Trade Wars and the Reallocation of Market Power in Global Export Markets*

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Abstract

By diverting and distorting bilateral trade flows, trade wars shift export patterns and market concentration around the globe. In this paper, we estimate parameters in n-country general equilibrium trade model featuring oligopolistic competition with data from a rich panel of firm-level exports from 11 low and middle-income countries to 165 destinations that report bilateral and multilateral tariffs to the World Trade Organization. Our analysis emphasizes the importance of firm entry into and exit from relatively concentrated product markets at the level of origin-destination country pairs. The impact of a trade war on welfare and prices is dominated by the entry, exit, and pricing decisions by a few large, productive firms. These decisions have first-order effects on the reallocation of market power among firms within and across borders.

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1 Introduction

The advent of a bilateral trade war between the US and China in 2018 ushered in a new era for the international economy. The impact of tariffs of 20% on over one-half of American exports to China and two-thirds of Chinese exports to the US was substantial on impact (see, e.g., Fajgelbaum et al. (2020)). Over longer horizons, shifts in bilateral trade flows point to a significant reshaping of domestic and international markets, with potentially far-reaching consequences for global competition and productivity (see, e.g., Freund et al. (2023)).

The point of departure for our analysis is the empirical observation that, at the granular product-market level, concentration in any destination country among exporting firms from a given origin is high. Using a large panel of annual customs transactions from 11 low and middle-income countries, including China and Mexico, to 165 foreign destinations, we document that only a handful of firms from a given origin serve a foreign product market. The median number of exporters from the same origin in our sample is 3, rising to 7 for the US, the world's largest economy (see table 1). This fact suggests that, once we close in on a product market, the mode of competition is better captured by oligopolistic rather than monopolistic models: price-setting is strategic and the entry or exit of a single firm can have a large effect on the product-market structure, prices, factor rewards, and, ultimately, welfare. In an oligopolistic market, bilateral tariff hikes simultaneously cause large exporters to reduce or discontinue their sales to protected countries, induce large firms from neutral third countries to start exporting or expanding their operations, and enable domestic producers from trade-war countries to gain domestic market share and rents associated with increased market power. In this paper, we bring empirical evidence and quantitative analysis to bear on the idea that capturing the first-order allocation and welfare effects of tariffs requires a model of global trade that incorporates oligopolistic competition and endogenous market participation decisions.

We make three contributions to the literature. First, we provide new econometric evidence on the elasticities of trade volumes, (tariff-exclusive) export prices, and import market shares to tariff changes, showing that these elasticities are three to four times larger in response to country-specific bliateral tariff increases compared to across-the-board non-discriminatory tariff hikes. These differential responses cannot be accounted for using conventional multi-country monopolistic competition models, where an exporter's response to a multilateral or bilateral tariff hike is the same. We use this empirical evidence to guide the building a model suitable for studying the effects of a trade war and use our econometric elasticities as the moments to match in estimating the structural parameters in our quantitative model.

Second, we set up a n-country general equilibrium trade model that incorporates oligopolistic competition and firms' endogenous entries and exits, and show that these features are crucial for aligning theoretical predictions with the empirical evidence. We use the simulated method of moments to estimate four model parameters by simultaneously matching eight tariff elasticities to our empirical estimates.

The model utilizes the triple-nested CES preferences of Crowley, Han and Prayer (2024) to capture the idea the consumers might view product varieties from one country as more substitutable with each other, i.e., *within-an-origin*, than they are with varieties from another country, i.e.,*across-different-origins*. The quantitative success of the model requires the *within-origin* elasticity of substitution across varieties to be higher than the *cross-origin* elasticity of substitution, which suggests firms compete more intensively with peers from their own origin than with rival firms from other origins. A quantitative assessment of a bilateral trade war shows that the welfare costs may be severely underestimated in models that do not endogenize the entry and exit of (relatively) large firms whose participation has the capacity to reshape market power in domestic and international markets.

Our final contribution is a decomposition of the welfare impacts of tariffs. We reconsider the decomposition by Baqaee and Farhi (2024) in a oligopolistic setting with entry and exit and love for variety. Our augmented decomposition enables us to quantify the welfare changes due to entry and exit of firms, which are captured as changes to varieties of goods, as well as how this entry and exit induces continuing domestic firms and exporters to adjust their prices, markups, and volumes.[1]

In view of the possibility of trade conflicts in the near future, our paper stresses that much of the impact of trade wars on welfare, incomes and prices is driven by the entry and exit of large, productive exporters in international markets, and the ensuing adjustment in pricing and sales by continuing exporters and domestic firms. Tariff policies may arise from political economic, rather than purely economic considerations. Whatever their motivation, their distortionary effects will bring about market structure changes with first-order implications for the reallocation of market power both within and across borders; this underscores the critical role of firms' participation in granular product-markets in shaping global trade and aggregate outcomes.

Literature. A growing literature has assessed the short-run impacts of the most substantial restrictions on imports since the Second World War. Amiti, Redding and Weinstein (2019) and Fajgelbaum et al. (2020) estimate complete pass-though of US tariffs into US import prices, leading Fajgelbaum et al. (2020) to estimate an aggregate real income loss to the US economy of 0.04% of GDP. Complementing these studies, Cavallo et al. (2021) highlight the importance of micro market structures. First, they estimate US exporters reduced their prices by 7% in response to foreign tariffs of around 15% (i.e., low pass-through into Chinese import prices). They suggest

[1]The benchmark model developed in this paper abstracts from global production chains—an extension encompassing these chains is in our agenda.

this important asymmetry between tariff pass-through in China relative to the US might be due to the relatively competitive nature of markets for agricultural commoditities and non-differentiated goods exported by the US in contrast to the more differentiated goods exported by China. Second, while they concur with other studies that found complete pass-through into US import prices, Cavallo et al. (2021) estimate almost no increase in US retail prices, suggesting that US retailers absorbed most of the tariff cost into their margins in the short run. Altogether, in finding different tariff pass-through for different classes of goods and finding differences in pass-though at the border and the retail outlet, these studies indicate that examining price and welfare consequences of tariffs at longer horizons, after market structures have adapted to the new high tariff environment, is a worthwhile exercise.

Our results call attention to the fact that analyses relying on monopolistic competition rest on the implicit assumption of a large number of firms operating in a product market—in these models the marginal firms that enter or exit following a trade policy shock are relatively small and have relatively modest impacts on aggregate prices and welfare.The empirical evidence points to the need to reconsider the relevance of firm-level adjustment in reshaping market power in trade-war analyses.

More generally, our paper contributes to a long literature that investigates the how trade policy changes affect markups (e.g., Brander and Krugman (1983), Brander and Spencer (1984), Helpman and Krugman (1985), Eaton and Grossman (1986), Markusen and Venables (1988), Epifani and Gancia (2011), Edmond, Midrigan and Xu (2015), Feenstra and Weinstein (2017), Feenstra (2018), Impullitti and Licandro (2018), Arkolakis et al. (2018), and Crowley, Han and Prayer (2024)). A well-known theoretical result from Brander and Spencer (1984) is that the price charged by a foreign monopolist rises in response to a tariff cut if, and only if, the elasticity of demand is decreasing in quantity along the demand curve; i.e., when Marshall's Second Law of Demand holds. A direct implication is that in a demand system where Marshall's Second Law of Demand fails to hold, a monopolistic firm may increase its markup when tariffs are raised. Recent work (Mrázová and Neary (2017), Mrázová and Neary (2024)) has examined markup adjustment to tariff changes under more general demand conditions. We work with the tiered CES demand function of Crowley, Han and Prayer (2024) and estimate markup elasticities to country-specific bilateral as well as non-discriminatory multilateral tariff changes, finding firms' markups are about four times more responsive to bilateral tariff changes. Relative to existing multi-sector oligopolistic competition models (e.g., Atkeson and Burstein (2008), Edmond, Midrigan and Xu (2015)), we highlight the importance of firm entry and the reallocation of import and domestic market shares across firms and countries.[2]

[2]Earlier work has emphasized the important role of free entry in models of imperfect competition. Markusen and Venables (1988) map out assumptions about market segmentation and free entry to show changes in assumptions about free entry nullify or flip predictions arising from changes in trade policy. More recently, Zhelobodko et al.

Our findings contribute to a growing empirical literature on the responses of firms' prices and markups to trade liberalizations.[3] Our analysis follows earlier contributions by Amiti et al. (2020), who highlight the quantitatively important role that new entry into the US by Chinese exporters over 2000-2006 had in reducing US manufacturing industry prices, and Jaravel and Sager (2023), who document that estimated declines in US CPI inflation arising from Chinese import penetration are consistent with trade models featuring strategic interactions in price-setting. In estimating different responses of markups to (country-specific) bilateral versus (non-discriminatory) multilateral tariff changes, we provide an empirical foundation to guide an n-country general equilibrium trade model featuring strategic price-setting to trade policy changes.

2 Oligopolistic Competition in Export Markets: Empirical Evidence

In this section, we present empirical evidence on the concentration of export markets and exporters' response to tariff changes in these markets based on the the universe of firm-level export data from 11 low and middle-income countries. First, we show that the number of firms in granular origin-destination-product-markets (e.g., the number of Chinese firms exporting a product to the UK) is small, implying that entry and exit of one firm could result in substantial reallocation of market shares. Second, we show that firms' exports, markups, and market shares respond more to a bilateral tariff change applied to a specific origin, than to a non-discriminatory tariff change applied to all origins. These findings suggest firms compete strategically in highly concentrated markets; trade wars likely induce entry and exit of large exporters, with non-negligible impacts on market structures.

2.1 Data

We bring together information on firms' product-level export values and quantities for eleven origins, and bilateral tariffs for 165 destinations to estimate the effect of trade policy on firms' exporting behaviour and markups. We use administrative data on the universe of Harmonized

(2012) propose a model of monopolistic competition with additive preferences and show markup adjustment of firms depends on whether the relative love for variety increases with individual consumption. De Blas and Russ (2015) show that limiting the number of firms in a Bernard et al. (2003) model help to match number of stylized facts from the empirical literature on markups, pass-through, and trade openness.

[3] For example, De Loecker et al. (2016) and Edmond, Midrigan and Xu (2015) find that trade liberalizations reduce the prices charged by domestic firms. Several papers (Bown and Crowley (2006), Amiti, Redding and Weinstein (2019), and Fajgelbaum et al. (2020)) examine foreign unit value responses to trade policy changes, but their product-level datasets do not allow for an analysis of markups. Kikkawa, Mei and Santamarina (2019) uses survey data on Mexican firms to examine the impact of NAFTA on markups domestically and for exported products.

System 6-digit product exports by firms for eleven developing and emerging economies, obtained from three different sources. Data for Albania, Bulgaria, Burkina Faso, Malawi, Mexico, Peru, Senegal, Uruguay and Yemen are taken from the World Bank Exporter Dynamics Database,[4] data for Egypt from the Economic Research Forum Exports Dataset and data for China from the Chinese Customs Database. Our final estimation dataset contains 13.3 million observations at the firm-product-origin-destination-year level and spans the years 2000-2013. While data for different countries are available for different years, 93% of observations in our final dataset are from 2000-2006. We provide more information about the dataset in Appendix A.

2.2 Stylized Facts on Market Concentration

Data on the universe of exporting firms from eleven countries allows us to unveil a crucial feature of international trade in goods — trade takes place in highly concentrated markets. Table 1 presents evidence on the pronounced concentration of product-level trade. Statistics for 165 destination markets are shown in Panel (a). Conditional on a non-zero product-level trade flow between an origin and a destination, the median number of firms from an origin country exporting a product to a foreign trading partner is three. The high concentration of origin-destination-product markets is confirmed by the Herfindahl-Hirschman Index and the fact that the median market share of the top-2 firms amounts to 99.6%. Most crucially, the table provides evidence on the market shares gained by new entrants in the market. As shown in Panel (a) row (iv) ("Entrants"), new exporters secure a substantial share of the exported product's sales from their origin to the foreign destination: the median market share captured by entrants exceeds one-third. New exporters are clearly large.

Even in the world's largest economy – the United States (Panel (b)) – at the product level the median number of exporters is seven. Product markets are highly concentrated, as indicated by the Herfindahl-Hirschman Index. While the median number of exporters of specific products to the US market is higher than the median for the global sample of 165 countries, the median market share of the top-2 firms remains highly concentrated at 89.2%. By the same token, new entrants account for non-trivial market shares from their own origin: the median value is about one-fifth. The primary conclusion from table 1 is that the number of firms active in granular product-origin-destination markets is limited.

The statistics in this section reveal that, although the *total* number of firms selling a product in any country may be large (see e.g., Bernard et al. (2003) and Helpman, Melitz and Yeaple (2004)),

[4]The data employed in this paper are transaction-level customs data for the period 2000-2013. The data was collected by the Trade and Integration Unit of the World Bank Research Department, as part of their efforts to build the Exporter Dynamics Database described in Bortoluzzi, Fernandes and Pierola (2015). The sources for the data for each country are detailed at http://econ.worldbank.org/exporter-dynamics-database.

the number of competitors from any given origin is small. This could lead to non-trivial strategic interactions in price-setting among these firms. With a limited number of firms in the market, the entry or exit of one can have a big impact on market structure and pricing.

Table 1: Concentrated granular origin-destination-product markets

	25th Percentile	Median	75th Percentile
(a) All destination markets			
(i) Number of firms	7.00	3.00	1.00
(ii) Herfindahl-Hirschman Index	0.34	0.64	1.00
(iii) Top-2 market share	74.0%	99.6%	100%
(iv) Cumulative market share cond. on ≥ 1 incumbent and ≥ 1 entrant			
– Incumbents	30.3%	61.9%	85.7%
– Entrants	69.7%	38.1%	14.3%
(b) US market			
(i) Number of firms	24.00	7.00	2.00
(ii) Herfindahl-Hirschman Index	0.25	0.50	0.92
(iii) Top-2 market share	61.6%	89.2%	100%
(iv) Cumulative market share cond. on ≥ 1 incumbent and ≥ 1 entrant			
– Incumbents	49.4%	81.9%	95.2%
– Entrants	51.6%	18.1%	4.8%

Note: This table presents statistics on the concentration of exporting firms in a market defined at the product-origin-destination-year level using an unbalanced panel of the universe of firms exporting from 11 origins to 165 destinations for approximately 3600 intertemporally-consistent HS06 products over 12 years. The first row presents distribution moments for the number of active firms at the product-origin-destination-year level for the 1.3 million product-origin-destination-year markets in our final estimation sample. The second row provides the distribution of the Herfindahl-Hirschman Index calculated within the product-origin-destination-year market. The third row reports the distribution of market share of the two largest firms in the market. The last statistics show the distribution of market share, conditional on product-origin-destination-year market with at least one incumbent and one entrant. The market share of the active firms in year t is divided into (i) "incumbents", i.e., those firms that sell in an origin-destination-product market in both t and $t-1$, and (ii) "entrants", i.e., those firms that did not sell in an product-origin-destination market in period $t-1$ but do so in period t.

2.3 Quantity, Markup and Market Share Elasticities to Tariff Changes

this subsection, we produce micro-econometric evidence on oligopolistic competition in granular origin-destination-product-markets. In doing so, we exploit the fact that our dataset encompasses both multiple origins and multiple destinations, which allows us to study firms' responses to (non-discriminatory) destination-average as well as origin-specific (bilateral) tariff changes. As shown in the model section below, under oligopolisic competition, firms respond more to origin-specific tariff changes than to destination-average tariff changes. In addition, entry and exit of large exporters bring about sizable reallocations of market shares and market power, which may amplify the differences in responses to bilateral origin-specific and non-dicriminatory destination-average tariff changes.

Our main variables of interest are (i) the firm's markup μ_{fiodt}, (ii) the quantity of a product demanded of a firm in a destination y_{fiodt}, (iii) the firm's (within-origin) ms_{fiodt}, i.e., the firm's share of product sales among all firms from its origin country selling in a destination, and (iv) the origin country's market share in a destination-product market ms_{iodt}.[5] The main challenge in our study is to identify the elasticities of these four variables to changes in trade policy, despite the fact that we observe neither a firm's marginal costs nor the total sales in a given product market in a destination (including sales by domestic firms).[6] To meet this challenge, we rely on two insights. First, firms' marginal costs in producing a given product are the same regardless of where the firm sells that product. This means we can leverage the presence of multiple destination markets in our dataset to difference out of firms' export prices the marginal cost component, as well as any global markup component that is common to all destinations. We can therefore identify adjustments in the destination-specific component of markups. Second, the overall size of a product market in a given destination country facing exporting firms is the same regardless of where a firm is based. This means we can leverage the presence of multiple countries of origin in our dataset to introduce controls for time-invariant (destination) product-market size.

Specifically, we identify the elasticities of quantities, markups and market shares to tariff changes by employing the following specification:[7]

$$\ln(\text{Outcome}_{fiodt}) = \beta_1 \cdot \text{Avg. Tariff}_{idt} + \beta_2 \cdot \text{Bilat. Tariff}_{iodt} + \gamma_{fiot} + \gamma_{id} + \zeta_{fiodt}, \tag{1}$$

where γ_{fiot}, γ_{id} are firm-product-origin-year and product-destination fixed effects, respectively, and

[5]The formal definition of the two market shares is given in equation (11).

[6]While it is possible to obtain data on domestic firms' sales in some countries, such as Belgium in Amiti, Itskhoki and Konings (2019), product-level domestic sales data comparable to imports is not collected or recorded by governments in many of the 165 destination countries in our estimation sample, including the US.

[7]We estimate the effect of tariffs on the origin's market share in the destination at the same level of aggregation and over the same sample as the other three variables, despite the fact that this market share does not vary across firms, to ensure that the estimated elasticities for the three market shares add up in the expected way. This essentially amounts to comparing an origin's market share across different destinations within a firm rather than within an origin as is common in the literature and corresponds to a weighting scheme that puts more emphasis on markets with more firms.

