firm-product and firm-sector specifications. Firm and year fixed effects are added for firm level specifications. The statistical significance is calculated based on robust standard errors with ***, **, * representing statistical significance at 1%, 5%, 10% respectively. Source: Chinese Customs Database, 2000-2006.

A.4 Distribution of Constructed Measures

The following tables give details on the distribution of constructed statistics of Chinese exporters. An extensive study on alternative samples and measures are reported in the online appendices.

Table 10: All Sectors - All Firms
Trade patterns are calculated at the firm-product(8-digit HS)-year level

			Distribution (Percentile)				
	Mean	Median	1st	25th	75th	99th	Observations
Number of Destination Markets	2.79	1.00	1.00	1.00	3.00	21.00	6,042,767
Number of Market Changes/ Number of Markets	0.95	0.67	0.00	0.00	1.50	5.00	3,662,453
Market Changes/ Markets (Value Measure)	8092.44	0.65	0.00	0.00	13.33	12465.22	3,658,615
Market Drop/ Market Changes	0.47	0.50	0.00	0.20	0.67	1.00	2,469,771
Market Drop/ Market Changes (Value Measure)	0.48	0.38	0.00	0.00	1.00	1.00	2,189,105
Probability of Churn	0.26	0.26	0.00	0.04	0.43	0.69	6,042,767

Source: Chinese Customs Database, 2000-2006.

Table 11: All Sectors - Large Firms
Trade patterns are calculated at the firm-product(8-digit HS)-year level

			Distribution (Percentile)				
	Mean	Median	1st	25th	75th	99th	Observations
Number of Destination Markets	4.67	2.00	1.00	1.00	5.00	31.00	1,795,746
Number of Market Changes/ Number of Markets	0.84	0.64	0.00	0.00	1.00	5.00	1,319,763
Market Changes/ Markets (Value Measure)	22119.43	2.21	0.00	0.00	18.13	32511.96	1,319,403
Market Drop/ Market Changes	0.45	0.50	0.00	0.13	0.70	1.00	974,393
Market Drop/ Market Changes (Value Measure)	0.44	0.35	0.00	0.01	0.90	1.00	974,393
Probability of Churn	0.33	0.33	0.00	0.04	0.54	0.83	1,795,746

This table represents calculations based on trading patterns of a restricted sample of large firms by trade values. Specifically, I restrict the sample to firms with trade values above the 50th percentile measured at 8-digit HS level across all years (2000-2006). Source: Chinese Customs Database, 2000-2006.

Table 12: By Industries (Median)
Trade patterns are calculated at the firm-product(8-digit HS)-year level

	Market Changes / Markets		Market Drops / Market Changes		Probability of Churn	Observations
		Value Measure		Value Measure		
1-5 Live animals; animal products	0.00	0.00	0.50	0.51	0.06	44,882
6-14 Vegetable products	0.00	0.00	0.50	0.46	0.06	134,952
15 Animal/vegetable fats	0.33	0.40	0.50	0.45	0.00	2,282
16-24 Prepared foodstuffs	0.00	0.00	0.50	0.41	0.03	85,874
25-27 Mineral products	0.25	0.00	0.50	0.45	0.09	32,180
28-38 Products of chemical and allied industries	0.61	3.33	0.50	0.44	0.25	379,742
39-40 Plastics/rubber articles	0.83	5.36	0.50	0.41	0.31	401,840
41-43 Rawhides/leather articles, furs	0.90	4.39	0.50	0.45	0.33	179,972
44-46 Wood and articles of wood	0.59	2.12	0.50	0.44	0.22	126,662
47-49 Pulp of wood/other fibrous cellulosic material	0.80	3.77	0.50	0.38	0.27	154,438
50-63 Textile and textile articles	0.67	3.65	0.50	0.42	0.25	1,620,660
64-67 Footwear, headgear, etc.	0.86	3.94	0.50	0.45	0.33	200,537
68-70 Misc. manufactured articles	0.75	2.21	0.50	0.42	0.27	230,100
71 Precious or semiprec. stones	0.80	4.55	0.50	0.39	0.20	25,929
72-83 Base metals and articles of base metals	0.71	3.96	0.50	0.40	0.29	652,357
84-85 Machinery and mechanical appliances, etc.	0.67	5.17	0.50	0.38	0.28	922,058
86-89 Vehicles, aircraft, etc.	0.73	7.56	0.50	0.37	0.29	118,649
90-92 Optical, photographic, etc.	0.67	2.62	0.50	0.42	0.29	180,550
93 Arms and ammunition	0.93	21.14	0.50	0.45	0.40	697
94-96 Articles of stone, plaster, etc.	0.86	3.40	0.50	0.43	0.33	542,511
97+ Others	0.50	3.91	0.50	0.47	0.00	8,633

Source: Chinese Customs Database, 2000-2006.

