ABSTRACT

Title of dissertation: TRADE POLICY
AND INDUSTRIAL CONCENTRATION

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Doctor of Philosophy, 2020

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I examine the interrelationship between industrial concentration, the CES industry price index and trade policy when a subset of firms in the market takes the effect of their decisions on industry aggregates into account.

In the first chapter, I develop a hybrid model that augments the standard monopolistic competition approach in the international trade literature to include an oligopolistic margin: a set of foreign and domestic heterogeneous granular firms competing in quantities. This margin predicts novel effects of trade liberalization on trade, consumer welfare, and industrial concentration. Specifically, trade liberalization generates lower consumer gains when foreign firms are more concentrated than domestic, and higher domestic industrial concentration of granular firms.

In the second chapter, I study the implications of hybrid competition for the gravity equation. I show that the trade cost elasticity is attenuated by foreign firm concentration and I test the novel oligopolistic margin using diff-in-diff variation from trade policy changes in Colombia. I find robust evidence for this margin. I

also show that the aggregate impact of trade liberalization can be substantially reduced by oligopolistic behavior. Moreover, foreign concentration heterogeneity across origin countries suggests a highly heterogeneous impact of trade liberalization: imports from countries in the top decile of concentration had 13 log points lower growth on average than imports from countries in the bottom decile.

In the third chapter, I explore the implications of the hybrid model when there is trade policy uncertainty. When firms are uncertain about future tariffs and exporting involves sunk investments, the value of waiting increases. In the setting I propose, potential entrants also consider the strategic reaction of oligopolistic competitors: when domestic granular firms are highly concentrated, the impact of trade policy uncertainty on foreign entry is mitigated since the eventual increase in tariffs is predicted to be partially offset by an increase in domestic markups. When foreign granular exporters are highly concentrated, the impact is amplified since the increase in tariffs is predicted to not be fully passed to the price index. I discuss an empirical application in the context of Brexit uncertainty and potential ways forward.

TRADE POLICY AND INDUSTRIAL CONCENTRATION

by

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Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2020

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Dedication

A Ada y Eva.

Acknowledgments

I am deeply indebted to my advisor Nuno Limão for his outstanding guidance, mentoring and support at all stages of my PhD. I am also very grateful to Eunhee Lee and Felipe Saffie for their invaluable advice throughout the process; and Thomas Drechsel and Serguey Braguinsky for providing excellent service as members of my Dissertation Committee. I benefited enormously from discussions and comments from Jeronimo Carballo, Pierre De Leo, Allan Drazen, Juan Echenique, Marcela Eslava, Alvaro García Marín, Pablo Gonzalez, Juan Carlos Hallak, Kyle Handley, Karam Jo, Melissa Kearney, Lerong Li, Peter Murrell, Luca David Opromolla, Emanuel Ornelas, Ingmar Prucha, Fernando Saltiel, John Shea, Andrew Sweeting, Mateo Uribe-Castro and Christian Volpe Martincus. I would also like to thank participants at both UMD Brownbag Workshops, Macro and Applied Micro, LACEA Annual Meeting, and the EGSC at Washington University in St. Louis for very helpful suggestions. I am especially grateful to members of the UMD Trade Group, who provided constructive feedback from the beginning of this project.

This dissertation would not have been possible without the support of my family. I would like to thank my parents, Cecilia and Eduardo, whose love and guidance are with me in whatever I pursue. I would also like to thank my sister, Corina, for always caring about my well-being; and my grandparents, who are not with me physically but were fundamental to who I am today. Nobody has been more important to me in the pursuit of this project than my wife, Eva, whose encouragement and love gave me the strength to start and finish the degree. Last but not least, I am profoundly grateful to my daughter, Ada, whose laughs and innocence were the most important engines towards the end.