ζ_{fiodt} is residual terms.[8] The two right-hand-side variables describe the destination-average and origin-specific components of the tariff in a product-destination market.[9] The first variable, Avg. Tariff$_{idt}$, denotes the weighted average of the natural logarithm of one plus the ad-valorem tariff applied to imports of product i by destination d, calculated across all origins o. We use the pre-sample trade values from 1997 to 1999 to construct time-invariant weights of the origin countries for each product-destination market:

$$\text{Avg. Tariff}_{idt} = \sum_{o} \omega_{iod} \ln \tau_{iodt} \tag{2}$$

where $\omega_{iod} = \sum_{t\in\{1997-1999\}} v_{iodt} / \sum_{o} \sum_{t\in\{1997-1999\}} v_{iodt}$ is the trade share of origin o selling product i in destination d from 1997 to 1999, taken from the UN Comtrade Database. v_{iodt} is the import value of product i from origin o in destination d at time t. The second variable, Bilat. Tariff$_{iodt}$, measures the difference between (the natural logarithm of one plus) the ad-valorem tariff on imports of product i from origin o, charged by destination d, and the destination-average level, Avg. Tariff$_{idt}$; it largely reflects bilateral tariff changes under preferential trade agreements and other preferential tariff systems like the US's General System of Preferences (GSP):

$$\text{Bilat. Tariff}_{iodt} = \ln \tau_{iodt} - \text{Avg. Tariff}_{idt} \tag{3}$$

Specification (1) allows us to identify firms' (destination-specific) markup adjustments in response to tariff changes. This is because the (tariff-exclusive) border price $\ln(p^b_{fiodt})$, which is directly observable in our dataset, can be decomposed into a destination-specific markup component, a component that captures the mean markup across all active destinations $\ln(\mu_{fiot})$, and the firm's product-level marginal cost $\ln(\text{mc}_{fiot})$:

$$\ln(p^b_{fiodt}) = \underbrace{\ln(\mu_{fiodt}) - \ln(\mu_{fiot})}_{\text{destination-specific markup}} + \underbrace{\ln(\mu_{fiot}) + \ln(mc_{fiot})}_{\text{absorbed by } fiot \text{ fixed effects}}. \tag{4}$$

[8]All continuous outcome variables enter our estimating equations in natural logarithms. We estimate these specifications with panel OLS rather than PPML regressions, as creating a full panel of zero trade flows at the firm-product-origin-destination-year level for eleven countries would result in a dataset of more than 100 million observations, rendering estimation in a reasonable time period infeasible. This means that we only use observations with positive trade flows. However, it is important to note that our fixed effects should absorb most of the variation in trade costs that prevents firms from entering markets, and thus account for the selection process that gives rise to positive trade flows, as noted in Baier, Bergstrand and Feng (2014) and Corsetti et al. (2023).

[9]See Online Appendix B.9 of Alexander et al. (2024) for a detailed discussion on the equivalence between our cost-based estimation approach and the method used in Amiti, Itskhoki and Konings (2019). Our method directly links changes in costs to markups, whereas Amiti, Itskhoki and Konings (2019) regress the outcome variable on the firm's own cost and its competitors' price changes (instrumented by the competitors' cost changes). While the implementations differ, both approaches ultimately capture the same underlying relationship.

Once we account for our firm-product-origin-year fixed effects, conventional in the pricing-to-market literature (see, e.g., Knetter (1989), Knetter (1993), and more recently Fitzgerald and Haller (2014), and Fitzgerald, Haller and Yedid-Levi (2023)), only the first component remains.[10]

Moreover, the inclusion of firm-product-origin-year fixed effects in the quantity and market share specifications helps control for unobserved production or cost shocks in the origin countries. Adding product-destination fixed effects captures the time-invariant demand shifters in a product-destination market. We also incorporate variables to account for time-varying changes in demand within the destination-product market, such as destination's exchange rate to the US dollar, consumer price index, real GDP, import-to-GDP ratio of destination country d, and product i's share of the destination's total imports. Our specification thus directly controls for the time-invariant level of product demand as well as time-varying aggregate fluctuations in different destinations. By doing so, it provides sufficient residual variation within and across destinations for us to identify the response to changes in destination-average tariffs, which are common across all origins serving a destination, distinct from the response to origin-specific (bilateral) tariff changes, which may disproportionately impact a subset of firms in an oligopolistic market structure.

Before turning to the empirical results, it is worth pointing out the theoretical motivation for our approach. As is well known, under monopolistic competition with a large number of firms, the response of any marginal exporting firm to bilateral or multilateral tariff hikes is the same. However, when the market is concentrated, firms compete oligopolistically and respond strategically to policy changes according to whether their competitors face the same tariff shock. A firm's quantity response to destination-average (non-discriminatory) tariff changes will be muted compared to origin-specific (bilateral) tariff changes. This is the direct implication of strategic response to cost shocks that impact all firms versus a subset of competitors under Cournot competition.[11]

Empirical results are shown in Table 2, which reports the elasticities of quantities, markups, and market shares to tariff changes. The first column shows the response of quantities to changes in destination-average tariffs as well as to changes in (origin-specific) bilateral tariff changes. A 10% increase in destination-average tariffs reduces the quantity demanded of the firm by 7.8%, while a 10% increase in origin-specific bilateral tariffs reduces demand on the firm by 24%. For example, if the tariff increases from 10% to 11% across all origins in a product-destination market, foreign firms lose 7.8% of their demand. If the tariff increases from 10% to 11% for a particular country, while tariffs against all other countries remain the same, then firms in the targeted origin

[10] Note that these fixed effects also control for any endogenous changes in marginal costs that might result from a preferential trade policy change, regardless of returns to scale in production. For example, even if a trade agreement increases the overall production of a firm and thereby reduces its marginal costs, this change should be reflected in the firms' prices in all of its destination markets and thus will be controlled for by our firm-product-origin-year fixed effects.

[11] We provide a quantitative discussion in the Appendix B.5.

Table 2: Elasticity of quantity, markup, and markets shares to tariff changes

	Quantity_{fiodt}	Markup_{fiodt}	Within-origin market share_{fiodt}	Origin's market share in dest_{iodt}
Destination-average tariff_{idt}	-0.78***	0.05**	1.18***	-1.19**
	(0.06)	(0.02)	(0.09)	(0.11)
Bilateral tariff_{iodt}	-2.40***	0.23***	3.54***	-3.89***
	(0.13)	(0.03)	(0.16)	(0.22)
Observations	13.3M	13.3M	13.3M	13.3M
R^2	0.715	0.888	0.776	0.887

Notes: The dependent variable is the firm's log export quantity in column (1), the firm's log (tariff-exclusive) unit value in column (2), the log of the firm's share of its country's trade with the destination in column (3) and the log of the country's (tariff-inclusive) export value to the destination market in column (4). Destination-average Tariff_{idt} and Bilateral Tariff_{iodt} capture the tariff changes that are common to all origins and specific to a particular origin for foreign firms in the destination market, respectively. Firm-product-origin-year and product-destination fixed effects are included. Control variables include destination's exchange rate to the US dollar, consumer price index, real GDP, import-to-GDP ratio of destination country, and product's share of the destination's total imports. Standard errors, reported in parentheses, are clustered at the product-destination level, and we denote statistical significance with *** p<0.01, ** p<0.05, and * p<0.1. Estimates are based on an integrated dataset of firms' exports from eleven countries built from the World Bank Exporter Dynamics Database, China's Customs Authority, and Egypt's Customs Authority, as well as tariff data from the WTO and Feenstra and Romalis (2014). The number of observation is 13,257,967.

country lose nearly a quarter (24%) of their demand. This observation suggests firms compete oligopolisticly, and that an origin-specific tariff shock has much larger impact on the subset of firms that received the shock.

Turning to the second column, a 10% increase in a destination-average tariff is associated with 0.5% increase in the (tariff-exclusive) markup charged by foreign exporters. A 10% increase in an origin-specific tariff raises the (tariff-exclusive) markup of targeted firms by 2.3%. In an oligopolisticly competitive market, the direction of markup adjustment depends on the reallocation of market shares within and across origins. With a tariff increase, a firm may lose market power as the market share of its country decreases in the destination market, but it may gain market power as its market share among exporters from its own origin country increases due to other firms' exits. We document the impact of tariff changes on the two market shares of exporters in columns (3) and (4).

As shown in column (3) of Table 2, a 10% increase in the destination-average tariff is associated with an 11.8% increase in a firm's market share in a destination among all firms from its own origin. In the case of targeted bilateral tariff, the same 10% increase in the tariff leads the within-origin market shares of continuing exporters to increase by 35.4%. By way of example, consider a firm that initially accounts for 50% of product exports from its own origin country. If the destination-average tariff increases from 10% to 11%, the market share of such a firm will rise to 55.9% of total exports from its own origin. However, if, instead, it is the the bilateral tariff applied to its origin country that rises from 10% to 11%, the same firm will expand its sales to claim a much bigger market share in the destination market, up to 67.7% *among allexporters from its own origin country.* Intuitively, firms that continue to export after a tariff increase gain market share as low-productivity firms exit the market; futhermore, reallocation of market share is stronger for an origin-specific tariff increase. Turning to the market share in the destination market of all exports from an origin country, we find that the origin's market share decreases by 11% in response to a broad-based multilateral tariff increase of 10%. This suggests domestic firms take market share from foreign exporters. If the destination raises its bilateral tariff against one origin country by 10%, while holding constant the tariff against other countries, then the targeted origin country will lose 38.9% of its market share in the destination market to both domestic firms and other foreign exporters.

3 Multi-country GE Model

With these empirical facts, we develop a quantitative version of the model introduced by Crowley, Han and Prayer (2024) that captures the observed market structure and matches these exporters' responses to tariff changes. We then use the model to study the price and welfare effects of a bilateral trade war.

The world consists of a set of countries denoted by $\mathcal{C}$ and trade among countries is indexed by origin $o \in \mathcal{C}$ and destination $d \in \mathcal{C}$.[12] In each country, there is a continuum of unit mass of industries, indexed by i, selling tradable goods.[13] Final consumption Y_{dt} and the price of the final consumption good P_{dt} in each country d in period t are aggregated over industries i:

$$Y_{dt} = \left(\int_i y_{idt}^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}}, \quad P_{dt} = \left(\int_i p_{idt}^{1-\eta} di \right)^{\frac{1}{1-\eta}} \tag{5}$$

where $\eta > 1$ is the elasticity of substitution across industries. Industry-level output y_{idt} and the industry-level price index p_{idt} are obtained by aggregating products across different origins:

$$y_{idt} = \left(\sum_{o \in \mathcal{C}} y_{iodt}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \quad p_{idt} = \left(\sum_{o \in \mathcal{C}} p_{iodt}^{1-\rho} \right)^{\frac{1}{1-\rho}} \tag{6}$$

where $\rho \geq \eta$ is the elasticity of substitution across products from different origins. Within each

[12]Throughout our paper, we use calligraphy math symbols to indicate a set of elements.

[13]In our empirical analysis, an "industry" is an HS6 product. We use the words "industry" and "product" interchangeably throughout the paper.

industry-origin-destination triplet, there is a finite number of firms, each producing a differentiated variety. The industry-origin-destination level output y_{iodt} and price p_{iodt} are obtained by aggregating across firms from the same origin:

$$y_{iodt} = \left(\sum_{f \in \mathcal{F}_{iodt}} (\alpha_{fiodt})^{1/\sigma} y_{fiodt}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad p_{iodt} = \left(\sum_{f \in \mathcal{F}_{iodt}} \alpha_{fiodt} p_{fiodt}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{7}$$

where $\sigma \geq \rho$ is the elasticity of substitution across varieties from the same origin, α_{fiodt} is a demand/preference shifter and $\mathcal{F}_{iodt}$ represents the set of active firms that sell product i from origin o to destination d at time t.[14]

Production. Labor is inelastically supplied and immobile across countries, and wages are identical across sectors in a given country. The production function is linear in labour L and productivity A, i.e., $Y \equiv AL$. The marginal cost of the firm is thus $mc_{fiot} = W_{ot}/A_{fiot}$, where W_{ot} is the nominal wage of the origin country o at time t and A_{fiot} is the productivity of firm f in industry i from country o at time t.

Price and export decisions. Firms compete by simultaneously choosing whether to enter a market, indicated by $\phi_{fiodt} \in \{0, 1\}$, and their optimal price p_{fiodt} if they enter. Since the production technology implies constant marginal costs, firms make their pricing and entry decisions separately for each destination market. The profit maximization problem of firm f in industry i from origin o selling in destination d is given by:

$$\pi_{fiodt} = \max_{p_{fiodt}, \phi_{fiodt}} \left[y_{fiodt} \left(\frac{p_{fiodt}}{\tau_{iodt}} - \iota_{iodt} mc_{fiot} \right) - \zeta_x \right] \phi_{fiodt}$$

subject to

$$y_{fiodt} = \alpha_{fiodt} \left(\frac{p_{fiodt}}{p_{iodt}} \right)^{-\sigma} \left(\frac{p_{iodt}}{p_{idt}} \right)^{-\rho} \left(\frac{p_{idt}}{P_{dt}} \right)^{-\eta} Y_{dt} \tag{8}$$

where τ_{iodt} and ι_{iodt} are one plus the ad-valorem tariff and non-tariff trade cost for firms in origin o to sell product i in destination d at time t.[15] ζ_x is a constant per-period export cost in terms of final consumption units. The firm will enter a market if the potential operating profit $y_{fiodt}(p_{fiodt}/\tau_{iodt} - \iota_{iodt} mc_{fiot})$ is larger than the fixed per-period exporting cost ζ_x in terms of final consumption

[14] We indicate a variable's level of aggregation in our model by its subscript. The most disaggregated variables have five dimensions, f, i, o, d and t, which stand for firm, industry, origin, destination, and time, respectively.

[15] Tariff is deducted from consumer price and is not received by the firms. We define $p^b_{fiodt} = p_{fiodt}/(1 + \tau_{iodt})$ as the border price before firm f's export of product i from origin o arrives at the border of destination d at time t. We model the trade cost δ_{iodt} as a Hicks-neutral productivity shock to firms in origin o to sell product i in destination t at time t.

units.[16] We follow Atkeson and Burstein (2008) and Gaubert and Itskhoki (2021) and assume that firms enter sequentially, in reverse order of marginal costs.[17] This framework allows us to calibrate the fixed cost of entry to ensure that each market that is open to trade is served by a plethora of domestic and international firms, but that only a handful of firms from the same country of origin enter each disaggregated product market in a destination.

Upon entry, the optimal price p_{fiodt} is equal to the endogenous (destination-specific) markup μ_{fiodt} multiplied by the tariff and trade cost-inclusive marginal cost mc_{fiodt}:

$$p_{fiodt} = \mu_{fiodt} mc_{fiodt}, \quad \mu_{fiodt} \equiv \frac{\varepsilon_{fiodt}}{\varepsilon_{fiodt} - 1}, \quad mc_{fiodt} \equiv mc_{fiot} \iota_{iodt} \tau_{iodt} \tag{9}$$

where ε_{fiodt} is the price elasticity of demand.

In what follows, we discuss the key implications of our extensions for the firm's optimal markup μ_{fiodt} under different assumptions about competition.

3.1 Market Structure and Demand Elasticity

The way in which firms compete varies with the structure of a market. This in turn can be characterized by (1) the market share distributions of firms and (2) the substitutability of varieties within an origin, across origins and across industries.

The general functional form of the demand elasticity under Cournot competition and the triple-nested demand structure described by expressions (5) - (7) can be derived as follows:[18]

$$\varepsilon_{fiodt} = \left[\frac{1}{\sigma} + \left(\frac{1}{\rho} - \frac{1}{\sigma} \right) ms_{fiodt} + \left(\frac{1}{\eta} - \frac{1}{\rho} \right) ms_{fiodt} ms_{iodt} \right]^{-1} \tag{10}$$

where the first market share ms_{fiodt} captures the importance of the firm among all exporters from its origin and the second market share ms_{iodt} captures the importance of the origin country in the destination market:

$$\underbrace{ms_{fiodt} = \frac{p_{fiodt} y_{fiodt}}{\sum_{f' \in \mathcal{F}_{iodt}} p_{f'iodt} y_{f'iodt}}}_{\text{firm's within-origin market share}}, \qquad \underbrace{ms_{iodt} = \frac{p_{iodt} y_{iodt}}{\sum_{o' \in \mathcal{C}} p_{io'dt} y_{io'dt}}}_{\text{origin's market share in the destination}} \tag{11}$$

[16] The production and pricing decisions for a firm selling in its own domestic (origin) market are similarly defined with a smaller fixed cost of operating in the domestic market, $\zeta_h < \zeta_x$, and bilateral tariff and trade costs normalized to one ($\tau_{ioot} = 1$, $\iota_{ioot} = 1$).

[17] This selects the equilibrium in which the most efficient firms operate (among multiple potential equilibria).

[18] Consistent with the literature, we have assumed Cournot competition in our benchmark model as this tends to better match the relationship between the estimated pass-through rates and empirical market share distributions (see Atkeson and Burstein 2008 and Amiti, Itskhoki and Konings 2019). All of our analytical results carry through with Bertrand competition, in which demand elasticity is given by: $\varepsilon_{fiodt} = \sigma - ms_{fiodt}[\sigma - \rho + (\rho - \eta) ms_{iodt}]$.

Special cases. Equation (10) nests many leading models in the literature. The demand elasticity ε_{fiodt} under different market structures can be summarized as:[19]

$$\varepsilon_{fiodt} = \begin{cases} \sigma, & \text{if } N_{iodt} \to \infty \text{ or } \sigma = \rho = \eta, \\ \left[\frac{1}{\sigma} + \left(\frac{1}{\eta} - \frac{1}{\sigma}\right)\omega_{fiodt}\right]^{-1}, & \text{if } N_{iodt} \text{ is finite and } \sigma = \rho, \\ \left[\frac{1}{\sigma} + \left(\frac{1}{\rho} - \frac{1}{\sigma}\right)ms_{fiodt}\right]^{-1}, & \text{if } N_{iodt} \text{ is finite and } ms_{iodt} \to 0, \end{cases} \tag{13}$$

where $N_{iodt} \equiv |\mathcal{F}_{iodt}|$ is the number of firms selling product i from origin o to destination d at time t and $\omega_{fiodt} \equiv ms_{iodt} \cdot ms_{fiodt}$ is the firm's market share in the destination market. Under monopolistic competition, i.e. when the number of firms $N_{iodt} \to \infty$ or when all three elasticities are the same $\sigma = \rho = \eta$, our model converges to the monopolistic competition model where firms charge constant markups, $\mu_{fiodt} = \frac{\sigma}{\sigma-1}$, and fully pass through trade costs. When the number of firms is finite and $\sigma = \rho$, our model converges to Atkeson and Burstein (2008), where the demand elasticity depends on $\varepsilon_{fiodt} = \left[\frac{1}{\sigma} + \left(\frac{1}{\eta} - \frac{1}{\sigma}\right)\omega_{fiodt}\right]^{-1}$ and tariff increases (reductions) reduce (raise) the markups of incumbent firms. When $ms_{iodt} \to 0$ and N_{iodt} is small, competition among firms from the same origin dominates and the demand elasticity becomes $\left[\frac{1}{\sigma} + \left(\frac{1}{\rho} - \frac{1}{\sigma}\right)ms_{fiodt}\right]^{-1}$. In this case, tariff increases (reductions) induce market exit (entry) by smaller firms, raising (lowering) the average market share and markups of surviving participants.