A.5 Alternative Market Change Measures

Figures 9 and 10 present alternative market change measures based on the deviation from common trade patterns. The constructed deviation measures provide alternative perspectives in clarifying cross-firm as well as within-firm market choices. More results regarding these measures are reported in the online appendices.

					Common Trade Pattern	**Deviation**		**M. Changes/ Markets**	**Drops/ Changes**
$t=1$	A	B			A	B		–	–
$t=2$	A		C		A-C			1/0	1/0
$t=3$	A		C	D	A-C		D	1/1	0/1
$t=4$	A		C		A	C		2/1	1/2

Figure 9: Measures Based on Deviation from the Common Trade Pattern across Firms

					Common Trade Pattern	**Deviation**		**M. Changes/ Markets**	**Drops/ Changes**
$t=1$	A	B			A-C	B $-C$		–	–
$t=2$	A		C		A-C			2/0	1/0
$t=3$	A		C	D	A-C		D	1/1	0/1
$t=4$	A		C		A-C			1/0	1/0

Figure 10: Measures Based on Deviation from the Common Trade Pattern over Time

B Full Model

B.1 Equilibrium and Calibration

The competitive equilibrium is characterized as follows. Firms in each country make decisions on whether to sell in each country and set prices to optimize their profits given their marginal

cost as in (10). The optimal prices are given by (3) and (9). Goods and labour markets clear:

Goods market clearing:

$$C_{d,t} = Y_{d,t} \tag{14}$$

$$\sum_{d} q_{f,i,o,d,t} = \Omega_{f,i,o,t} l_{f,i,o,t} \tag{15}$$

$$q_{N,d,t} = \sum_{i}\sum_{o}\sum_{f} q_{f,i,o,d,t} = \Omega_{N,d,t} L_{N,d,t} \tag{16}$$

Labor market clearing:

$$\sum_{i}\sum_{f} l_{f,i,o,t} + L_{N,o,t} + \sum_{i}\sum_{d\neq o}\sum_{f} \phi_{f,i,o,d,t} F_x + \sum_{i}\sum_{f} \phi_{f,i,o,o,t} F_h = L_{o,t} = 1 \tag{17}$$

Balance of trade:

$$\sum_{i}\sum_{f} (p_{f,i,d,o,t} - \chi_i P_{N,d,t}) q_{f,i,d,o,t} = \sum_{i}\sum_{f} (p_{f,i,d,o,t} - \chi_i P_{N,o,t}) q_{f,i,o,d,t} * e_{o,d,t} \quad \forall o \neq d \tag{18}$$

The nominal wage $W_{o,t}$ in county 1 is set as the numeraire. In this model, the productivity distribution can be asymmetric across industries, sectors and countries. As a result, the bilateral nominal exchange rate is not necessarily equal to one. Under the financial autarky case, the steady state bilateral exchange rate is determined by the bilateral balance of trade condition.

Calibration: The most two important parameters of the model are within and cross industry elasticity of substitutions. These two parameters are calibrated according to the empirical estimates of destination-specific markup elasticity and cross-market supply elasticities of Corsetti, Crowley, Han and Song (2018). There are bunch of parameters related to match within-industry and cross-industry elasticity of substitutions. I currently work on a case of 3 symmetric countries and calibrate the distribution of productivities, fixed cost of domestic and export operation, and the tariff rate (including trade cost) following Edmond, Midrigan and Xu (2015).

I am still working on matching the empirical moments of both intensive and *extensive* margins of within-firm adjustment across markets. Practically, a multi-country model poses new challenge in calibration as it requires to simultaneously matching the firm-level markup adjustments and markup distributions in every country of the model. This problem is discussed in more detail in my working paper "Firm level pass through: a machine learning approach", where I develop a machine learning algorithm to estimate firm and product level

markup adjustments and therefore the distribution of markups in a multi-country AB model. There is one additional parameter that governs the distribution margin of firms in the model: I set $\theta = 2$ such that the distribution margin is around 50-60% for exporters and 10-20% for domestic firms.

The benchmark model is simulated for a maximum of 837 firms in each industry, 30 industries and 3 countries.

Table 13: Benchmark Calibration

Parameter	Value
Based on the estimates of Corsetti, Crowley, Han and Song (2018)	
Cross-industry elasticity of substitution, η	1.33
Within-industry elasticity of substitution, ρ	7.51
Measure of retail bargaining power, θ	2
Based on Edmond, Midrigan and Xu (2015) to match firm and sector distributions	
Pareto shape parameter, idiosyncratic productivity	4.58
Pareto shape parameter, sector productivity	0.51
Kendall correlation for Gumbel copula	0.94
Fixed cost of domestic operations	0.004
Fixed cost of export operations	0.203
Tariff rate	0.129