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List of Abbreviations

ALADI	Latin American Integration Association
CARICOM	Caribbean Community
CIF	Cost, Insurance, and Freight Valuation
DANE	National Administrative Department of Statistics (Colombia)
EAM	Annual Manufacturing Survey (Colombia)
EDD	Exporter Dynamic Database
EFTA	European Free Trade Association
EU	European Union
FOB	Free on Board Valuation
FTA	Free Trade Agreement
HHI	Herfindahl-Hirschman Index
HS	Harmonized System
ISIC	Standard Industrial Classification of All Economic Activities
LAC	Latin America and the Caribbean
MERCOSUR	Southern Common Market
MFN	Most Favoured Nation
TPU	Trade policy uncertainty
UK	United Kingdom
UTL	Unilateral Trade Liberalization
WTO	World Trade Organization

Chapter 1: A Model of Hybrid Competition in International Trade

1.1 Introduction

In recent years, interest in industrial concentration has been fueled by evidence showing an increase in this measure in the US, Japan and European countries (OECD, 2018, Bajgar et al., 2019).[1] Over the same period of time, the decrease in trade barriers has made competition between domestic and foreign firms a more common feature of markets. In this chapter, I propose a theory that establishes a link between industrial concentration, competition and trade policy.

Large firms dominate international trade.[2] It has been shown that the top five exporters account for an average of about 30% of country exports and explain about half of its variation in developing countries (Freund and Pierola, 2015); whereas the top decile accounts for an 95% of total exports in average in the US (Bernard et al., 2018), and an average of 87% in European countries (Mayer and Ottaviano, 2008).[3]

[1] In the case of the US, the rise in the relative importance of large firms has been associated with other secular trends such as the decline in the labor share of income and the rise of superstar firms (Autor et al., 2017; Autor et al., 2019), the decrease in domestic competition and investment (Gutierrez and Philippon, 2018, Grullon et al., 2019), and the rise of markups (De Loecker et al., 2020).

[2] I use the terms "large" and "granular" interchangeably, and the term "small" for nongranular firms throughout the dissertation.

[3] Freund and Pierola (2015) employ the Export Dynamic Database (EDD), a World Bank database that included 32 developing countries at the time they published the paper.

Despite this evidence, standard trade models with heterogeneous firms leave little room for the role of large firms in their mechanism through which changes in trade costs affect trade flows and consumer welfare.[4] Given that, I investigate a channel through which large firms can differ: their oligopolistic behavior.[5]

In this chapter, I theoretically examine the interrelation between industrial concentration, the CES industry price index and trade policy. I extend the standard model of international trade in which monopolistically competitive firms with heterogeneous productivity produce differentiated varieties by adding a set of more productive granular firms. These origin-specific large firms sell their varieties in the domestic market and take the impact of their decisions on industry aggregates into account.[6] This model allows me to identify a novel channel through which trade liberalization affects competition: I find that relative industrial concentration between domestic and foreign firms matters in determining the total impact of trade liberalization on the industry price index. When domestic firms are relatively more concentrated, a tariff reduction shifts demand towards the less concentrated, lower aggregate markup segment of the market, magnifying the impact of tariffs on the price index. This mechanism is especially important the more productive

[4] Head and Spencer (2017) show that the share of papers published in the top field journal (JIE) mentioning "monopolistic competition" and "heterogeneous firms", two features of the standard model, surged in the 2000s and continued increasing in the 2010s. On the contrary, papers mentioning "oligopoly" continuously decreased since the 1990s. However, the authors identify a promising resurgence of oligopoly models in the last years.

[5] Even though observing that large firms charge higher markups than small firms is not sufficient to conclude they are behaving in an oligopolistic fashion, there is substantial empirical evidence showing that the distribution of markups is positively skewed (De Loecker et al., 2016; De Loecker et al., 2020), and firms price to market (Atkeson and Burstein, 2008). These two features suggest oligopolistic behavior.

[6] The workhorse model with heterogeneous firms was introduced by Melitz (2003) and modified by Chaney (2008) to focus on the gravity equation implications. In this paper I focus on the industry level version of this model where I take income as given.

oligopolistic firms are with respect to small monopolistic competitive firms.