Properties of the model. Our model identifies relevant dimensions in which the market share reallocation that occurs under a tariff change matters. First, a tariff increase has *across-origin effects*— reducing market access for firms from an origin country as a whole which hampers the collective market power of its firms, resulting in lower markups. Second, there are *within-origin reallocation effects*—higher tariffs discourage firms from the targeted origin from continuingto sell in the market. Exit however raises the market share of continuing exporters from the same origin, who can thus charge higher markups. The interaction and balance between these effects determines whether exporters respond to tariff hikes by decreasing their markups (an anti-competitive outcome) or increasing them (a pro-competitive outcome).

While our model shares many fundamental features of leading models in the literature, such as having firms draw their productivity from a Pareto distribution, it also incorporates a realistic market structure, in line with the small, discrete number of firms at the origin-product-destination

[19] The special cases for Bertrand competition:

$$\varepsilon_{fiodt} = \begin{cases} \sigma, & \text{if either } N_{iodt} \to \infty \text{ or } \sigma = \rho = \eta, \\ \rho - \omega_{fiodt}(\rho - \eta), & \text{if } N_{iodt} \text{ is finite and } \sigma = \rho, \\ \sigma - ms_{fiodt}(\sigma - \rho), & \text{if } N_{iodt} \text{ is finite and } ms_{iodt} \to 0. \end{cases} \tag{12}$$

level documented in the data. In our setting, the impact of entry and exit on market structure is not negligible; in fact, trade policy changes greatlyaffect the extensive margin, resulting in substantial within-origin market share reallocation for incumbent firms.

Remarkably, this within-origin reallocation can even outweigh conventional Vinerian "across-origin" trade diversion effects when goods from the same origin are more substitutable with each other than with goods from other origins. When the elasticity of substitution among varieties from the same country exceeds that across countries, firms face the strongest competition from their national peers. For instance, the markup of a Chinese firm is heavily influenced by the pricing strategies of other Chinese firms selling the same product in the destination market and to a much larger extent than the pricing strategy of competitors from other countries. In this context, the exit (entry) of a single firm in response to a preferential tariff rise (cut) can increase (reduce) the markups of incumbent exporters.

An important implication of our model is that the import market share measure at the destination level (calculated as a firm's trade value divided by the total trade value of all firms) is no longer a sufficient statistic for markup adjustments. The differential effects of within- versus across-origin market share changes imply that a firm can raise its markup even as its overall market share in the destination drops. This occurs when firms are more responsive to within-origin market share changes, driven by a higher elasticity of substitution among goods from the same origin.

3.2 Calibration

We discipline the model by requiring it to match the empirical estimates of destination-specific quantity and markup elasticities, as well as the within-origin market share and origin's market share responses to tariff changes. Formally, the calibration procedure involves simultaneously choosing a set of parameters that minimizes the weighted distance between model moments and their data counterparts. As shown in Table 3, the model requires the within-origin elasticity of substitution to be much higher than the cross-origin elasticity of substitution, which suggests firms compete more intensively with their peers from the same origin than firms from other origins. We calibrate the fixed cost of operating in the the foreign market such that only 25% of firms export, and set the fixed cost of operating in the domestic market at 10% of the fixed cost to enter the foreign market, in line with the estimates of Edmond, Midrigan and Xu (2015).[20]

[20]In our benchmark simulation, we consider four ex-ante symmetric countries and 1000 sectors. Motivated by the empirical evidence in the previous section, we set the number of potential firms in a origin-destination-product market to five. The calibrated fixed costs of entering the domestic and foreign markets are 1.83 and 0.18, respectively— this results in over 98% of potential firms entering domestic markets, and about 25% of potential firms entering foreign markets.

Table 3: Estimated parameters

Parameter	Value
Within-country elasticity of substitution (ρ)	6.05
Cross-industry elasticity of substitution (σ)	3.49
Pareto shape parameter, idiosyncratic productivity (ξ)	9.95
Dispersion of idiosyncratic demand preference (ς)	0.39

Notes: The cross-industry elasticity of substitution (η) is exogenously set as 1.2, which is in line with Atkeson and Burstein (2008) and Edmond, Midrigan and Xu (2015). The number of potential firms in a origin-destination-product market is five, and each potential firm draws productivity from a Pareto distribution, with cumulative distribution function $F_x(x) = 1 - (\frac{1}{x})^{\frac{1}{\xi}}$. Dispersion of idiosyncratic demand preference (ς) governs the distribution of idiosyncratic demand preference α_{fiodt}, which is drawn from a lognormal distribution with mean zero and variance ς^2.

Our model closely reproduces the tariff elasticities estimated in our empirical exercise, simultaneously matching eight data moments with four model parameters. As shown in table 4, the flexible market structure embedded in our model allows us to replicate the positive and differential markup adjustments to tariff changes applied indiscriminately to all origins as opposed to a specific origin. In addition, the model predicts a low quantity elasticity, in line with the empirical evidence. As discussed above, this dimension of the data is difficult to match in a monopolistic competition model. We provide a detailed discussion of the reason why oligopolistic competition is essential to match the empirical estimates in Appendix B.5.

Table 4: Moments in the Data and the Model

	Data		Model	
Targeted tariff elasticity estimates	Common	Bilateral	Common	Bilateral
Quantity	-0.78	-2.40	-1.58	-2.39
Markup	0.05	0.23	0.11	0.22
Firm's within-origin market share	1.18	3.54	1.16	2.70
Origin's market share in dest.	-1.19	-3.89	-1.41	-3.93

Notes: The data moments are tariff elasticities reported in Table 2. The model moments are the model-implied tariff elasticities, estimated using simulated data from four ex-ante symmetric countries and 1000 sectors.

4 Dissecting the Effects of Bilateral Trade Wars

Using the calibrated model, we conduct an experiment involving a 10 percentage point increase in the bilateral tariff between two of the four countries in the model. We compare model predictions in four different scenarios, allowing for different combinations of adjustments at the extensive and intensive (markup) margins. In our first set of experiments, we keep the set of firms in each market fixed. That is, the firms that optimally chose to participate in each market before the tariff increase may change their prices and quantities in response to the tariff increase, but are not allowed to change their participation decision (i.e., the fixed costs of exporting are treated as sunk costs).[21] In the other set of experiments, we allow for endogenous entry and exit of exporters in a market. For each set of experiments, we present results from our variable-markup (benchmark) model alongside a constant-markup version of the model. To allow for a fair comparison of results across models, we calibrate the demand parameter σ in the constant-markup model to match the trade elasticity of the variable-markup model.[22]

To understand the sources of welfare effects in a bilateral trade war, we decompose the aggregate welfare changes into different reallocation channels. In doing so, we augment the welfare decomposition in Baqaee and Farhi (2024) to allow for entry and exit of firms.[23]

4.1 Prices and Welfare with Market Power Reallocation

Figure 1 depicts outcomes for the two belligerents in the bilateral trade war.[24] Panel (a) shows the percentage change in aggregate prices and panel (b) presents welfare. The dashed lines refer to simulations holding the number of firms in a market fixed, the solid lines refer to the simulations allowing for endogenous entry. Beginning with the impacts on aggregate prices (panel (a)), for the cases of no entry or exit, the red dashed line represents the responses from the oligopolistic competition model, while the blue dashed line corresponds to a counterfactual model where markup

[21] Specifically, we simulate the model twice: before and after the bilateral tariff increase. In the first simulation, prior to the tariff increase, firms make optimal entry decisions based on whether their operating profit in a market exceeds the fixed cost of exporting. In the second simulation, with the bilateral tariff increase in place, we keep firms' sets of markets fixed to those optimally chosen in the first simulation, and examine these firms' intensive margin choices of prices and quantities.

[22] The aggregate trade elasticity ϵ_d is one minus the sales weighted demand elasticity faced by each firm-product-year triplet from the foreign country, calculated for each destination. See footnote 28 for the definition of the aggregate trade elasticity in the variable-markup model. In the constant markup model, we set the three elasticities of the triple-nested CES preferences to be equal, i.e., $\sigma = \rho = \eta$. This degenerates to the first special case in equation (12). We then calibrate the trade elasticity of the constant-markup model (i.e., $1 - \sigma$) to match the aggregate trade elasticity in the variable-markup model.

[23] Our focus on the entry and exit of firms emphasizes the contributions to welfare arising from changes in factor income due to changes in firms' profits. See Borusyak and Jaravel (2021) and Borusyak and Jaravel (2024) for a rich treatment of the factor demand channel emphasizing wage impacts across workers.

[24] Analysis of outcomes for the two neutral economies is presented in Appendix B.1.

(a) Aggregate Price Change

(b) Welfare Change

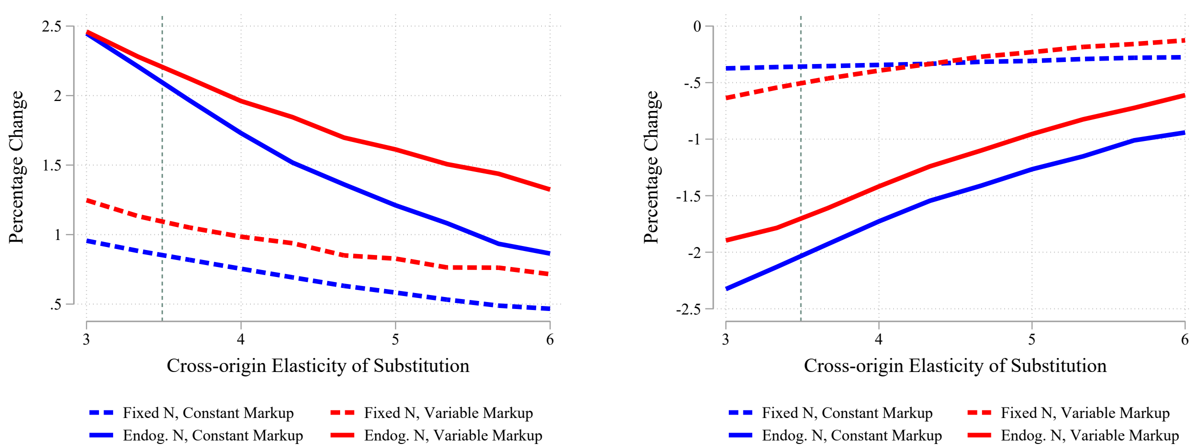

Figure 1: Aggregate Prices and Welfare Changes in Trade War Economics

Notes: This figure illustrates the model's prediction of aggregate price change and welfare change for trade-war economies after the bilateral trade war. We use the estimated parameters reported in Table 3, where σ=6.05, and vary the cross-origin elasticity of substitution (ρ) from 3 to 6. As ρ approaches 6, it converges to the preference structure of Atkeson and Burstein (2008). The red lines plot the responses of our variable-markup model, and the blue lines plot the responses of a constant-markup model, in which we calibrate the elasticity of substitution to match the trade elasticity of our variable-markup model to facilitate the comparison. We also contrast the model response for fixed entry and endogenous entry scenarios. The dashed lines plot the responses in the fixed entry case, in which firms do not adjust entry or exit decisions after tariffs are increased in the trade war, while the solid lines plot the responses in the endogenous entry case, in which firms optimally choose the set of markets they serve under bilateral trade war tariffs. The vertical line indicates the value of the cross-origin elasticity of substitution set in our benchmark calibration.

adjustments are shut down. Comparing the red and blue dashed lines in the left panel of the figure, we observe that the price increase is larger in the oligopolistic competition case. This is mainly driven by the rise in markups charged by domestic firms. Essentially, the tariff hike shifts market power towards domestic firms; these firms gain market share and charge higher markups. The price increases are, however, larger when firms optimally choose export markets during the bilateral trade war — these cases are depicted by the solid red and blue lines; both solid lines lie above the dashed ones. In the trade war, each belligerent's tariffs drive out exports of firms residing in its opponent. This exit of (relatively large) exporters, in turn, drives large increases in the aggregate price index. Notably, aggregate price increases are largest in the model with variable-markups (solid red line) in which continuing firms re-optimize their markups under the trade war (compare this increase against that of the constant markup model with endogenous participation represented by the solid blue line). Overall, our simulations show that the price impact is highest when we (realistically) account for both oligopolistic competition and endogenous entry.

Turning to panel (b), we see that endogenous entry (solid lines) significantly amplifies the welfare losses from a bilateral trade war. Interestingly, under oligopolistic competition with variable markups (solid red line), losses are smaller (relative to the solid blue line constant-markup-model) because foreign firms can lower their markups and remain in the market. In contrast, in a monopolistic model with constant markups (solid blue line), unproductive firms hit by the tariff shock choose to exit.

The welfare impact of a trade war is much more limited in our simulations shutting down the extensive margin adjustments—the dashed lines are well above the solid lines. Our simulations indicate that the welfare implications of oligopolistic competition relative to monopolistic competition under fixed participation are ambiguous—the two dashed lines cross—, a finding consistent with the existing literature (e.g. Edmond, Midrigan and Xu 2015, Arkolakis et al. 2018).

4.2 Welfare Decomposition with Entry and Exit of Large Exporters

To gain theoretical insight into the drivers of the welfare impacts of trade wars, we decompose welfare changes into different wedges by extending the framework of Baqaee and Farhi (2024).[25] While the welfare decomposition by these authors is very general and allows for a wide range of misallocation wedges, it does not account for entry and exit of firms. Our extension incorporates adjustment at the extensive margin, in order to bring the decomposition to bear on the welfare effects of changes in market composition. Since we focus on tariffs, our welfare decomposition will

[25] We focus on Baqaee and Farhi (2024), as its original framework accounts for oligopolistic competition and markup changes. With oligopolistic competition and endogenous entry, the Arkolakis, Costinot and Rodríguez-Clare (2012) formula may no longer accurately approximate the true welfare change. A detailed discussion is provided in Appendix B.8.

capture reallocation wedges only.[26]

With extensive margin adjustments, the welfare changes can be decomposed as follows:

$$\mathrm{d}\log W_d \approx \underbrace{I_d}_{\text{Change in reallocation in continuing firms}} + \underbrace{E_d}_{\text{Variety effect}}, \tag{14}$$

where

$$I_d \approx \underbrace{-\sum_{a\in\mathcal{A}_{dt}\cap\mathcal{A}_{dt-1}} \tilde{\lambda}_{ad}\,\mathrm{d}\log\tau_{ad}}_{\text{Tariff wedge}} \underbrace{-\sum_{a\in\mathcal{A}_{dt}\cap\mathcal{A}_{dt-1}} \tilde{\lambda}_{ad}\,\mathrm{d}\log\mu_{ad}}_{\text{Markup wedge}} + \underbrace{\sum_{b\in\mathcal{B}_{dt-1}\cap\mathcal{B}_{dt}} \left(\Lambda_{bd}-\tilde{\lambda}_{bd}\right)\mathrm{d}\log\Lambda_b}_{\text{Factor income wedge}}, \tag{15}$$

$$E_d \approx \underbrace{-\frac{1}{\epsilon_d}\left[\sum_{a\in\mathcal{A}_{dt}\cap a\notin\mathcal{A}_{dt-1}} \tilde{\lambda}_{ad} - \sum_{a'\notin\mathcal{A}_{dt}\cap a'\in\mathcal{A}_{dt-1}} \tilde{\lambda}_{a'd}\right]}_{\text{Effect on aggregate prices}} + \underbrace{\sum_{b\in\mathcal{B}_{dt}\cap b\notin\mathcal{B}_{dt-1}} \Lambda_{bd} - \sum_{b'\notin\mathcal{B}_{dt}\cap b'\in\mathcal{B}_{dt-1}} \Lambda_{b'd}}_{\text{Effect on factor income}}. \tag{16}$$

where $\mathrm{d}\log W_d$ is the change in welfare of destination d, which is identical to the change in real consumption $\mathrm{d}\log Y_d$. It can be decomposed into changes in reallocation wedges due to intensive margin adjustments by firms that operate in both periods denoted by I_d and a variety effect that arises from changes in the set of firms in the market. In equations (15) and (16), a denotes a firm-product-origin triplet, and b represents labor, tariff revenue, or profit factors. $\tilde{\lambda}_{ad}$ measures d's expenditure exposure to goods produced by a, and $\tilde{\lambda}_{bd}$ measures d's expenditure exposure to goods produced using b. $\mathcal{A}_{dt}$ and $\mathcal{B}_{dt}$ denote the set of active firm-product-origin triplets a and income factors b that are available at t, respectively. Λ_{bd} and Λ_b represent the shares of factor b in d's income and world income, respectively.[27] Finally, ϵ_d in (16) represents the aggregate trade elasticity.[28]

As in Baqaee and Farhi (2024), the welfare effect of intensive margin adjustments can be decomposed into three terms. The first term in equation (15) reflects the tariff wedge, which quantifies the direct effect of the tariff distortion on consumer prices. The second term captures the markup wedge, which represents changes in consumer prices driven by markup adjustments.

[26] Relative to Baqaee and Farhi (2024), our current model and decomposition do not allow for intermediate inputs. We are currently working on a version of the model with realistic input-output production networks.

[27] We discuss how the expenditure exposures are derived in Appendix B.6.

[28] The aggregate trade elasticity ϵ_d is one minus the sales weighted demand elasticity faced by each firm-product-year triplet from the foreign country, calculated for each destination. Formally, $\epsilon_d \equiv 1 - \frac{\sum_a \varepsilon_{ad} p_{ad} y_{ad}}{\sum_a p_{ad} y_{ad}}$, where y_{ad}, p_{ad}, and ε_{ad} are the quantity, price, and demand elasticity of firm-product-origin triplet a in destination d, defined in equations (8), (9), (10), respectively.