B.2 Aggregation and Welfare

Let $\Omega_{o,t}$ denote the aggregate productivity of country o at time t and $\widetilde{L}_{o,t}$ denote the amount of labour employed net of fixed costs. The aggregate output $Y_{o,t}$ can be written as

$$Y_{o,t} = \Omega_{o,t}\widetilde{L}_{o,t}$$

Using expressions of final and industry level consumptions [(1) and (6)] and the market clear conditions [(14), (15), (16) and (17)], it can be shown that

$$\Omega_{o,t} = \left[\sum_{d}\sum_{i}\sum_{f} \tau_{o,d,t}\left(\frac{1}{\Omega_{f,i,o,t}}\right)\frac{q_{f,i,o,d,t}}{Y_{o,t}}\right]^{-1}$$

where $\Omega_{f,i,o,t}$ represents the productivity of firm f in industry i from origin o at time t. As

in Edmond, Midrigan and Xu (2015), dispersion in markups reduces aggregate productivity. Note that quantity-weighted aggregate productivity $\Omega_{o,t}$ can be rewritten in terms of relative markups:

$$\Omega_{o,t} = \left(\sum_i \left(\frac{\mu_{i,o,t}}{\mu_{o,t}} \right)^{-\eta} \Omega_{i,o,t}^{\eta-1} \right)^{-1}$$

where the aggregate markup is sales-weighted and can be written as

$$\mu_{o,t} = \left(\sum_d \sum_i \sum_f \frac{1}{\mu_{f,i,o,d}} \frac{p_{f,i,o,d,t} q_{f,i,o,d,t}}{P_{o,t} Y_{o,t}} \right)^{-1}$$

and the industry-level productivity $\Omega_{i,o,t}$ is given by

$$\Omega_{i,o,t} = \left[\sum_d \left(e_{o,d,t} \tau_{o,d,t}^{1-\rho} \sum_f \phi_{f,i,o,d,t} \alpha_{f,i,o,d,t} \left(\frac{\mu_{f,i,o,d,t}}{\mu_{i,o,t}} \right)^{-\rho} \Omega_{f,i,o,t}^{\rho-1} \right) \right]^{\frac{1}{\rho-1}}$$

Efficient allocation is achieved when $\frac{\mu_{f,i,o,d,t}}{\mu_{i,o,t}} = 1$ and $\frac{\mu_{i,o,t}}{\mu_{o,t}} = 1$.

Inefficient allocation means misalignment of resources across producers, i.e., relative prices are not aligned with relative marginal costs. Whether idiosyncratic shocks are distortionary depends on their effect on markup distributions. If variable markups are endogenous to the size of the firm or the distribution margin, it can be distortionary. Efficient allocation is achieved when there is no dispersion in markups. Let $\Omega_{o,t}^{efficient}$ denote the efficient level of aggregate productivity. The efficiency loss is calculated as

$$\text{Efficiency loss} = 1 - \frac{\Omega_{o,t}}{\Omega_{o,t}^{efficient}}$$

B.3 First Order Approximations of Model Responses and the Multilateral Effects

This subsection presents first order approximations for changes in border/producer prices, consumer prices and quantities, producer markups and profits in each destination upon entry. I start with decomposing changes in the market share of the firm.

$$\widehat{ms}_{k,i,o,d,t} = \widehat{\alpha}_{f,i,o,d,t} + (1-\rho)\widehat{p}_{k,i,o,d,t} - (1-\rho)\widehat{P}_{i,o,d,t} \tag{19}$$