The model allows me to study how trade liberalization affects domestic concentration. I formally show that trade liberalization increases domestic concentration if oligopolistic domestic firms have a higher market share than monopolistic competitive domestic firms. To the best of my knowledge, this is the first structural domestic concentration equation that relates domestic concentration to the CES industry price index. I decompose the effect of competition on a widely used concentration measure, the Herfindahl-Hirschman Index (HHI), into (i) the reallocation of market shares within large firms, (ii) the reallocation of market shares within small firms through entry and exit, and (iii) the reallocation of market shares between small and large firms. An increase in competition (i.e. a decrease in the CES industry price index) leads to an increase in concentration within large firms because larger, more productive firms face more competitive pressure and end up with lower markups and thus lower prices. In the case of small firms, the sign of such impact depends on their underlying productivity distribution. In the case of a bounded Pareto distribution, the distribution I assume throughout the chapter, the rise in competition increases domestic concentration.[7] Finally, market share reallocation between large and small firms depends on which group of domestic firms have a higher market share. When large firms do, an increase in competition increases concentration through this channel because large firms gain more market share (their prices decrease and small firms exit). When small firms do, such reallocation lowers

[7]Given that the unbounded Pareto distribution is a special case of the distribution I use, the result also holds for it.

concentration because it shifts demand away from small firms. [8]

The model can be used to study and quantify the potential relationship between the increase in import penetration and the increase in domestic concentration many countries have experienced in the last two decades. In light of the model, an increase in the productivity of foreign firms would increase the competitive pressure firms in other countries face, causing large firms to decrease their prices and less productive small firms to exit, increasing concentration. I calibrate the model to parameter values commonly used in the literature to numerically illustrate this and show that the model can imply an increase in domestic concentration of about 2 percentage points and a reduction in the number of small domestic firms of about 55% when import prices are halved.[9]

I contribute to understanding the role of industrial concentration in international trade when large firms have oligopolistic behavior. Industrial concentration does not have a distortive role at the industry level when consumers have CES preferences (cf. Dhingra and Morrow, 2019).[10] Therefore, models covered by the seminal Arkolakis et al. (2012) provide no insights in this regard. Arkolakis et al. (2018) depart from CES preferences to allow for variable markups, but they assume

[8]Autor et al. (2019) argue that the fall of the labor share in the US is due to the reallocation of market shares from low to high productivity firms, which have higher markups. That mechanism is consistent with reallocation from small to large firms in my model due to tougher competition.

[9]Between 1997 and 2012, the HHI rose between 1 and 4 percentage points in manufacturing sectors in the US (Gutierrez and Philippon, 2017), and based on US Census data the number of manufacturing firms fell by about 20%.

[10]Nocke and Schutz (2018) show that concentration as measured by the Herfindahl-Hirschman Index can capture the impact of welfare distortions on consumer surplus due to oligopolistic behavior around a monopolistic competitive setting under a general family of consumer preference, including CES. I show that the HHI is proportional to the industrial concentration measure I propose.

away the role of market structure in welfare.[11] My model allows for both distortive and non-distortive firm behavior and stresses the importance of specific differences in the realized productivity distributions of large firms across their origins.

The theoretical role of industrial concentration in international trade models depends on how consumers preferences, competition and firms' productivity distribution are modeled. For example, firm concentration is associated with decreasing welfare gains of new varieties in Feenstra and Weinstein (2018): a decrease in overall concentration is interpreted as a less crowded product space, which increases welfare.[12] In my model, the fact that CES preferences are neutral in terms of the market power of small firms implies that the distortive role of country-specific industrial concentration necessarily comes from the state of competition in the market. In this sense, the ability of large firms to charge high markups depends both on all the firms acting in the market and on the distribution of prices across origins, including ad-valorem tariffs. Therefore, the pro-competitive effect of trade liberalization depends on foreign firms who benefit from trade liberalization and domestic firms who do not, especially when markets are highly integrated and the overall share of granular firms is high.

I decompose the impact of tariffs on the CES industry price index into a direct price effect, a relative concentration effect, an entry effect and a cross-size

[11] They assume monopolistic competition and a common unbounded Pareto distribution for firms' productivities across countries.