The third term captures how factor rewards affects households through consumption exposure and factor income.

In addition to these intensive margin adjustments, the inclusion of entry and exit introduces an additional variety effect, E_d. The first term in (16) reflects how changing varieties affect the price index, as shown by Feenstra (1994). The second term captures the change in factor income driven by firm entry and exit. For example, if, following a trade war, a Chinese firm ceases exporting to the US, the second term in the equation will reflect the associated profit loss for China and the associated tariff loss for the US.

4.3 Quantitative Assessment

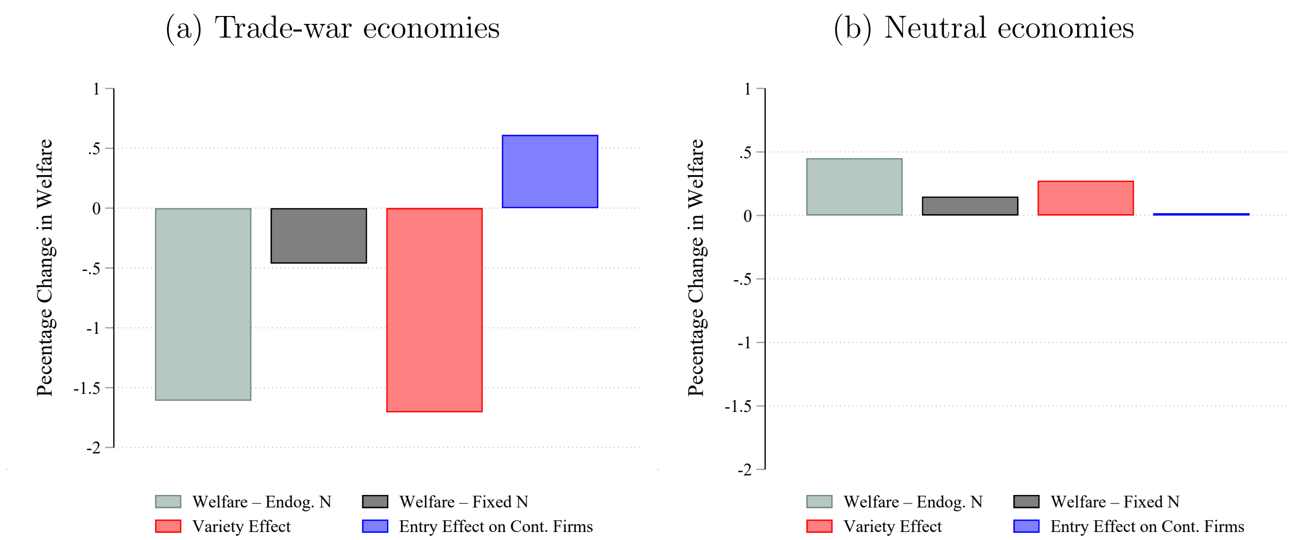

Figure 2: Decomposing the entry and exit effects on welfare

Notes: This figure summarizes the impact on welfare for trade-war economies and neutral economies. We report the welfare change predicted by the calibrated oligopolistic competition model; the light grey bars report welfare for the model with endogenous entry and exit, the dark grey bars report welfare for the case in which participation under the trade war is fixed at the pre-war status. We then decompose the difference between the endogenous entry and exit and fixed participation cases into two components, one is the direct effect of extensive margin adjustment (or, variety effect), captured by the red bars, and the other is the indirect effect of entry and exit on continuing firms, captured by the blue bars.

Before delving into a quantitative analysis of the decomposition derived in the previous section, in Figure 2 we show the global welfare effects of a trade war under our benchmark calibration. The left panel shows these effects in the trade-war economies, the right panel refers to the neutral economies. In each panel, the first bar indexes the welfare change in our benchmark model with oligopolistic competition and endogenous entry (corresponding to the solid red line in Figure 1(b) evaluated at $\sigma = 3.49$); the second bar represents the welfare effect without any extensive margin adjustments (corresponding to the dashed red line in Figure 1(b) evaluated at $\sigma = 3.49$). It is apparent from the figure that endogenous entry significantly amplifies the welfare losses for the trade-war countries, as well as the trade gains for the neutral economies.

The difference between the first two bars reflects the entry and exit effect on welfare, which in turn can be decomposed as follows:

$$\mathrm{d}\log W_d^{\text{Endog. N}} - \mathrm{d}\log W_d^{\text{Fixed N}} = \underbrace{E_d^{\text{Endog. N}}}_{\text{Variety effect}} + \underbrace{(I_d^{\text{Endog. N}} - I_d^{\text{Fixed N}})}_{\text{Entry effect on continuing firms}} \quad . \tag{17}$$

The first term on the right-hand side captures the welfare impact of changes in the set of firms operating in the economy; the second term (in brackets) reflects the differential intensive margin adjustment of continuing firms under endogenous and exogenous market participation. A quantification of these terms under our benchmark calibration is shown in Figure 2, as the third (red) and fourth (blue) bar in each panel. We see these two effects work in opposing directions. On the one hand, the trade war countries experience welfare losses due to the exit of foreign firms, which reduces the variety of goods available to consumers. On the other hand, the exit of foreign firms shifts market power towards domestic firms, allowing them to gain market share and increase profits. Since firms are owned by households, thisredistribution of market power raises the real purchasing power of domestic households, thereby improving welfare.

The neutral countries, i.e., the countries not involved in the trade war, generally benefit from the bilateral trade war—as shown in panel (b) of Figure 2. Their firms gain market share lost by firms from the trade-war economies, and their households benefit from improved factoral terms of trade, as the real wage in the trade-war economies decline. Entry amplifies the welfare gains of neutral economies.

4.3.1 The Variety Effect with Extensive Margin Adjustment

The variety effect is the novel component in the welfare decomposition (14). We find it appropriate to present first a detail discussion of its approximation (16). In Figure 3, panels (a) and (b) compare the true variety effect and the approximated variety effect. The true variety effect is calculated as the difference between the welfare change and the reallocation wedges contributed by the continuing firms, which maps to E_d in equation (14). The approximated variety effects is calculated using equation (16). Our results show that the approximation performs well and matches the shape of the true variety effect for a large range of cross-origin elasticities of substitution, but admittedly becomes less precise as the value of this elasticity becomes small.[29]

[29] This is likely due to the large size of the shock and the curvature in the demand schedule introduced by a lower elasticity of substitution. We are working on second-order approximation in order to handle the non-linearity more gracefully. We discuss the performance of the approximation in Appendix B.3.

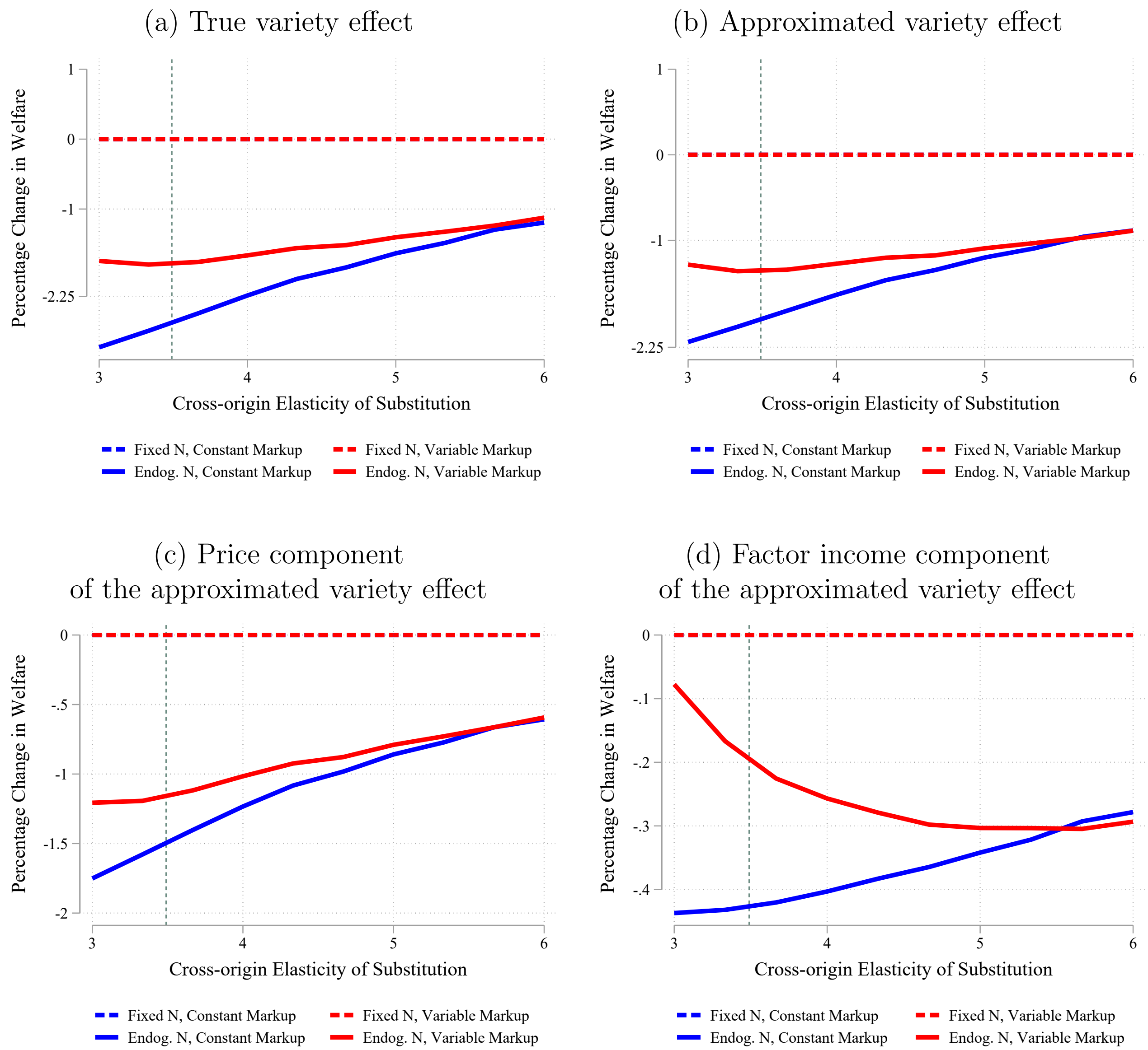

Figure 3: Decomposing the variety effect on trade war economics

Notes: This figure decomposes the variety effect induced by entry and exit, and compares the approximated variety effect with the true value implied by the model. Panel (a) shows the true variety effect, calculated as the difference between the welfare change and the reallocation wedges accruing to continuing firms, which maps to E_{dt} in equation (14). Panel (b) illustrates the approximated variety effect, calculated following equation (16). Panel (c) and (d) describe the price and factor income components of the variety effect, respectively. The solid lines depict the variety effect induced by entry and exit when firms optimally choose their export markets. The dashed lines depict outcomes for the cases in which export markets are fixed at the pre-war status — the dashed lines are horizontal because, by definition, there is no variety effect when firms cannot enter or exit. The solid red lines plot the responses in the variable-markup model, and the blue lines plot the responses in a constant-markup model, in which we calibrate the elasticity of substitution to match the trade elasticity of our variable-markup model to facilitate the comparison. The vertical line indicates the value of the cross-origin elasticity of substitution set in our benchmark calibration.

In panels (c) and (d), we decompose the variety effect into a price effect and a factor income effect. The price effect reflects the fact that the exit of foreign firms leads to a sizeable loss of varieties, with the result of pushing up the (welfare-relevant) aggregate price. Conversely, the price response to entry and exit is attenuated by oligopolistic competition, as shown by the difference between the blue solid line and the red solid line. This is because under oligopolistic competition (solid red line) firms have the option to lower their markups in order to remain in the market—in contrast with the prediction of the constant-markup model (solid blue line) where firms exit if operating profits turn negative.

Turning to the factor income effect induced by entry and exit (panel d), we observe that welfare in the trade-war economies suffers from the combined loss of profits *and* tariff revenue due to firm exit. Note also that, under oligopolistic competition (solid red line), the factor income component is a smaller drag on welfare when the cross-origin elasticity of substitution (ρ) becomes smaller than the within-origin elasticity of substitution ($\sigma = 6$). As we depart from the Atkeson and Burstein (2008) model, that is, the calibration in which $\rho = \sigma = 6$, the difference between the variable-markup model (solid red line) and constant-markup model (solid blue line) becomes larger.[30]

4.3.2 Offsetting Effects at the Intensive Margin

There are first-order effects on welfare arising from intensive margin adjustment by continuing firms and corresponding changes in factor rewards due to exit by foreign exporters targeted by trade war tariffs. We turn to these effects in Figure 4. The first takeaway from this figure is that, for the trade-war economies, the overall welfare effect of intensive margin adjustment is positive at most parameter values under trade war tariffs when export participation is endogenous — see the solid red line in panel (a). This is in sharp contrast to the intensive margin contribution when foreign firms' export market participation is fixed at their pre-war status. Underlying the largely positive contribution of the intensive margin to welfare under a trade war are two offsetting effects. On the one hand, tariffs allow domestic firms to increase their markups, resulting in misallocation and thus reducing welfare (see the solid red line in panel (b)) . On the other hand, since households own domestic firms, higher markups and profits of domestic firms boost domestic incomes and increase welfare (see the solid red line in panel (f)). Both channels are strengthened by endogenous market participation, but *quantitatively* endogenous exit of foreign firms reinforces the income effect more than the price effect.[31]

[30] We discuss the variety effect in the Atkeson and Burstein (2008) special case where $\sigma = \rho$ in Appendix B.2. Relative to the findings presented here, the variety effects under the Atkeson and Burstein (2008) model are much more similar to constant-markup counterpart.

[31] Endogenous participation lowers the tariff revenue of the trade war economies, because some foreign firms exit the market after the tariff hike. However, the loss of tariff revenue is small compared to the increase in domestic

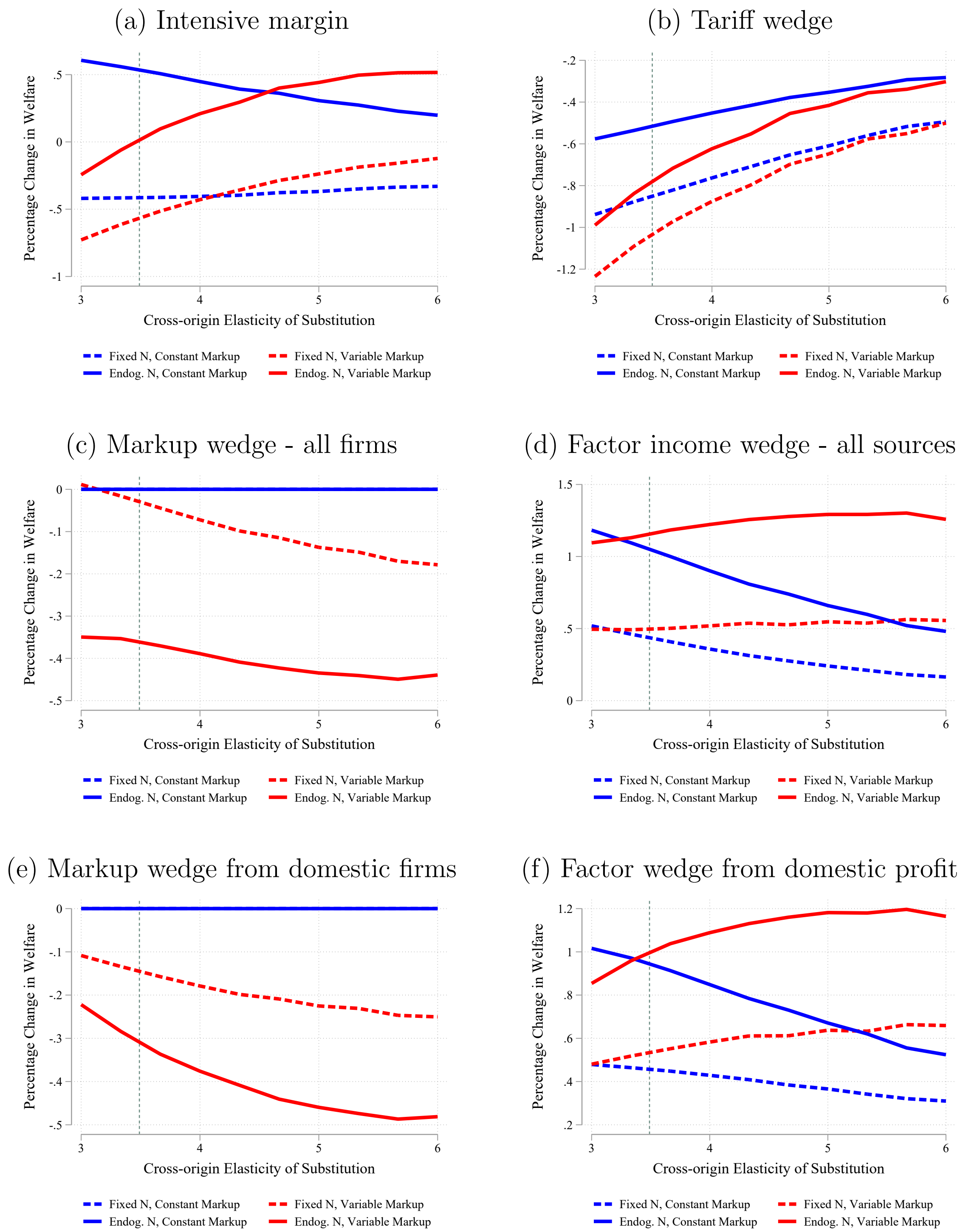

Figure 4: Intensive margin welfare components in trade war belligerents

Notes: This figure decomposes the change in welfare along the intensive margin due to price changes of continuing firms and changing factor rewards. Panel (a) shows the sum of the intensive margin components, which can be further decomposed into tariff, markup, and factor income wedges in panels (b) - (d). Panel (e) isolates welfare effects of markup changes by domestic firms, and panel (f) singles out the contribution of profits earned in the domestic market to the factor income change. The vertical line indicates the calibrated cross-origin elasticity of substitution.