where the last term $(1-\rho)\widehat{P}_{i,o,d,t}$ can be rewritten as

$$\begin{aligned}
\frac{P_{i,o,d,t+1}^{1-\rho} - P_{i,o,d,t}^{1-\rho}}{P_{i,o,d,t}^{1-\rho}} &= \frac{\sum_o \sum_f \phi_{f,i,o,d,t+1}\alpha_{f,i,o,d,t+1}p_{f,i,o,d,t+1}^{1-\rho} - \sum_o \sum_f \phi_{f,i,o,d,t}\alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}}{\sum_o \sum_f \phi_{f,i,o,d,t}\alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}} \\
&= \frac{\sum_o \sum_f \phi_{f,i,o,d,t+1}\phi_{f,i,o,d,t}\left(\alpha_{f,i,o,d,t+1}p_{f,i,o,d,t+1}^{1-\rho} - \alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}\right)}{\sum_o \sum_f \phi_{f,i,o,d,t}\alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}} \\
&\quad + \frac{\sum_o \sum_f \phi_{f,i,o,d,t+1}(1-\phi_{f,i,o,d,t})\alpha_{f,i,o,d,t+1}p_{f,i,o,d,t+1}^{1-\rho}}{\sum_o \sum_f \phi_{f,i,o,d,t}\alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}} \\
&\quad - \frac{\sum_o \sum_f (1-\phi_{f,i,o,d,t+1})\phi_{f,i,o,d,t}\alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}}{\sum_o \sum_f \phi_{f,i,o,d,t}\alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}} \\
&= \frac{\sum_o \sum_f \phi_{f,i,o,d,t+1}\phi_{f,i,o,d,t}\left(\alpha_{f,i,o,d,t+1}p_{f,i,o,d,t+1}^{1-\rho} - \alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}\right)}{\sum_o \sum_f \phi_{f,i,o,d,t}\alpha_{f,i,o,d,t}p_{f,i,o,d,t}^{1-\rho}} \\
&\quad + \sum_o \sum_f \phi_{f,i,o,d,t+1}(1-\phi_{f,i,o,d,t})ms_{f,i,o,d,t+1} \\
&\quad - \sum_o \sum_f (1-\phi_{f,i,o,d,t+1})\phi_{f,i,o,d,t}ms_{f,i,o,d,t} \\
&\approx \sum_o \sum_f \phi_{f,i,o,d,t+1}\phi_{f,i,o,d,t}ms_{f,i,o,d,t}\left[\widehat{\alpha}_{f,i,o,d,t} + (1-\rho)\widehat{p}_{f,i,o,d,t}\right] \\
&\quad + \sum_o \sum_f \phi_{f,i,o,d,t+1}(1-\phi_{f,i,o,d,t})ms_{f,i,o,d,t+1} \\
&\quad - \sum_o \sum_f (1-\phi_{f,i,o,d,t+1})\phi_{f,i,o,d,t}ms_{f,i,o,d,t}
\end{aligned} \tag{20}$$

Using (20), changes in market share can be expressed as

$$\widehat{ms}_{k,i,o,d,t} = (1-ms_{k,i,o,d,t})[\widehat{\alpha}_{f,i,o,d,t} + (1-\rho)\widehat{p}_{k,i,o,d,t}] - \widehat{CE}_{k,i,o,d,t} \tag{21}$$

Note that changes in prices is a function of changes in market share. By log-linearizing equation (9), changes in price denominated in the exporter's currency can be decomposed

into changes in markups and marginal costs, i.e.,

$$\widehat{p}_{k,i,o,d,t} + \widehat{e}_{o,d,t} = \underbrace{\kappa_{k,i,o,d,t}\widehat{ms}_{k,i,o,d,t} - \omega_{k,i,o,d,t}(\widehat{mc}_{k,i,o,t} - \widehat{e}_{o,d,t} - \widehat{\chi}_{k,i,o,d,t})}_{\text{changes in markup } \widehat{\mu}_{k,i,o,d,t}} + \widehat{mc}_{k,i,o,t} \tag{22}$$

Substituting (22) into (21), changes in market share can be decomposed into changes in firm-specific factors ($\widehat{mc}_{k,i,o,t}, \widehat{\chi}_{f,i,o,d,t}, \widehat{\alpha}_{f,i,o,d,t}$), the bilateral exchange rate $\widehat{e}_{o,d,t}$, and the total competitors' effect $CE_{k,i,o,d,t}$.

$$\begin{aligned}\widehat{ms}_{k,i,o,d,t} = (1-\lambda_{k,i,o,d,t})(1-ms_{k,i,o,d,t})(1-\rho)\left[(1-\omega_{k,i,o,d,t})(\widehat{mc}_{k,i,o,t} - \widehat{e}_{o,d,t}) + \omega_{k,i,o,d,t}\widehat{\chi}_{k,i,o,d,t}\right] \\ + (1-\lambda_{k,i,o,d,t})[(1-ms_{k,i,o,d,t})\widehat{\alpha}_{k,i,o,d,t} - \widehat{CE}_{k,i,o,d,t}]\end{aligned} \tag{23}$$

The relative importance of these factors are governed by the following three components:

$$\begin{aligned}\text{(i) degree of competition} \quad & \lambda_{k,i,o,d,t} \equiv 1 - \frac{1}{1-(1-ms_{k,i,o,d,t})(1-\rho)\kappa_{k,i,o,d,t}} \\ \text{(ii) degree of local integration} \quad & \omega_{k,i,o,d,t} \equiv \frac{\chi_{f,i,o,d,t}e_{o,d,t}}{mc_{k,i,o,t} + \chi_{f,i,o,d,t}e_{o,d,t}} \\ \text{(iii) price elasticity to market share} \quad & \kappa_{k,i,o,d,t} \equiv \frac{\partial p_{k,i,o,d,t}}{\partial ms_{k,i,o,d,t}}\frac{ms_{k,i,o,d,t}}{p_{k,i,o,d,t}} = \frac{\rho - \varepsilon_{k,i,o,d,t}}{(\varepsilon_{k,i,o,d,t})^2 - \varepsilon_{k,i,o,d,t}}\end{aligned}$$