Panels (b) through (f) further illustrate the economics underlying the intensive margin contributions to welfare changes under a trade war. With endogenous entry and exit (see the solid red line in panel (b)), as some exporters choose to exit, in welfare terms the tariff-related distortions are smaller than in the case in which participation is fixed at the pre-war status (see the dashed red line in panel (b)). However, at the same time, the distortion due to endogenous markup adjustments by domestic firms are higher — see the solid red line panel (e). As domestic firms gain market power when targeted foreign firms exit, they raise their markups.

The negative welfare effects of sizeable markup increases by domestic firms is partly offset by changes in factor incomes (see panel (d)). Domestic households, the owners of domestic firms, benefit from the increase in income accruing to their corporations that, under oligopolistic competition, gain market share and market power. Endogenous entry is once again crucial for the balance between price and income effects. A comparison of panels (e) and (f) suggests that, quantitatively, the increase in income dominates the welfare reduction due to the price hike due to markup increases.

The role of variable markups in driving the welfare impact of intensive margin adjustment deserves further discussion. As shown in panel (a), the overall welfare impact of a variable markup depends on the extent of substitution across and within origins. In the figure, the solid red line (variable-markup model) lies below the solid blue line (constant markup model) when the substitution across origins is weaker than the substitution within origins—implying that variable-markup models predict a lower (even negative) contribution of the intensive margin adjustment to welfare, relative to their constant-markup counterparts. To gain insight into this result, consider the contribution of tariff, markup, and factor incomes wedges, shown in panels (b) through (d). As the substitutability of products across origins becomes weaker, the tariff distortions become larger, since households cannot easily shift consumption away from products supplied by the trade-war economies—see panel (b). Panel (c) shows that markup distortions are higher in the variable-markup model, because domestic firms raise their prices when they take over the market. Yet, this effect is attenuated if the substitutability of varieties across origins grows weaker —with a lower degree of substitutability, sales losses by foreign firms are smaller, and domestic firms cannot raise their markups as much. Correspondingly, panel (d) shows that, while variable markups result in larger factor income gains for the residents in the trade-war economies, this effect diminishes as the cross-origin elasticity of substitution becomes smaller.

To summarize: the welfare impact of intensive margin adjustment depends on (a) changes in consumer prices due to tariff and markup changes and (b) changes in factor income. In general, variable markups amplify the negative impact of higher consumer prices, but they also strengthen the positive impact of factor rewards changes. Under the special case in which the elasticities of

profit due to endogenous exit of foreign exporters.

substitution within and across origin are the same, the contribution of variable markups to the welfare impact of intensive margin adjustment is positive. However, in general, this contribution is ambiguous, depending on the relative degree of competition within and across origins.

5 Conclusion

The disruption of bilateral trade flows caused by trade wars results in significant shifts in firms' market power in domestic and international markets, and affects productivity at the country and global level. In this paper, we argue that understanding the welfare and allocation effects of tariffs requires modeling that incorporates oligopolistic competition and endogenous market participation decisions.

Empirically, we exploit a large data set of exports from 11 low and middle-income economies to document that most origin-destination-product markets are highly concentrated, implying that entry and exit decisions by firms with large market shares have first order effects on market structure. We produce econometric evidence on responses of quantities, prices, and market shares to tariff changes, showing that these changes are larger in response to country-specific as opposed to non-discriminatory tariff hikes. We take this empirical evidence as the core guidance for the specification of a model suitable to study the effects of a trade war.

Theoretically, we set up a n-country general equilibrium trade model that incorporates oligopolistic competition and firms' endogenous market participation, and show that these features are crucial for aligning theoretical predictions with the empirical evidence. We use the simulated method of moments to estimate four model parameters by simultaneously matching eight tariff elasticities to our empirical estimates. The quantitative success of the model requires the within-origin elasticity of substitution be higher than the cross-origin elasticity of substitution, which suggests firms compete more intensively with their peers from the same origin than firms from other origins.

To dissect the drivers of the effects of tariffs on welfare, we reconsider the decomposition by Baqaee and Farhi (2024) in a oligopolistic setting with entry and exit and love for variety. Our augmented decomposition allows us to focus specifically on the implications of extensive margin changes as well as on the impact of extensive margin changes on the intensive margins of domestic firms and continuing exporters. The benchmark model developed in this paper abstracts from global production chains—an extension encompassing these chains is in our agenda.

In view of the possibility of trade conflicts in the near future, our paper stresses that much of the impact of trade wars on welfare, incomes and prices is driven by the entry and exit of large, productive exporters in international markets, and the ensuing adjustment in pricing and sales by continuing exporters and domestic firms. These market dynamics have first-order implications for the reallocation of market power both within and across borders, underscoring the critical role of granular firm-level adjustments in shaping global trade and aggregate outcomes.

References

Alexander, Patrick, Lu Han, Oleksiy Kryvtsov, and Ben Tomlin. 2024. "Markups and Inflation in Oligopolistic Markets: Evidence from Wholesale Price Data." Bank of Canada Working Paper.

Amiti, Mary, Mi Dai, Robert C. Feenstra, and John Romalis. 2020. "How did China's WTO entry affect U.S. prices?" *Journal of International Economics*, 126: 103339.

Amiti, Mary, Oleg Itskhoki, and Jozef Konings. 2019. "International Shocks, Variable Markups, and Domestic Prices." *The Review of Economic Studies*, 86(6): 2356–2402.

Amiti, Mary, Stephen J. Redding, and David E. Weinstein. 2019. "The Impact of the 2018 Tariffs on Prices and Welfare." *Journal of Economic Perspectives*, 33(4): 187–210.

Arkolakis, Costas, Arnaud Costinot, and Andrés Rodríguez-Clare. 2012. "New Trade Models, Same Old Gains?" *American Economic Review*, 102(1): 94–130.

Arkolakis, Costas, Arnaud Costinot, Dave Donaldson, and Andrés Rodríguez-Clare. 2018. "The Elusive Pro-Competitive Effects of Trade." *The Review of Economic Studies*, 86(1): 46–80.

Atkeson, Andrew, and Ariel Burstein. 2008. "Pricing-to-Market, Trade Costs, and International Relative Prices." *The American Economic Review*, 98(5): 1998–2031.

Baier, Scott L., Jeffrey H. Bergstrand, and Michael Feng. 2014. "Economic integration agreements and the margins of international trade." *Journal of International Economics*, 93(2): 339 – 350.

Baqaee, David Rezza, and Emmanuel Farhi. 2024. "Networks, barriers, and trade." *Econometrica*, 92(2): 505–541.

Bernard, Andrew B., Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum. 2003. "Plants and Productivity in International Trade." *American Economic Review*, 93(4): 1268–1290.

Bortoluzzi, Aldo Pazzini, Ana Margarida Fernandes, and Martha Denisse Pierola. 2015. "Exporter Dynamics Database – Version 2.0: A Technical Note." *World Bank Techincal Note*.

Borusyak, Kirill, and Xavier Jaravel. 2021. "The Distributional Effects of Trade: Theory and Evidence from the United States."

Borusyak, Kirill, and Xavier Jaravel. 2024. "Are trade wars class wars? The importance of trade-induced horizontal inequality." *Journal of International Economics*, 150: 103935.

Bown, Chad P., and Meredith A. Crowley. 2006. "Policy Externalities: How US Antidumping Affects Japanese Exports to the EU." *European Journal of Political Economy*, 22(1): 696–714.

Brander, James A., and Barbara J. Spencer. 1984. "Trade warfare: Tariffs and cartels." *Journal of International Economics*, 16(3-4): 227–242.

Brander, James, and Paul Krugman. 1983. "A 'reciprocal dumping' model of international trade." *Journal of International Economics*, 15(3): 313–321.

Cavallo, Alberto, Gita Gopinath, Brent Neiman, and Jenny Tang. 2021. "Tariff Pass-Through at the Border and at the Store: Evidence from US Trade Policy." *American Economic Review: Insights*, 3(1): 19–34.

Cebeci, Tolga. 2015. "A Consistent Concordance Among Harmonized System 1996, 2002, 2007, and 2012 Classifications." *World Bank Techincal Note.*

Corsetti, Giancarlo, Meredith Crowley, Lu Han, and Huasheng Song. 2023. "Markets and Markups : A New Empirical Framework and Evidence on Exporters from China." *CEPR Discussion Paper*, 13904.

Crowley, Meredith A., Lu Han, and Thomas Prayer. 2024. "The pro-competitive effects of trade agreements." *Journal of International Economics*, 150: 103936.

De Blas, Beatriz, and Katheryn N. Russ. 2015. "Understanding Markups in the Open Economy." *American Economic Journal: Macroeconomics*, 7(2): 157–180.

De Loecker, Jan, Pinelopi K. Goldberg, Amit K. Khandelwal, and Nina Pavcnik. 2016. "Prices, Markups, and Trade Reform." *Econometrica*, 84(2): 445–510.

Eaton, Jonathan, and Gene M. Grossman. 1986. "Optimal Trade and Industrial Policy under Oligopoly." *The Quarterly Journal of Economics*, 101(2): 383–406.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu. 2015. "Competition, Markups, and the Gains from International Trade." *The American Economic Review*, 105(10): 3183–3221.

Epifani, Paolo, and Gino Gancia. 2011. "Trade, markup heterogeneity and misallocations." *Journal of International Economics*, 83(1): 1–13.

Fajgelbaum, Pablo D, Pinelopi K Goldberg, Patrick J Kennedy, and Amit K Khandelwal. 2020. "The Return to Protectionism." *The Quarterly Journal of Economics*, 135(1): 1–55.

Feenstra, Robert C. 1994. "New Product Varieties and the Measurement of International Prices." *The American Economic Review*, 157–177.

Feenstra, Robert C. 2018. "Restoring the product variety and pro-competitive gains from trade with heterogeneous firms and bounded productivity." *Journal of International Economics*, 110: 16–27.

Feenstra, Robert C., and David E. Weinstein. 2017. "Globalization, Markups, and US Welfare." *Journal of Political Economy*, 125(4): 1040–1074.

Feenstra, Robert C., and John Romalis. 2014. "International Prices and Endogenous Quality." *The Quarterly Journal of Economics*, 129(2): 477–527.

Fitzgerald, Doireann, and Stefanie Haller. 2014. "Pricing-to-Market: Evidence from Plant-Level Prices." *The Review of Economic Studies*, 81(2): 761–786.

Fitzgerald, Doireann, Stefanie Haller, and Yaniv Yedid-Levi. 2023. "How Exporters Grow." *The Review of Economic Studies*, rdad070.

Freund, Caroline, Aaditya Mattoo, Alen Mulabdic, and Michele Ruta. 2023. "Is US Trade Policy Reshaping Global Supply Chains?" *World Bank Policy Research Working Paper*, 10593.

Gaubert, Cecile, and Oleg Itskhoki. 2021. "Granular comparative advantage." *Journal of Political Economy*, 129(3): 871–939.

Helpman, Elhanan, and Paul Krugman. 1985. *Market Structure and Foreign Trade.* Cambridge, MA:MIT Press.

Helpman, Elhanan, Marc J. Melitz, and Stephen R. Yeaple. 2004. "Export Versus FDI with Heterogeneous Firms." *American Economic Review*, 94(1): 300–316.

Impullitti, Giammario, and Omar Licandro. 2018. "Trade, firm selection and innovation: The competition channel." *The Economic Journal*, 128(608): 189–229.

Jaravel, Xavier, and Erick Sager. 2023. "What are the price effects of trade? Evidence from the US and implications for quantitative trade models." , (dp1642).

Kikkawa, Ayuma Ken, Yuan Mei, and Pablo Robles Santamarina. 2019. "The Impact of NAFTA on Prices and Competition: Evidence from Mexican Manufacturing Plants." CESifo CESifo Working Paper Series 7700.

Knetter, Michael M. 1989. "Price Discrimination by US and German Exporters." *The American Economic Review*, 79(1): 198–210.

Knetter, Michael M. 1993. "International Comparisons of Pricing-to-Market Behavior." *The American Economic Review*, 83(3): 473–486.

Markusen, James R., and Anthony J. Venables. 1988. "Trade policy with increasing returns and imperfect competition: Contradictory results from competing assumptions." *Journal of International Economics*, 24(3): 299–316.

Mrázová, Monika, and J Peter Neary. 2017. "Not so demanding: Demand structure and firm behavior." *American Economic Review*, 107(12): 3835–3874.

Mrázová, Monika, and J Peter Neary. 2024. "Strategic yet not demanding: The Empirical Reach of Oligopoly with CES Preferences."

Zhelobodko, Evgeny, Sergey Kokovin, Mathieu Parenti, and Jacques-François Thisse. 2012. "Monopolistic Competition: Beyond the Constant Elasticity of Substitution." *Econometrica*, 80(6): 2765–2784.

A Data Appendix

A.1 Firm-level Trade

Apart from the Chinese Customs Database, which contains monthly data for HS8 products, the raw datasets provide information on non-zero annual firm-level export values and volumes to individual foreign destinations by HS6 product. Export values are provided in US dollars and reported on a FOB basis for all countries except Senegal, which reports CIF figures. Export volumes represent net weight in kilograms, with the exception of China and Egypt, which use a variety of measures, as well as Mexico, which does not specify the measures used between 2000 and 2009. To ensure that our data are comparable across our eleven origin countries, we aggregate the monthly Chinese data to the annual level. For all eleven countries, we drop observations for which we cannot determine the destination country, observations which report a product code that is not part of any HS revision during our sample period and observations with missing or negative reported trade values.[32] As our dataset spans multiple revisions of the HS classification system, we further convert the raw HS6 codes to consolidated HS codes which are stable over time. The final estimation dataset contains 3646 intertemporally-consistent consolidated HS products. To create theory-consistent market share measures, we construct tariff-inclusive exports sales values by applying the relevant preferential or MFN tariff to the free-on-board export values observed in the data. Similar to other studies using administrative data, we use trade unit values as a proxy for prices.

A.2 Trade Policy

We source data on preferential and most favoured nation (MFN) tariffs from the WTO Integrated Database (WTO IDB). To capture the phase-in of trade agreements, we supplement the data sourced from the WTO IDB with information contained in the tariff data compiled by Feenstra and Romalis (2014).

The WTO IDB contains HS6-product-level data on preferential and applied MFN ad-valorem tariffs for the years 2000-2013 for 138 and 165 destination countries, respectively.[33] We aggregate the raw data to consolidated HS codes by taking a simple average across HS6 codes. To address

[32] Additionally, we drop exports from China to Hong Kong, which likely acts as an entrepot during this period.

[33] The eleven national customs databases report exports to a total of 249 foreign destinations. Omitting observations for the smaller destinations for which no tariff data is available reduces the size of the initial dataset from 26,069,241 to 24,963,950. Removing singleton observations which are absorbed by fixed effects in our baseline specification further reduces the size of our estimation dataset to 14,534,183. Dropping observations with missing destination-average tariff and origin-specific tariff due to zero trade values during 1997 - 1999 to construct the weights reduces the sample size to 13,901,014. Omitting observations with no information on control variables reduces the size of our final estimation dataset to 13,257,967.

Table A-1: Firm-level trade data: countries and years

Country	Years	Firms	Observations	... with Tariff	... with Δ Tariff
Albania	2004 - 2012	1,006	9,023	9,023	765
Bulgaria	2001 - 2006	8,922	288,945	288,945	27,297
Burkina Faso	2005 - 2007	190	1,923	1,923	71
	2008 - 2012	258	2,004	2,004	69
China	2000 - 2006	152,726	13,495,561	13,495,561	1,190,735
Egypt	2005 - 2013	7,471	246,445	246,445	23,108
Malawi	2006 - 2008	156	1,298	1,298	30
	2009 - 2012	265	2,751	2,751	151
Mexico	2000 - 2007	17,402	655,228	655,228	83,730
	2008 - 2009	9,168	202,762	202,762	7,779
	2010 - 2011	9,580	234,688	234,688	9,279
	2012	7,777	132,754	132,754	0
Peru	2000 - 2013	7,850	349,238	349,238	38,955
Senegal	2000 - 2012	840	25,183	25,183	2,559
Uruguay	2001 - 2012	1,586	60,142	60,142	8,376
Yemen	2008 - 2012	335	4,556	4,556	325

Notes: The datasets for Burkina Faso, Malawi and Mexico feature multiple distinct panels as a result of changes to the system of firm identifiers. The columns "...with Tariff" and "...with Δ Tariff" refer to the number of observations for which data on bilateral tariffs between the origin and the destination is available, and for which there is a change in the level of bilateral tariffs firms face.

missing values, we follow Feenstra and Romalis (2014). For applied MFN tariffs, we replace missing values with the closest preceding value, on the basis that updated tariff schedules are more likely to be available after significant changes. In cases where there is no preceding value, we use the closest subsequent value. For preferential tariffs, we extract information about the phase-in of trade agreements from the dataset compiled by Feenstra and Romalis (2014), and then use this data to impute missing values. We then set our bilateral tariff variable equal to the lowest reported preferential tariff a destination offers to exporters from a given origin, when it is available, and use data on the MFN tariff applied by the destination, when it is not.

A.3 Consolidated Product Codes

We consolidate HS codes to ensure that the product codes in our analysis are consistent over time. Our trade, tariff and commodity classification data are reported based on the HS product classification system. Since our data span a large number of years and the HS system is updated periodically, our data could feature up to four different revisions of the HS system (HS1996, HS2002, HS2007 and HS2012). We transform HS codes into consolidated HS codes which are constant over time by identifying networks of related product codes and assigning a unique consolidated code to each network, similar to Cebeci (2015). This reduces the number of distinct products in the HS system from 6,293 to 4,039. The final estimation dataset includes observations in 3646 consolidated Harmonized System product codes.

A.4 Additional Statistics on Market Concentration

Table A-2 reports additional statistics on the concentration of market in the UK and Canada. The table suggests that in advanced economies such as UK and Canada, granular origin-destination-product markets are highly concentrated.

We also investigate concentration of granular export market by industry, for all destinations and the USA. (See Table A-3 and Table A-4) The market is highly concentrated across industries for the whole estimation sample. For the US market, there is heterogeneity in market concentration, suggesting that the tariff increase due to bilateral trade war is likely to affect the industries differentially.

A.5 Elasticities of Quantities, Markups, and Markets Shares to Tariff Changes - Excluding Chinese Exports

From Table A-1, we observe that the majority of the observations in our sample are from Chinese exporters. Table A-5 shows that the estimation results in Table 2 remain robust when we exclude

Table A-2: Concentrated granular origin-destination-product markets

	25th Percentile	Median	75th Percentile
(a) United Kingdom			
(i) Number of firms	10.00	3.00	1.00
(ii) Herfindahl-Hirschman Index	0.31	0.65	1.00
(iii) Top-2 market share	70.3%	99.1%	100%
(iv) Cumulative market share cond. on ≥ 1 incumbent and ≥ 1 entrant			
– Incumbents	39.9%	70.9%	89.4%
– Entrants	60.1%	29.1%	10.7%
(b) Canada			
(i) Number of firms	9.00	3.00	1.00
(ii) Herfindahl-Hirschman Index	0.33	0.66	1.00
(iii) Top-2 market share	72.6%	99.2%	100.0%
(iv) Cumulative market share cond. on ≥ 1 incumbent and ≥ 1 entrant			
– Incumbents	35.8%	68.3%	88.2%
– Entrants	64.2%	31.7%	11.8%

Note: This table presents statistics on the concentration of exporting firms in a market defined at the product-origin-destination-year level using an unbalanced panel of the universe of firms exporting from 11 origins to 165 destinations for approximately 3600 intertemporally-consistent HS06 products over 12 years. The first row presents distribution moments for the number of active firms at the product-origin-destination-year level for the 1.3 million product-origin-destination-year markets in our final estimation sample. The second row provides the distribution of the Herfindahl-Hirschman Index calculated within the product-origin-destination-year market. The third row reports the distribution of market share of the two largest firms in the market. The last statistics show the distribution of market share, conditional on product-origin-destination-year market with at least one incumbent and one entrant. The market share of the active firms in year t is divided into (i) "incumbents", i.e., those firms that sell in an origin-destination-product market in both t and $t-1$, and (ii) "entrants", i.e., those firms that did not sell in an product-origin-destination market in period $t-1$ but do so in period t.

Table A-3: Concentrated granular origin-destination-product markets - by industry

Industry (HS2 + name)	N. firms	Herfindahl index	Top-2 share	Incumbent share	Entrant share	N. markets
1-5 Live animals; animal products	2	0.69	100.00	73.79	26.21	36.8
6-14 Vegetable products	3	0.59	99.61	69.97	30.03	85.4
15 Animal/vegetable fats	2	0.84	100.00	68.72	31.28	6.3
16-24 Prepared foodstuffs	2	0.83	100.00	76.65	23.35	77.5
25-27 Mineral products	2	0.82	100.00	74.30	25.70	32.9
28-38 Products of chemical and allied industries	2	0.71	100.00	69.40	30.60	247.2
39-40 Plastics/rubber articles	2	0.73	100.00	64.89	35.11	122.4
41-43 Rawhides/leather articles, furs	3	0.61	98.42	56.39	43.61	37.7
44-46 Wood and articles of wood	3	0.64	99.89	58.89	41.11	30.6
47-49 Pulp of wood/other fibrous cellulosic materials	2	0.81	100.00	58.00	42.00	61.0
50-63 Textile and textile articles	3	0.58	97.78	53.82	46.18	370.1
64-67 Footwear, headgear, etc.	4	0.50	89.32	56.05	43.95	39.4
68-70 Misc. manufactured articles	3	0.67	99.98	59.10	40.90	100.6
71 Precious or semiprec. stones	3	0.65	99.78	63.50	36.50	13.6
72-83 Base metals and articles of base metals	3	0.65	99.54	60.81	39.19	276.1
84-85 Machinery and mechanical appliances, etc.	3	0.65	99.34	63.16	36.84	371.8
86-89 Vehicles, aircraft, etc.	3	0.59	97.99	63.60	36.40	50.0
90-92 Optical, photographic, etc.	3	0.64	99.18	60.60	39.40	100.4
93 Arms and ammunition	2	0.92	100.00	67.42	32.58	1.0
94-96 Articles of stone, plaster, etc.	4	0.53	93.42	55.70	44.30	127.0
97+ Others	2	0.80	100.00	39.43	60.57	4.1

Note: This table presents statistics on the concentration of exporting firms in a market defined at the product-origin-destination-year level using an unbalanced panel of the universe of firms exporting from 11 origins to 165 destinations for approximately 3600 intertemporally-consistent HS06 products over 12 years. The first column is the breakdown of industry. For the industry name, the leading numbers indicate the range of 2-digit Harmonized System code covered by the industry. The second column provides the median number of firms in the granular market. The third column shows the median Herfindahl Index calculated within the product-origin-destination-year market. The fourth column reports the distribution of market share of the two largest firms in the market. The fifth and sixth statistics show the median market share of incumbent firms and entrants, conditional on product-origin-destination-year market with at least one incumbent and one entrant. The last column indicates the number of granular origin-destination-product market with positive import values that belongs to the industry, expressed in thousands. The market shares are all expressed in percentage (%).

Table A-4: Concentrated granular origin-destination-product markets - by industry in USA

Industry (HS2 + name)	N. firms	Herfindahl index	Top-2 share	Incumbent share	Entrant share	N. markets
1-5 Live animals; animal products	5	0.51	90.96	81.51	18.49	2.0
6-14 Vegetable products	6	0.46	85.84	84.49	15.51	4.7
15 Animal/vegetable fats	4	0.66	98.46	84.84	15.16	0.5
16-24 Prepared foodstuffs	5	0.55	93.13	87.36	12.64	3.6
25-27 Mineral products	3	0.72	99.54	85.45	14.55	1.9
28-38 Products of chemical and allied industries	4	0.61	96.65	82.38	17.62	9.8
39-40 Plastics/rubber articles	8	0.51	90.72	83.56	16.44	3.6
41-43 Rawhides/leather articles, furs	12	0.36	76.68	79.55	20.45	1.3
44-46 Wood and articles of wood	12	0.36	77.41	81.57	18.43	1.3
47-49 Pulp of wood/other fibrous cellulosic materials	9	0.49	86.69	74.77	25.23	2.0
50-63 Textile and textile articles	6	0.51	90.44	73.42	26.58	17.2
64-67 Footwear, headgear, etc.	12	0.38	79.74	85.56	14.44	1.3
68-70 Misc. manufactured articles	9	0.48	86.36	84.86	15.14	3.5
71 Precious or semiprec. stones	8	0.43	82.26	80.58	19.42	0.8
72-83 Base metals and articles of base metals	7	0.52	90.66	82.97	17.03	9.7
84-85 Machinery and mechanical appliances, etc.	10	0.46	84.91	83.26	16.74	12.6
86-89 Vehicles, aircraft, etc.	6	0.55	92.33	87.90	12.10	1.9
90-92 Optical, photographic, etc.	9	0.48	85.88	83.00	17.00	4.0
93 Arms and ammunition	2	0.86	100.0	71.53	28.47	0.2
94-96 Articles of stone, plaster, etc.	15	0.4	78.75	87.08	12.92	3.4
97+ Others	7	0.44	80.93	60.36	39.64	0.4

Note: This table presents statistics on the concentration of exporting firms in a market defined at the product-origin-destination-year level using an unbalanced panel of the universe of firms exporting from 11 origins to 165 destinations for approximately 3600 intertemporally-consistent HS06 products over 12 years. The first column is the breakdown of industry. For the industry name, the leading numbers indicate the range of 2-digit Harmonized System code covered by the industry. The second column provides the median number of firms in the granular market. The third column shows the median Herfindahl Index calculated within the product-origin-destination-year market. The fourth column reports the distribution of market share of the two largest firms in the market. The fifth and sixth statistics show the median market share of incumbent firms and entrants, conditional on product-origin-destination-year market with at least one incumbent and one entrant. The last column indicates the number of granular origin-destination-product market with positive import values that belongs to the industry, expressed in thousands. The market shares are all expressed in percentage (%).

Chinese exporters. For the other ten developing and emerging countries, we apply the same empirical strategy outlined in equation (1). The estimated elasticities are largely in line with those in Table 2.

Table A-5: Elasticity of quantity, markup, and markets shares to tariff changes - excluding Chinese exports

	Quantity_{fiodt}	Markup_{fiodt}	Within-origin market share_{fiodt}	Origin's market share in dest_{iodt}
Destination-average tariff_{idt}	-0.41***	0.24***	0.17	0.08
	(0.15)	(0.06)	(0.17)	(0.20)
Bilateral tariff_{iodt}	-2.71***	0.26***	3.86***	-5.14***
	(0.15)	(0.04)	(0.22)	(0.27)
Observations	1.8M	1.8M	1.8M	1.8M
R^2	0.834	0.910	0.809	0.861

Notes: The dependent variable is the firm's log export quantity in column (1), the firm's log (tariff-exclusive) unit value in column (2), the log of the firm's share of its country's trade with the destination in column (3) and the log of the country's (tariff-inclusive) export value to the destination market in column (4). Destination-average Tariff_{idt} and Bilateral Tariff_{iodt} capture the tariff changes that are common to all origins and specific to a particular origin for foreign firms in the destination market, respectively. Firm-product-origin-year and product-destination fixed effects are included. Control variables include destination's exchange rate to the US dollar, consumer price index, real GDP, import-to-GDP ratio of destination country, and product's share of the destination's total imports. Standard errors, reported in parentheses, are clustered at the product-destination level, and we denote statistical significance with *** p<0.01, ** p<0.05, and * p<0.1. Estimates are based on an integrated dataset of firms' exports built from the World Bank Exporter Dynamics Database, and Egypt's Customs Authority, as well as tariff data from the WTO and Feenstra and Romalis (2014). The number of observation is 1,802,286.

B Model Appendix

B.1 Impact on Neutral Economics

In this subsection, we detail the impact of a bilateral trade war on the neutral economies. Specifically, figures B-1, B-2, B-3 are counterparts of Section 4 figures 1, 3, 4 for the non-belligerent neutral economies.

To start with, we observe that there is an increase in the aggregate price due to increasing nominal wages, but the change is smaller in magnitude compared to the aggregate price change in the trade-war economies. The welfare effect for the neutral economies is positive, but the magnitude of their gain is smaller compared to the welfare loss of the trade-war economies.

Figure B-2 shows the approximation of the variety effect and its decomposition into a price and a factor-income component. Panels (a) and (b) show that the approximation of the variety effect

(a) Aggregate Price Change

(b) Welfare Change

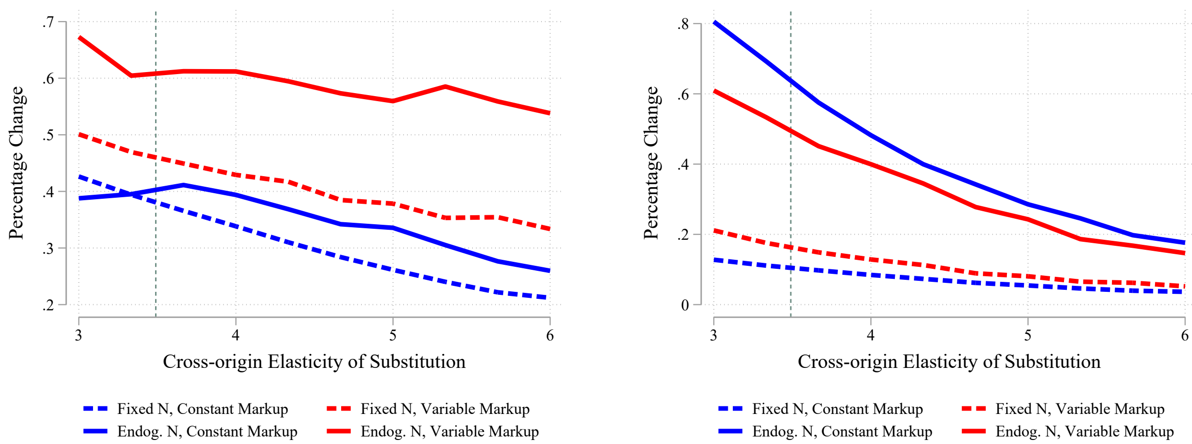

Figure B-1: Aggregate Prices and Welfare Changes in Neutral Economics

Notes: This figure illustrates the model's prediction of aggregate price change and welfare change for trade-war economies after the bilateral trade war. We use the estimated parameters reported in Table 3, where =6.05, and vary the cross-origin elasticity of substitution () from 3 to 6. As ρ approaches 6, it converges to the preference structure of Atkeson and Burstein (2008). The red lines plot the responses of our variable-markup model, and the blue lines plot the responses of a constant-markup model, in which we calibrate the elasticity of substitution to match the trade elasticity of our variable-markup model to facilitate the comparison. We also contrast the model response for fixed entry and endogenous entry scenarios. The dashed lines plot the responses in the fixed entry case, in which firms do not adjust entry or exit decisions after tariffs are increased in the trade war, while the solid lines plot the responses in the endogenous entry case, in which firms optimally choose the set of markets they serve under bilateral trade war tariffs. The vertical line indicates the value of the cross-origin elasticity of substitution set in our benchmark calibration.

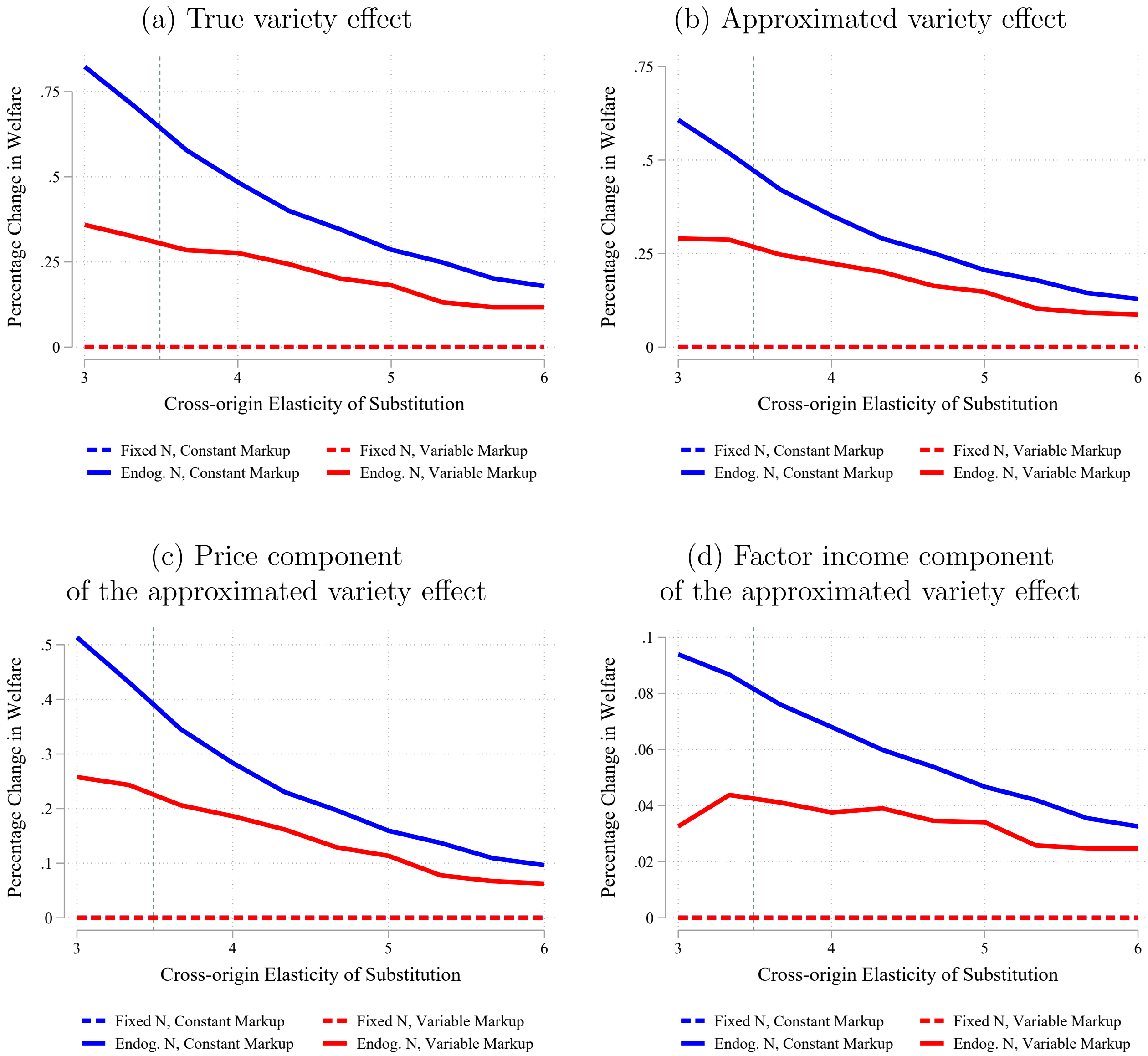

Figure B-2: Decomposing the variety effect on neutral economics

Notes: This figure decomposes the variety effect induced by entry and exit, and compares the approximated variety effect with the true value implied by the model. Panel (a) shows the true variety effect, calculated as the difference between welfare change and the reallocation wedges accrued to continuing firms, which maps to E_{dt} in equation (14). Panel (b) illustrates the approximated variety effect, calculated following equation (16). Panel (c) and (d) describes the price and factor income components of the variety effect, respectively. The solid lines depict the variety effect induced by entry and exit when firms optimally choose their export markets. The dashed lines depict outcomes for the cases in which export markets are fixed at the pre-war status — the dashed lines are horizontal because, by definition, there is no variety effect when firms cannot enter or exit. The vertical line indicates the value of the cross-origin elasticity of substitution set in our benchmark calibration.