Recall that the distribution margin $dm_{k,i,o,d,t}$ is defined as the retail cost $\chi_{k,i,o,d,t}$ over the consumer price $p_{k,i,o,d,t}$, i.e.,

$$dm_{k,i,o,d,t} \equiv \frac{\chi_{k,i,o,d,t}}{p_{k,i,o,d,t}} = \omega_{k,i,o,d,t}\frac{\varepsilon_{k,i,o,d,t} - 1}{\varepsilon_{k,i,o,d,t}}$$

The relationship among consumer prices, border/producer prices, markups at the consumer and the border prices are governed by

$$\widehat{p}_{k,i,o,d,t} = (1 - dm_{k,i,o,d,t})\widehat{p}^{b}_{k,i,o,d,t} + dm_{k,i,o,d,t}\widehat{\chi}_{k,i,o,d,t} \tag{24}$$

$$\widehat{p}_{k,i,o,d,t} = (1 - dm_{k,i,o,d,t})(\widehat{\mu}^{b}_{k,i,o,d,t} + \widehat{mc}_{k,i,o,t} - \widehat{e}_{o,d,t}) + dm_{k,i,o,d,t}\widehat{\chi}_{k,i,o,d,t} \tag{25}$$

$$\widehat{\mu}_{k,i,o,d,t} = (1 - dm_{k,i,o,d,t})\widehat{\mu}^{b}_{k,i,o,d,t} + dm_{k,i,o,d,t}(\widehat{e}_{o,d,t} - \widehat{mc}_{k,i,o,t} + \widehat{\chi}_{k,i,o,d,t}) \tag{26}$$

Using (7), quantity responses are given by

$$\widehat{q}_{k,i,o,d,t} = \widehat{\alpha}_{k,i,o,d,t} - \varepsilon_{k,i,o,d,t}\widehat{p}_{k,i,o,d,t} - \frac{\rho - \eta}{\rho - 1}\widehat{CE}_{k,i,o,d,t} + \eta\widehat{P}_{d,t} + \widehat{C}_{d,t} \tag{27}$$

Finally, using the above relationships, the changes in the potential profit can be derived

as follows.

$$
\begin{aligned}
\widehat{\pi}_{k,i,o,d,t} \propto\ & \widehat{q}_{k,i,o,d,t} + \widehat{mc}_{k,o,d,t} + \frac{\mu^b_{k,i,o,d,t}}{\mu^b_{k,i,o,d,t}-1}\widehat{\mu}^b_{k,i,o,d,t} \\
=\ & \widehat{\alpha}_{k,i,o,d,t} - \varepsilon_{k,i,o,d,t}\widehat{p}_{k,i,o,d,t} - \frac{\rho-\eta}{\rho-1}\widehat{CE}_{k,i,o,d,t} + \eta\widehat{P}_{d,t} + \widehat{C}_{d,t} + \widehat{mc}_{k,o,d,t} + \frac{\mu^b_{k,i,o,d,t}}{\mu^b_{k,i,o,d,t}-1}\widehat{\mu}^b_{k,i,o,d,t} \\
=\ & \widehat{\alpha}_{k,i,o,d,t} - \varepsilon_{k,i,o,d,t}\left[(1-dm_{k,i,o,d,t})(\widehat{\mu}^b_{k,i,o,d,t} + \widehat{mc}_{k,i,o,t} - \widehat{e}_{o,d,t}) + dm_{k,i,o,d,t}\widehat{\chi}_{k,i,o,d,t}\right] \\
& - \frac{\rho-\eta}{\rho-1}\widehat{CE}_{k,i,o,d,t} + \eta\widehat{P}_{d,t} + \widehat{C}_{d,t} + \widehat{mc}_{k,o,d,t} + \frac{\mu^b_{k,i,o,d,t}}{\mu^b_{k,i,o,d,t}-1}\widehat{\mu}^b_{k,i,o,d,t} \\
=\ & \widehat{\alpha}_{k,i,o,d,t} - [\varepsilon_{k,i,o,d,t}(1-dm_{k,i,o,d,t})-1]\widehat{mc}_{k,o,d,t} - \varepsilon_{k,i,o,d,t}dm_{k,i,o,d,t}\widehat{\chi}_{k,i,o,d,t} \\
& - \frac{\rho-\eta}{\rho-1}\widehat{CE}_{k,i,o,d,t} + \varepsilon_{k,i,o,d,t}(1-dm_{k,i,o,d,t})\widehat{e}_{o,d,t} + \eta\widehat{P}_{d,t} + \widehat{C}_{d,t} \qquad (28)
\end{aligned}
$$

B.3.1 Approximating for competitors' reactions $\widehat{CE}$ in a symmetric multi-country setting

Under the presence of $\widehat{ms}_{f,i,o',d,t}$, there is no closed form solution for the change in market share after a shock even under the first order approximation, i.e., (23). Given a set of realised shocks and a prior market structure distribution, market share conditions will formulate a system of M_i nonlinear equations that can be solved numerically.