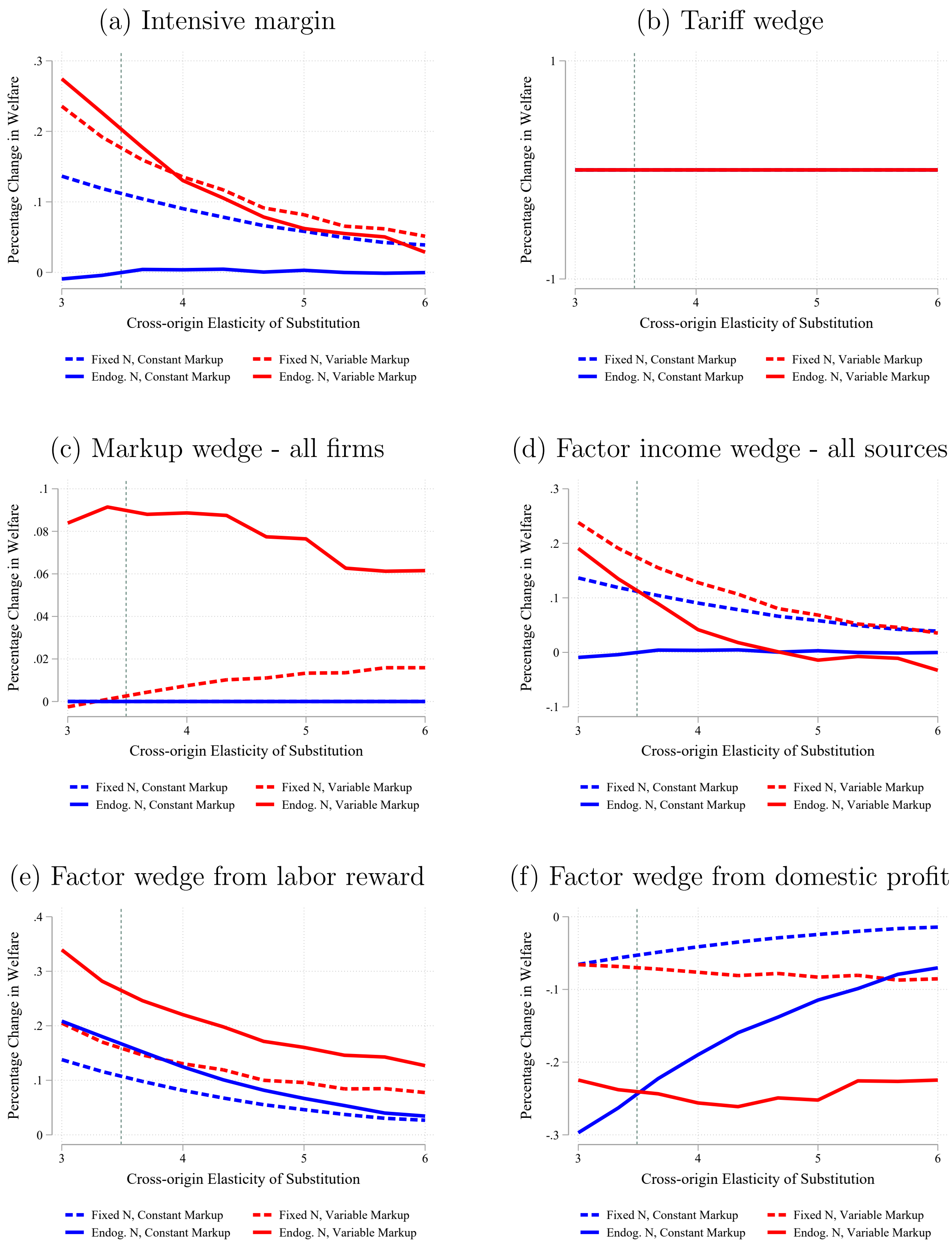

Figure B-3: Intensive margin welfare components in neutral economies

Notes: This figure decomposes the change in intensive margin of welfare due to price change of continuing firms and factor rewards. Panel (a) shows the sum of intensive margin, which can be further decomposed into tariff, markup, and factor income wedges in panels (b) - (d). Panel (e) demonstrates welfare effects of markup changes by domestic firms, and panel (f) shows the contribution of profit to factor income change. The vertical line indicates the calibrated cross-origin elasticity of substitution.

outlined in equations (14) and (16) performs well for neutral economies as well. As highlighted by Panel (c), most of the welfare gain from the extensive margin is driven by the price effect. Firms from the trade-war economies enter the neutral economies, because in the trade-war economies the real wage falls, boosting the international competitiveness of their exports. As foreign firms enter the neutral-economies' markets, the increase in varieties available to consumers lowers the aggregate price index. Panel (d) shows that the neutral economies also benefit from higher factor rewards—their nominal wages increase and their exporters gain more profit from operating in the trade-war economies.

Figure B-3 focuses on the welfare impact of adjustment at the intensive margin by continuing firms. Panel (a) shows that the overall impact of intensive margin adjustment is positive for neutral economies. Breaking down the intensive margin into the three components described in panels (b) - (d), we observe that the tariff wedge does not contribute to welfare change (as there is no change in tariff for neutral economies); the markup wedge contributes little. Most of the gains comes from the change in *real* factor income. As shown in Panel (e), households in neutral economies benefit from the lower price at which they can buy consumption goods from the trade-war economies (real wage in the trade-war economies decreases after the trade war). This benefit is partly offset by the decline in domestic firms' profit, since these lose market share to foreign firms from the trade-war economies (which have become more competitive because of the decline in their real wages).

B.2 The Variety Effect under Atkeson and Burstein (2008)

In this subsection, we highlight that the original specification of Atkeson and Burstein (2008), in which the cross-origin elasticity of substitution (ρ) and the within-origin elasticity of substitution (σ) are identical, represents a special case where the variety effect is of the same magnitude in both constant- and variable-markup models.

Figure B-4 illustrates the model's prediction of the variety effect by simultaneously varying the cross-origin elasticity of substitution (ρ) and the within-origin elasticity of substitution (σ). Panels (a) and (b) demonstrate that the model continues to approximate the variety effect described in equation (16) accurately. However, in this case, the variety effect in the variable-markup model almost entirely overlaps with its constant-markup counterpart. We conjecture that this is because the entry and exit of foreign firms have minimal impact on the markups of continuing foreign exporters when $\sigma = \rho$ (see Proposition 2 and Figure 3 in Crowley, Han and Prayer 2024). Proof to be added.

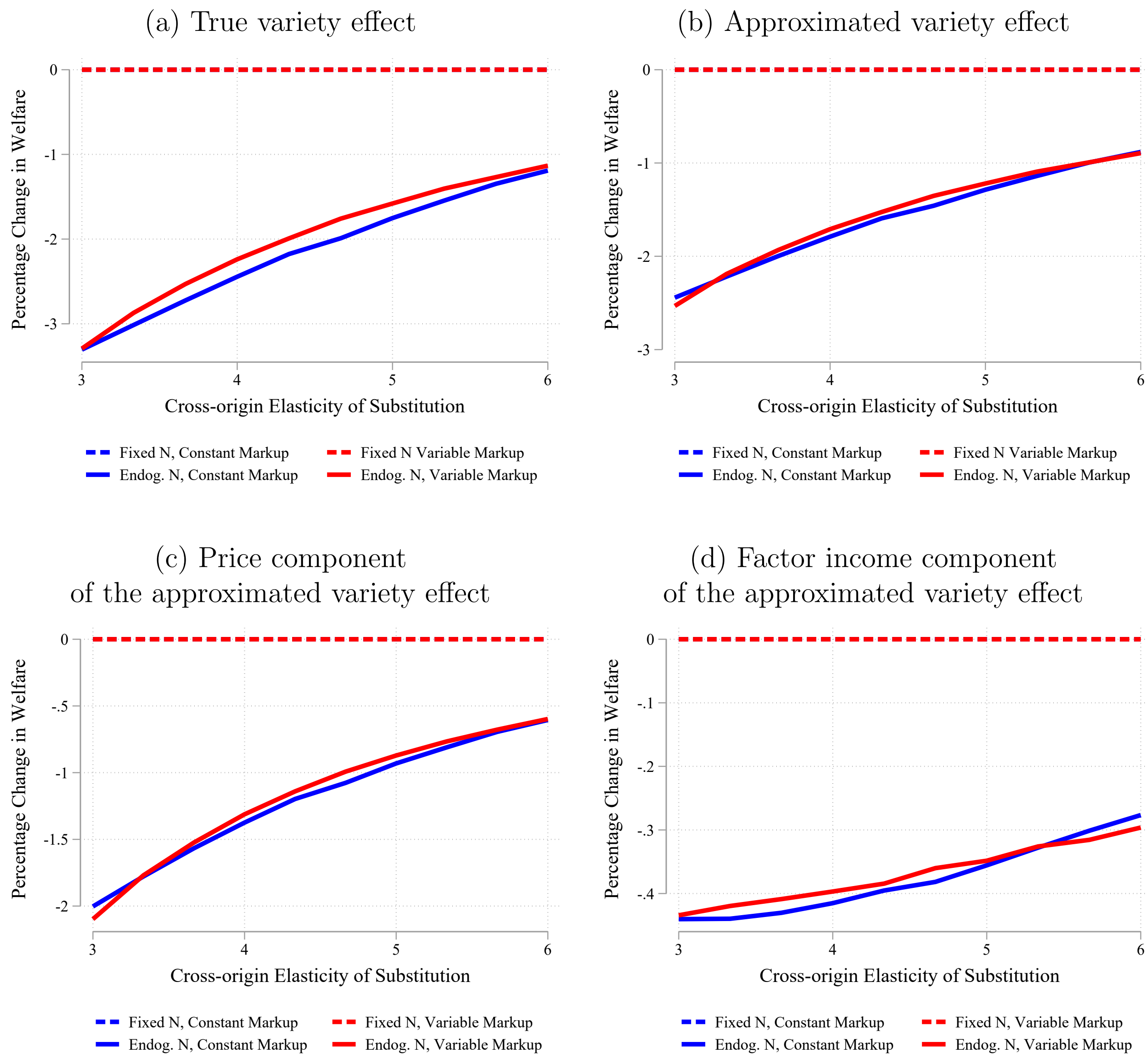

Figure B-4: Decomposing the variety effect - Atkeson and Burstein case

Notes: This figure decomposes the variety effect induced by entry and exit, in an Atkeson and Burstein (2008) case and compare the approximated variety effect with the true value implied by the model. We take the calibrated parameters reported in Table 3, and vary the cross-origin elasticity of substitution (ρ) and within-origin elasticity of substitution (σ) from 3 to 6. Panel (a) shows the true variety effect, calculated as the difference between welfare change and the reallocation wedges accrued to continuing firms, which maps to E_{dt} in equation (14). Panel (b) illustrates the approximated variety effect, calculated following equation (16). Panel (c) and (d) describes the price and factor income components of the variety effect, respectively. The solid line depicts the variety effect induced by entry and exit when we allow for firms to re-optimize the markets. The dashed line is for the case in which entry is fixed after the shock, and hence the lines are horizontal with no variety effect. The red lines plot the responses of our variable-markup model, and the blue lines plot the responses of a constant-markup model, in which we calibrate the elasticity of substitution to match the trade elasticity of our variable-markup model to facilitate the comparison.

B.3 Approximation Error and the Size of the Tariff Shock

In Figure B-5 we investigate the approximation error in our decomposition of the variety effects as the magnitude of tariffs between the trade-war economies rises. The vertical axis shows the difference between the true welfare change implied by the change in real consumption, and the approximated welfare change predicted by equation (14), expressed in percentage term relative to the size of the true welfare change. Panel (a) shows that our approximation performs well when participation is fixed at the pre-war status (blue and red dashed lines), but the approximation error becomes larger when firms optimize their entry and exit decisions after the tariff increase (blue and red solid lines)—especially for large tariff shocks. This suggests a first-order approximation is insufficient to handle the non-linearity well with endogenous entry—we are working on a second-order approximation to improve the performance. However, note that, without the additional approximation of the variety effect in equation (16), the original decomposition by Baqaee and Farhi (2024) would result in a much bigger error (the black and grey solid lines). In other words, while inaccurate for large tariff shocks, the additional variety effect significantly improves the welfare approximation with entry and exit. Lastly, Panel (b) shows that the approximation works better for neutral economies, where the intensive margin adjustment mainly comes from indirect general equilibrium forces, and the extent of extensive margin adjustment is smaller.

B.4 General Equilibrium Conditions

The general equilibrium is described by firms' prices $\{p_{fiodt}\}$ and entry decisions $\{\phi_{fiodt}\}$, such that $\{p_{fiodt}\}$ and $\{\phi_{fiodt}\}$ solve for firms' optimization problem and all markets clear.

Labor market clearing condition:

$$\bar{L}_d = \sum_{d'} \sum_{i} \sum_{f} l_{fidd't} = L_{dt} \tag{B-1}$$

where $\bar{L}_d$ is labor endowment for destination d, which is inelastically supplied. $l_{fidd't} \equiv y_{fidd't}/A_{fidt}$ is the labor demand for firm f from origin d to sell product i to destination d' in time t. $y_{fidd't}$ is the quantity, and A_{fidt} is the firm's productivity. L_{dt} is the aggregate labor demand.

Balanced trade condition:

$$IMP_{dt} = \sum_{o \neq d} \sum_{i} \sum_{f} p^b_{fiodt} y_{fiodt} = \sum_{o \neq d} \sum_{i} \sum_{f} p^b_{fidd't} y_{fidd't} = EXP_{dt} \tag{B-2}$$

where $p^b_{fiodt} = p_{fiodt}/\tau_{iodt}$ is the tariff-exclusive price of firm f's export of product i before it arrives

(a) Trade-war economies

(b) Neutral economies

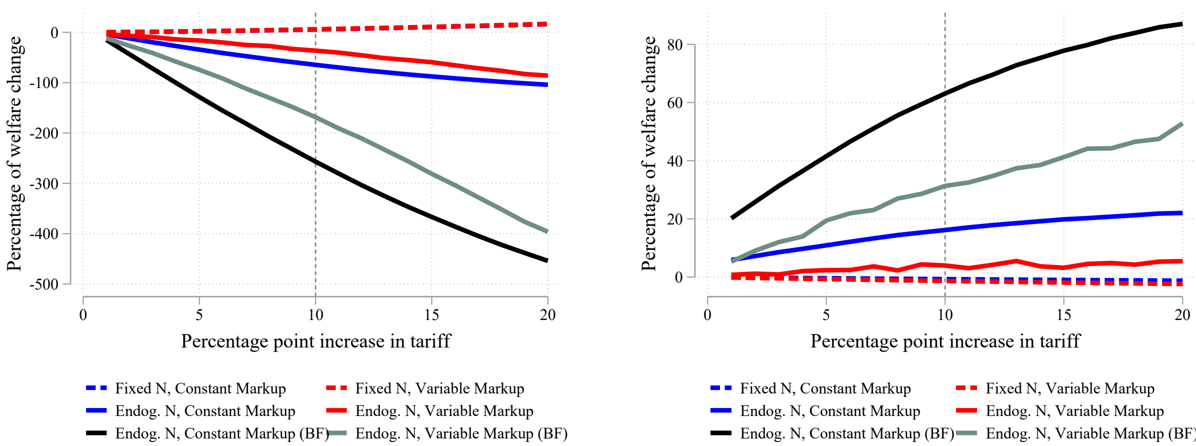

Figure B-5: Approximation error and size of tariff shock

Notes: This figure illustrates the performance of our welfare decomposition outlined in equation (14). We take the calibrated parameters reported in Table 3, and vary the the size of tariff increase between trade-war economies from 1 percentage point to 20 percentage points. The red lines plot the response of our variable-markup model, and the blue lines plots the response of a constant-markup model, in which we calibrate the elasticity of substitution to match the trade elasticity of our variable-markup model to facilitate the comparison. We also contrast the model response for fixed entry and endogenous entry scenarios. The dashed lines plot the response in the fixed entry case, in which firms do not adjust entry-exit decision after the trade war, while the solid lines plot the response in the endogenous entry case, in which firms re-optimize the set of markets they serve after the trade war. The black and grey solid lines plot the approximation error of the original Baqaee and Farhi (2024) decomposition for the constant-markup model and variable-markup model with endogenous entry, respectively. The original formula of these authors corresponds to equation (14) without the variety effect E_d. The vertical line indicates the shock size used in our calibration.

at the border of destination d at time t. The left-hand side of equation (B-2) is the value of imports of country d and the right-hand side of equation (B-2) is the value of exports of country d. The nominal wage W_{dt} in country one is set as the numeraire, and the steady state equilibrium nominal wage is determined by the balance of trade condition.

Equivalence of budget constraint and balanced trade condition:

$$
\begin{aligned}
GNE_{dt} &= \underbrace{\sum_{o}\sum_{i}\sum_{f} p_{fiodt}y_{fiodt}}_{\text{value of total final consumption}} \\
&= \underbrace{\sum_{o=d}\sum_{i}\sum_{f} p_{fiodt}y_{fiodt}}_{\text{expenditure on domestic production}} + \underbrace{\sum_{o\neq d}\sum_{i}\sum_{f} p_{fiodt}y_{fiodt}}_{\text{expenditure on foreign final production}} \\
&= \underbrace{\sum_{o=d}\sum_{i}\sum_{f} p_{fiodt}y_{fiodt}}_{\text{expenditure on domestic goods}} + \underbrace{\sum_{o\neq d}\sum_{i}\sum_{f} p^{b}_{fiodt}y_{fiodt}}_{\text{expenditure on foreign goods (ex. tariff)}} + \underbrace{\sum_{o\neq d}\sum_{i}\sum_{f} (\tau_{iodt}-1)p^{b}_{fiodt}y_{fiodt}}_{\text{tariff on foreign goods}} \\
&= \underbrace{\sum_{d'=d}\sum_{i}\sum_{f} p_{fidd't}y_{fidd't}}_{\text{revenue of home goods consumed domestically}} + \underbrace{\sum_{d'\neq d}\sum_{i}\sum_{f} p^{b}_{fidd't}y_{fidd't}}_{\text{revenue of exported goods (ex. tariff)}} + \underbrace{\sum_{o\neq d}\sum_{i}\sum_{f} (\tau_{iodt}-1)p^{b}_{fiodt}y_{fiodt}}_{\text{tariff on foreign goods}} \\
&= GNI_{dt} \qquad \text{(B-3)}
\end{aligned}
$$

From the decomposition of gross national expenditure (GNE_{dt}) and gross national income (GNI_{dt}), we can find that tariff-exclusive value of import must equal tariff-exclusive value of export for the budget constraint to hold.

B.5 Calibration

From the moment matching exercise, the calibrated parameters indicate that the model requires different elasticities of substitution to match the key characteristics in the data. This implies that allowing for oligopolistic competition brings the model closer to the data. Figure B-6 illustrates the difference between tariff elasticities predicted by an oligopolistic competition model and its constant-markup counterpart. In addition, it shows the role of entry and exit in shaping the tariff elasticities.

The empirical moments suggest that quantity elasticities to tariff changes are low. In panel (a) of Figure B-6, the brown dashed line shows that the quantity elasticity predicted by a constant-markup model is identical to the elasticity of substitution, which is larger than the empirical estimates—in the figure marked by the gray and black horizontal lines. Once we turn to the

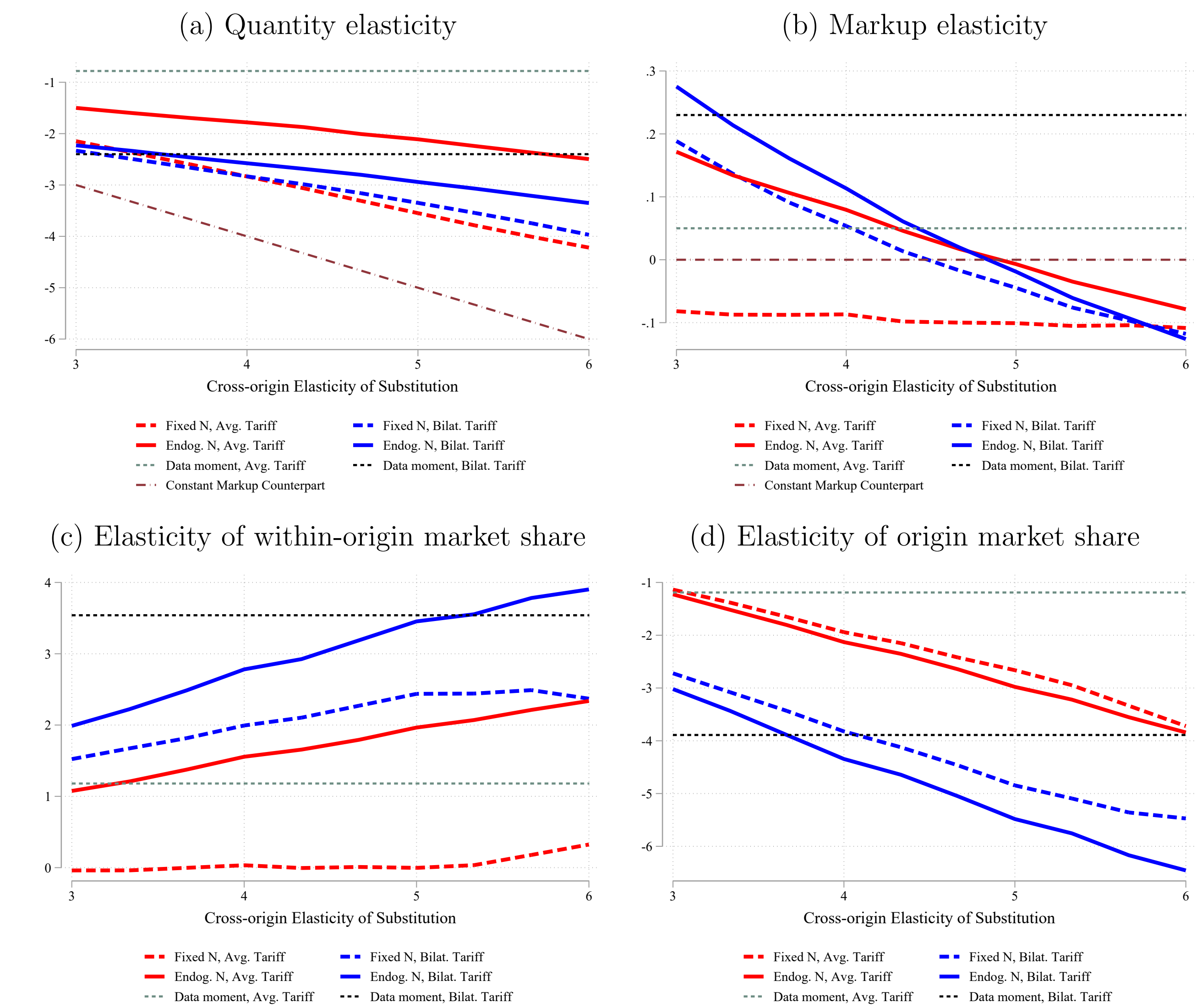

Figure B-6: Matching model moments with data moments

Notes: This figure illustrates the role of cross-origin elasticity of substitution (rho) in determining the model's prediction of elasticity of quantity, markup, and market share. We take the calibrated parameters reported in Table 3, and vary the cross-origin elasticity if substitution (rho) from 3 to 6. As ρ approaches 6, it converges to the preference structure of Atkeson and Burstein (2008). We plot the elasticities of quantity, markup, and market share to destination-average tariff changes (Avg. Tariff) and origin-specific tariff changes (Bilat. Tariff), estimated using model simulated data. In addition, we separately estimate the elasticities to tariff changes for two scenario, one in which firm's entry decision is fixed before the tariff shock, and the other in which we allow firms to re-optimize the markets they serve. To facilitate comparison, we added horizontal lines showing the data moments reported in Table 2. For quantity and markup elasticity, we also illustrate the response of a constant-markup model, in which we set all elasticity of substitution to the same as the cross-origin elasticity of substitution.

oligopolistic competition model and allow firms to adjust entry-exit decision after the shock, the model is able to reproduce the differential response of quantity to destination-average tariff changes and origin-specific tariff changes. In the case of oligopolistic competition, firms adjust prices and quantities taking into consideration the response of their competitors. Therefore, the quantity adjustment will be smaller in response to an increase in destination-average tariff that applies to firms from all origins. In addition, the continuing firms may take over the market share of firms that exit after a tariff hike, which further dampens the quantity response.

Turning to markups, panel (b) shows once again that the constant-markup model fails to replicate the markup elasticity estimated from the data (the constant-markup is shown in the figure by the brown horizontal line). Furthermore, the constant-markup model requires a low cross-country elasticity of substitution to match the empirical moments. Allowing for markup adjustment, recall that, as the cross-country elasticity of substitution approaches the calibrated within-origin elasticity of substitution ($\sigma = 6.05$), the model converges to Atkeson and Burstein (2008). Along this convergence, the direction of markup adjustment turns negative, which is inconsistent with the empirical estimates. Conversely, letting the cross-origin elasticity approach the value in our calibration ($\rho = 3.49$), the model successfully replicates the estimated markup elasticities. In addition to quantity and markup adjustment, panels (c) and (d) illustrate that firms gain more market shares in response to a tariff increase targeted at its own origin, but the market share for its origin as a whole falls by more compared to a tariff increase applied to all origins. This differential response of market shares also highlights the oligopolistic nature of competition at the granular level of origin-product destination markets. Finally, endogenous entry and exit strengthen the reallocation of market share in response to a tariff shock, which helps improve the model prediction concerning market share elasticities.

B.6 Expenditure Exposure (Welfare Decomposition)

A contribution of this paper consists of offering an extension of the welfare decomposition by Baqaee and Farhi (2024) allowing for firm entry and exit. Hereafter we discuss the expenditure exposure used for the decomposition in Section 4.2.

Firstly, the Heterogeneous-Agent Input-Output matrix is a $(C+N+F)\times(C+N+F)$ matrix Ω, where C is the number of countries, N is the number of potential firm-product-origin triplets, and F is the number of primary factors of production.[34] The ij'th element of Ω is i's expenditure share on j. In addition, households are not involved in production (zero columns), and factors consume no resources (zero rows). In the current version of our model, there is no production

[34] In our model, the number of primary factors is equal to the number of countries, because labor is the only primary factor used in production in each country. In addition to the primary factor, there are fictitious factors that collects profit and tariff revenue accrued to the country.

network. Hence, the expenditure share on intermediate inputs is zero for the firms, and a firm's expenditure is all loaded on domestic labor. We also calculate the cost-based input-output matrix $\tilde{\Omega}$ by weighting the expenditure share with the wedges, including tariffs and markups, to account for how a price change of j affect the marginal cost of i.

Although households do not directly buy from primary factors (labor), they are indirectly exposed to a price change of the factors through their purchases of domestic and foreign goods produced by firms. We thus calculate the Leontief inverse matrix $\tilde{\Psi}$ to record households' direct and indirect exposure to changes in the price of firms and factor rewards. ($\tilde{\Psi} = (I - \tilde{\Omega})^{-1}$)

For households in country d, the expenditure exposure to firm-product-origin triplet a is denoted by:

$$\tilde{\lambda}_{ad} = \tilde{\Omega}_{ad} \tag{B-4}$$

This term is the households' weighted expenditure share on a in the absence of firm-to-firm trade. In addition, the households' expenditure exposure to factor b is:

$$\tilde{\lambda}_{bd} = \sum_{a \in \mathcal{A}_{dt} \cap \mathcal{A}_{dt-1}} \tilde{\Omega}_{ad} \tilde{\Psi}_{ab} \tag{B-5}$$

where $\tilde{\Psi}_{ab}$ is equal to one if firm a is located in country that owns the factor primary factor b. $\mathcal{A}_{dt}$ and $\mathcal{B}_{dt}$ denote the set of active firm-product-origin triplet a and income factors b that are available at t, respectively. Intuitively, this term represents the households' weighted expenditure share on goods produced using factor b, where the factors are the labor endowments in each country.

B.7 Computational Solutions

B.7.1 Productivity Dispersion

Firms in all countries draw productivity from Pareto distribution. Countries are therefore ex-ante symmetric but ex-post different due to productivity draws. The cumulative distribution function of a Pareto random variable with parameters ξ and x_m is definec by:

$$F_X(x) = \begin{cases} 1 - (\frac{x_m}{x})^{\xi} & \text{if } x \geq x_m \\ 0 & \text{otherwise} \end{cases}$$

We assume $x_m = 1$ (consistent with Edmond, Midrigan and Xu (2015)). ξ is the Pareto shape parameter that governs the ex-post productivity dispersion. Low value of ξ implies large ex-post production dispersion. Note that, we do not consider sectoral productivity dispersion.

B.7.2 Numerical Algorithm

1. Guess outputs $\{Y_{dt}^{old}\}$, nominal wages $\{W_{ot}^{old}\}$, and market shares $\{ms_{fiodt}^{old}\}$ and $\{ms_{iodt}^{old}\}$.

2. Derive prices $\{p_{fiod't}^{new}\}$, entry decisions $\{\phi_{fiodt}^{new}\}$, and new market shares $\{ms_{fiodt}^{new}\}$ and $\{ms_{iodt}^{new}\}$ from equation (8)-(11).

3. Derive new outputs $\{Y_{dt}\}$ from equation (5)-(7), labor demand $\{L_{dt}\}$ from equation (B-1), and value of import and export $\{IMP_{dt}\}$, $\{EXP_{dt}\}$ from equation (B-2).

4. If $error = \max\{|ms_{fiodt}^{new} - ms_{fiodt}^{old}|\} + \{Y_{dt}^{new} - \hat{Y}_{dt}^{old}\} + \{W_{dt}^{new} - W_{dt}^{old}\} < 10^{-8}$, break. If not, go to the next step and update guesses.

5. If labor supply $\{\bar{L}_d\}$ is larger than labor demand $\{L_{dt}\}$, update outputs $\{Y_{dt}^{old}\}$ by making a bigger guess. If value of export $\{EXP_{dt}\}$ is larger than value of import $\{IMP_{dt}\}$, update nominal wages $\{W_{ot}^{old}\}$ by making a bigger guess. Go back to step 1.

B.8 Approximating Welfare with the ACR Formula

In monopolistic competition models, the modeling of fixed costs of firm plays a critical role. Below we contrast two leading specifications. In one, fixed costs are denominated in units of consumption, in the other in units of labor. The key difference is that, in the latter case, firm entry reduces the labor available for the production of goods, resulting in higher distortions hence (other things equal) lower welfare. It turns out that this consideration matters in welfare analysis, especially when this is based on approximation following the seminal paper by Arkolakis, Costinot and Rodríguez-Clare (2012).

Using our model, we show that, when fixed entry costs are in consumption units, the model's welfare predictions closely align with the ACR formula. In contrast, when fixed costs are in labor units, the approximation via the ACR formula is less accurate—under oligopolistic competition, the more so, the smaller the number of firms.

In Figure B-7, we study the welfare impact of a 10% increase in bilateral trade cost between country 1 and 2, contrasting the monopolistic competition to the oligopolistic competition model. In this exercise we consider a change in trade costs—not a trade war—since the ACR formula do not apply to tariff.[35]

[35] Tariffs and trade costs are different in many respects. Firstly, an increase in trade cost leads to a resource loss—it is typically modeled as a Hicks-neutral productivity change for exporters. In contrast, an increase in tariff does not lead to a loss of resource, and the tariff revenue is rebated to households in the importing country. Second, border prices are the unit value the exporting firm receives before the goods arrive at the border: tariffs are deducted from the consumer price and do not count toward the border price. In contrast, trade costs do not discount border prices.

Panel (a) and (b) illustrate the role of the fixed-cost specification in driving welfare results in the monopolistic competition model. If fixed costs are in final consumption units, fixed costs of operation do not lead to distortions, and the welfare changes predicted by the model and the ACR formula coincide. In contrast, when fixed costs are in labor units, entry into the market reduces the factor supply available for production of the final good. As shown in panel (b), the welfare loss (gain) in countries 1 and 2 (3 and 4) is smaller. In response to a hike in trade costs in countries 1 and 2, these economies pay less fixed costs in terms of labor, as their firms exit from the market of its rival country; the other two economies pay more fixed cost, as their firms enters foreign markets. The ACR formula overestimates welfare changes relative to the model predictions.

Turning to oligopolistic competition, panel (c) and (d) show that the number of firms is critical to the performance of ACR formula. When the number of potential firms at the granular product-origin-destination market is four, the ACR formula is far from the welfare change implied by the model. As the number of potential firms increases to twenty, the ACR formula approximates welfare much better.

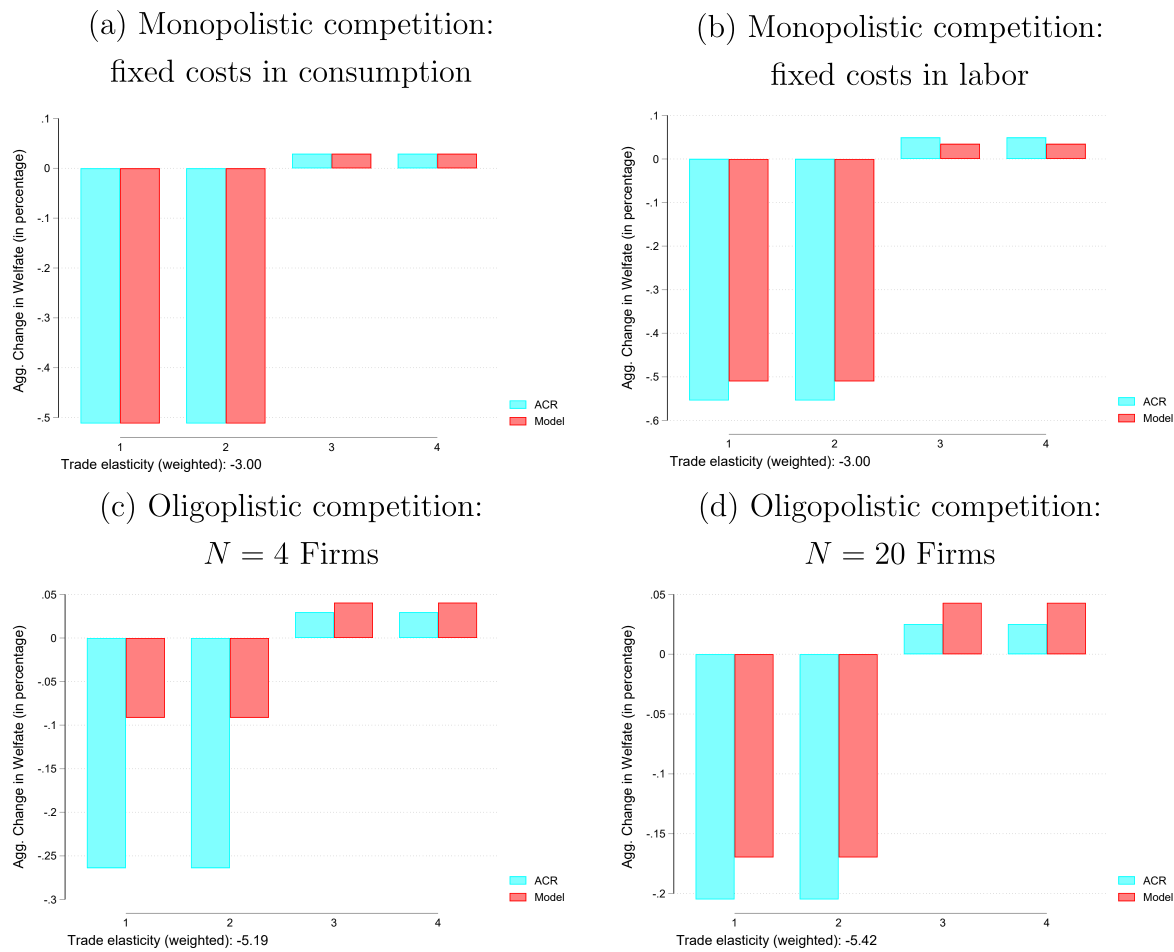

Figure B-7: Comparing ACR formula under monopolistic and oligoplistic competition models

Notes: This figure illustrates the performance of ACR formula in approximating the welfare effect of trade war, separately for monopolistic competition model and oligopolistic competition models. We simulate 4 countries, 1000 sectors, with parameters $(\eta, \rho, \sigma, \xi, \varsigma) = (4,\ 4,\ 4,\ 3.5,\ 0.0)$ for the monopolistic competition model, and $(\eta, \rho, \sigma, \xi, \varsigma) = (1.2,\ 8.5,\ 8.5,\ 3.5,\ 0.0)$ for the oligopolistic competition model. Here we consider bilateral trade cost increase between country 1 and 2 by 10% due to the trade war, because ACR formula do not apply for tariff. N denotes the number of potential firms at the granular product-origin-destination market.