To gain insights, I now solve equation (23) under the case where firms are *ex ante* identical after adjusting for exchange rate differences within industry i and destination d. That is, I analyse the case that

$$\frac{mc_{k,i,o',t}}{e_{o',d,t}} = \frac{mc_{f,i,o,t}}{e_{o,d,t}} \quad \forall k \in \mathbb{1}_f, o' \in \mathbb{1}_o$$

This condition implies the same market share $ms_{k,i,o,d,t}$, share of distribution cost $\omega_{f,i,o,d,t}$, price elasticity with respect to market share $\kappa_{k,i,o,d,t}$, and the degree of horizontal competition $\lambda_{k,i,o,d,t}$ across firms. I drop all unnecessary subscripts for clarity.

$$
\begin{aligned}
\widehat{ms}_{k,o}\left[1-(1-ms)(1-\rho)\kappa\right] =& (1-ms)(1-\rho)\left[(1-\omega)(\widehat{mc}_{k,o} - \widehat{e}_o) + \omega\widehat{P}_N\right] \\
& - ms(1-\rho)\sum_{o'}\sum_{f\neq k}\left[(1-\omega)(\widehat{mc}_{k,o'} - \widehat{e}_{o'}) + \omega\widehat{P}_N + \kappa\widehat{ms}_{f,o'}\right]
\end{aligned}
$$

Note that $\sum_{o'}\sum_{f\neq k}\widehat{ms}_{f,o'} = -\widehat{ms}_{k,o}$. Rearrange and get

$$\begin{aligned}\widehat{ms}_{k,o} =& \frac{(1-\lambda)(1-\rho)(1-ms)}{1-\kappa(1-\lambda)(1-\rho)ms}\left[(1-\omega)(\widehat{mc}_{k,o}-\widehat{e}_o)+\omega\widehat{P}_N\right] \\ &- \frac{(1-\lambda)(1-\rho)ms}{1-\kappa(1-\lambda)(1-\rho)ms}\sum_{o'}\sum_{f\neq k}\left[(1-\omega)(\widehat{mc}_{f,o'}-\widehat{e}_{o'})+\omega\widehat{P}_N\right]\end{aligned}$$

Define $\Upsilon \equiv \kappa(1-\lambda)(1-\rho)ms$. I can write

$$\begin{aligned}\kappa\widehat{ms}_{k,o} =& \frac{1-ms}{ms}\left[(1-\omega)(\widehat{mc}_{k,o}-\widehat{e}_o)+\omega\widehat{P}_N\right]\Upsilon\left(1+\frac{\Upsilon}{1-\Upsilon}\right) \\ &- \sum_{o'}\sum_{f\neq k}\left[(1-\omega)(\widehat{mc}_{f,o'}-\widehat{e}_{o'})+\omega\widehat{P}_N\right]\Upsilon\left(1+\frac{\Upsilon}{1-\Upsilon}\right)\end{aligned}$$

The change in markup denominated in the exporter's currency can be written as

$$\begin{aligned}\widehat{\mu}_{k,o} =& \left[1-(1-\lambda)(1-\omega)\right](\widehat{e}_o-\widehat{mc}_{k,o})+(1-\lambda)\omega\widehat{P}_N \\ &- \Upsilon\sum_{o'}\sum_{f\neq k}\left[(1-\omega)(\widehat{mc}_{f,o'}-\widehat{e}_{o'})+\omega\widehat{P}_N\right] \\ &+ \frac{1-ms}{ms}\frac{\Upsilon}{1-\Upsilon}\left[(1-\omega)(\widehat{mc}_{k,o}-\widehat{e}_o)+\omega\widehat{P}_N\right] \\ &- \frac{\Upsilon^2}{1-\Upsilon}\sum_{o'}\sum_{f\neq k}\left[(1-\omega)(\widehat{mc}_{f,o'}-\widehat{e}_{o'})+\omega\widehat{P}_N\right]\end{aligned}$$

The first line represents the direct effect of shocks. The second line reflects how the competitors' reactions to these shocks would directly affect the optimal markup of exporter k. The third and fourth lines represent the indirect effects of changing competitors' market shares.

Consider the case where the destination country depreciates against all of its trade partners. That is, $\widehat{e}_{o'} = \widehat{e}_o \ \forall o \neq d$ and $\widehat{e}_d = 0$. For clarity, I also keep the marginal cost of all firms fixed and assume the price of non-tradable goods does not change in the destination.

$$\begin{aligned}\widehat{\mu}_{k,o} =& \left[1-(1-\lambda)(1-\omega)\right]\widehat{e}_o + \Theta\frac{1-ms}{ms}\Upsilon(1-\omega)\widehat{e}_o \\ &- \frac{1-ms}{ms}\frac{\Upsilon}{1-\Upsilon}(1-\omega)\widehat{e}_o + \Theta\frac{1-ms}{ms}\frac{\Upsilon^2}{1-\Upsilon}(1-\omega)\widehat{e}_o \\ =& \left[1-(1-\lambda)(1-\omega)\right]\widehat{e}_o - \kappa(1-\lambda)\widehat{CE}_{k,o}\end{aligned} \tag{29}$$

Where Θ is the proportion of domestic firms in the residual market of industry i at destination d. In a symmetric setup, Θ is the number of domestic firms divided by the total number of firms in industry i minus one, i.e., $M_d/(M-1)$. The last three terms of equation

(29) represent the total effect of competitors' reactions, which can be written as

$$\begin{aligned}\kappa(1-\lambda)\widehat{CE}_{k,o} &= \frac{1-ms}{ms}\Upsilon(1-\omega)\widehat{e}_o\left(\frac{1-\Theta}{1-\Upsilon}\right) \\ &= (1-\omega)(1-\lambda)\kappa(\rho-1)(1-ms)\widehat{e}_o\left(\frac{1-\Theta}{1-\Upsilon}\right) \end{aligned} \tag{30}$$

where Υ is an increasing function of market share, i.e.,

$$\frac{\partial\Upsilon}{\partial ms} = \Upsilon^2\frac{\rho[\rho(1-ms)+\eta ms-1]}{ms^3(\rho-1)(\rho-\eta)} > 0 \tag{31}$$

B.4 Key Statistics

Table 14 reports key statistics for the model simulated with different number of countries. Table 15 reports the related market change measures for the trade war scenario.

Table 14: Model Statistics ($ABCD^H$)

	3 countries	2 countries	1 country
Aggregate Output	1.000	0.947	0.865
Efficiency loss * 100	3.649	3.937	4.317
Fraction of exporters (A to B or C)	0.174	0.194	-
Fraction exporters (A to B)	0.169	0.194	-
Fraction exporters (A to C)	0.170	-	-
Firms of A: Home markup relative to B (mean)	1.082	1.078	-
Firms of A: Home markup relative to B (median)	1.089	1.085	-
Firms of A: Home markup relative to C (mean)	1.082	-	-
Firms of A: Home markup relative to C (median)	1.090	-	-
Exporters of A: Markup in B relative to C (mean)	1.000	-	-
Exporters of A: Markup in B relative to C (median)	1.000	-	-
Firms of A: Home quantity relative to B (mean)	1.389	1.423	-
Firms of A: Home quantity relative to B (median)	1.289	1.355	-
Firms of A: Home quantity relative to C (mean)	1.394	-	-
Firms of A: Home quantity relative to C (median)	1.297	-	-
Exporters of A: Quantity in B relative to C (mean)	1.000	-	-
Exporters of A: Quantity in B relative to C (median)	1.000	-	-
Markup of domestic firms (mean)	1.430	1.369	2.323
Markup of domestic firms (median)	1.260	1.246	1.348
Markup of 1-country exporters (mean)	3.422	2.270	-
Markup of 1-country exporters (median)	2.375	2.307	-
Markup of 2-country exporters (mean)	6.619	-	-
Markup of 2-country exporters (median)	3.883	-	-
Distribution margin of domestic firms (mean)	0.208	0.198	0.194
Distribution margin of domestic firms (median)	0.153	0.148	0.098
Exporters of A: Distribution margin in B (mean)	0.532	0.507	-
Exporters of A: Distribution margin in B (median)	0.596	0.568	-
Exporters of A: Distribution margin in C (mean)	0.533	-	-
Exporters of A: Distribution margin in C (median)	0.597	-	-

Note: Statistics calculated based on the average of 10 simulations under the benchmark calibration. Efficiency loss is calculated as percentage difference between the efficient allocation and the competitive equilibrium.

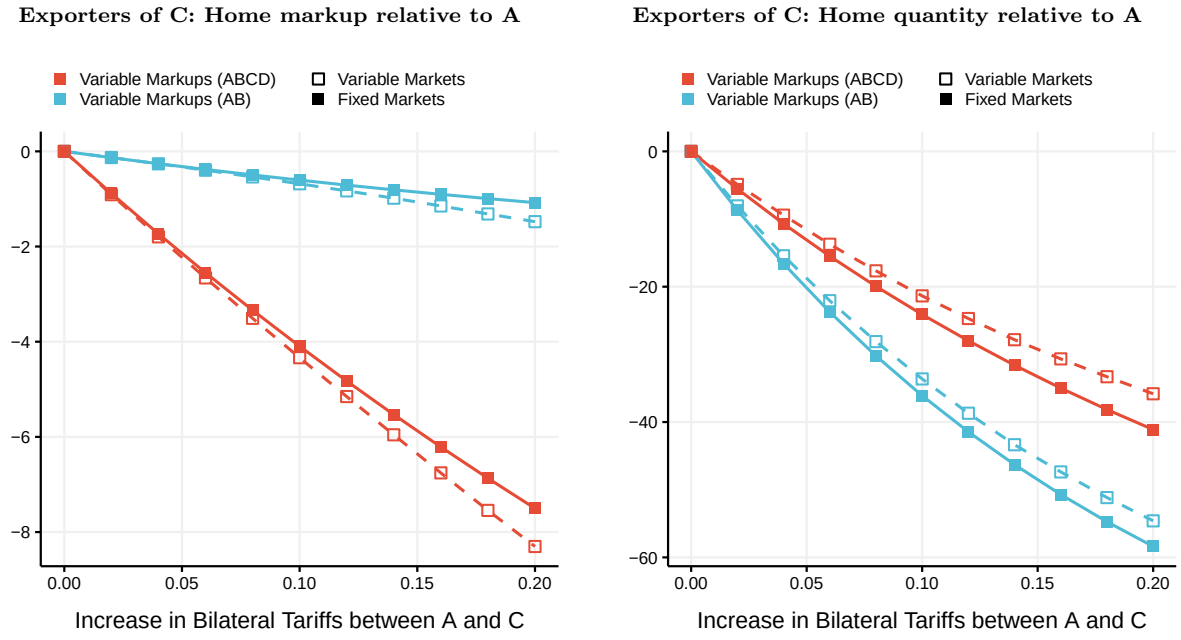
Table 15: In response to a 20% increase in bilateral tariffs between A and C
Model: $ABCD^H$ with variable markets

	A or C	B
Market Change Measures		
Market Changes / Markets	24.0	10.6
Market Drop / Market Changes	91.0	0.0
Probability of Churn	6.8	0.0
Percentage Changes in Intensive and Extensive Margins		
Import Share	-11.0	2.7
Fraction of Exporters	-3.1	6.6
Fraction of Exporters (Destination 1)	-26.0	6.5
Fraction of Exporters (Destination 2)	-0.8	5.7
Number of Exporters (Destination 1)	-22.5	5.9
Number of Exporters (Destination 2)	3.9	5.0

Note: Statistics calculated based on the average of 10 simulations under the benchmark calibration.

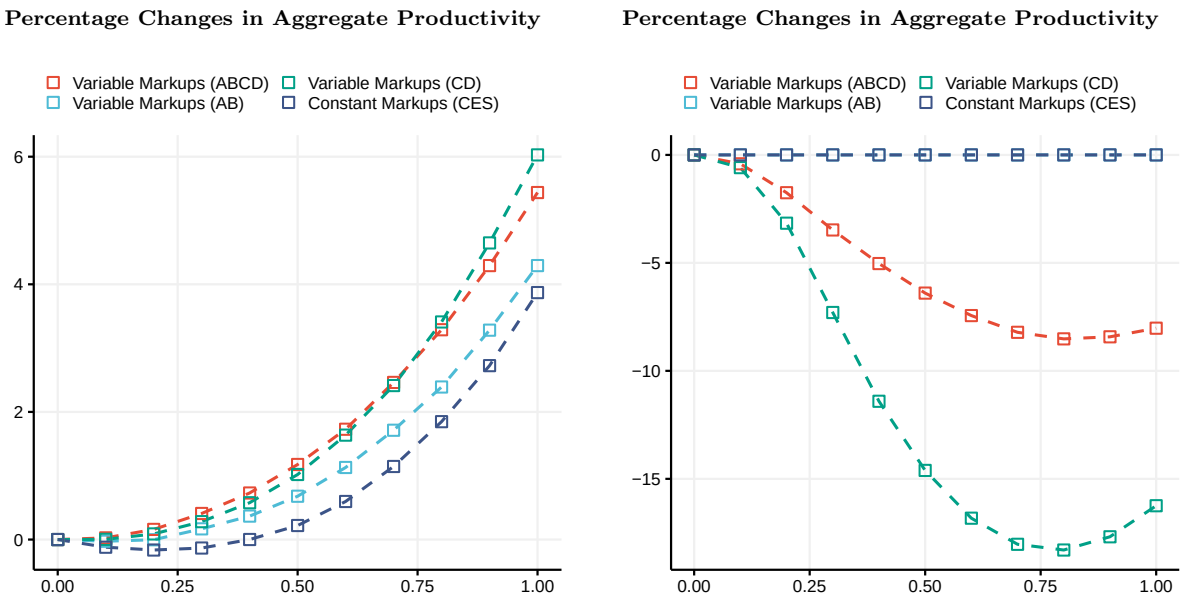
B.5 Additional Simulation Results

Figure 11: Trade War: Changes in Relative Markups and Quantities



Note: The y axis indicates the percentage changes of variables between two time periods.

Figure 12: Exogenous Shocks that Lead to Market Changes



(a) Size of Preference Shock

(b) Size of Local Distribution Shock

Note: The y axis indicates the percentage changes of variables between two time periods.The sign of aggregate productivity depends on the simulation setting. The quantitative relationship among models hold in absolute terms.