[12] In the welfare formula they derive, the product variety term includes the overall Herfindahl-Hirschman Index (HHI), which positively impacts welfare. The authors argue that this term captures crowding of the variety space: a high HHI implies a low number of firms and thus fewer varieties. Nonetheless, we can write $HHI = (1+CV^2)N^{-1}$, where CV is the coefficient of variation of sales and N is the number of firms, to see that high concentration does not necessarily mean a low N.

effect, and show that trade liberalization always decreases it. The entry effect disappears under unbounded Pareto distribution, illustrating that welfare gains from variety are only present when the productivity distribution is bounded, as argued by Feenstra (2018). The two other terms are novel in the context of the standard monopolistic model with heterogeneous firms. The relative concentration term arises from the existence of large firms, whereas the cross-size effect summarizes how large and small firms react to each other. Redding and Weinstein (2018) do a different decomposition of the CES price index and conclude that firm dispersion within sectors can increase consumer welfare given that consumers can substitute away from high demand-adjusted prices. In my model firm dispersion in large firms captures lower misallocation conditional on the underlying productivity distribution because it implies lower markups. However, relative dispersion as identified by relative concentration captures the relative first-order response of markups between foreign and domestic firms. Hence, my decomposition isolates the pro-competitive effect due to oligopolistic behavior.

To the best of my knowledge, Parenti (2018) was the first to construct an international trade model in which small and large firms compete.[13] My model differs from his in two key aspects. First, I assume firm heterogeneity within each group of firms and therefore I am able to nest standard industry trade models with a continuum of heterogeneous firms. Specifically, my model can be understood as an extension of Melitz and Redding (2015), which features heterogeneous small firms

[13] Shimomura and Thisse (2012) were the first to construct a hybrid model where homogeneous large and small firms interact but in a closed economy.

and bounded Pareto productivity distribution but no firm granularity. Therefore, I contribute to the existing literature by adding an extra margin of adjustment in trade capturing market power. Second, Parenti (2018) assumes that large firms can decide both prices and the number of products they produce and therefore his setting is richer along that dimension.[14][15] Finally, the focus of his paper is different too. In my case, I focus on the role of industrial concentration in international trade, showing that it can capture markup responses and be affected by competition in a setting with firm turnover. Parenti (2018) focuses on how trade liberalization conclusions can differ from other papers with homogeneous firms such as Krugman (1979) due to granularity.

I also contribute to the body of papers that allows for oligopolistic behavior in international trade models. Head and Spencer (2017) argue for the importance of accounting for large firms given the aforementioned evidence and the fact that they can modify theoretical and empirical predictions. Edmond et al. (2015) study the impact of trade liberalization on welfare by using a oligopolistic model with heterogeneous firms.[16] Even though the underlying mechanism in the case of large firms is the same, my model allows for the inclusion of entry of small firms as in standard models of trade with monopolistic competition. Given the long tail of

[14] My model can be extended to allow large firms to be multiproduct. Given that both large and small firms are heterogeneous in my model, conclusions may differ from Parenti (2018). I leave this extension for future research.

[15] There are other channels through which large firms can modify the impact of trade liberalization. For instance, Ludema and Yu (2016) focus on the quality upgrade mechanism: high productivity firms have a low pass-through due to their choice of high quality products, especially in products with high quality scope.

[16] Other relevant questions that were already addressed are how oligopolistic firms can influence aggregate trade flows (Eaton et al., 2012), the exchange rate pass-through (Amiti et al., 2014; Auer and Schoenle, 2015), the comparative advantage of countries (Gaubert and Itshoki, 2018), and the strategic complementarities between foreign and domestic firms (Amiti et al., 2019).

small firms usually observed in trade data and the relatively lower exit probability of large firms, I argue that constructing a hybrid model can help in both solving the technical limitations imposed by oligopoly models and addressing the differential market power of large firms.[17][18] Moreover, the focus of this chapter is not to quantify the gains from trade under misallocation as it was theirs, but rather to identify and characterize the specific role of large firms in microfounding industrial concentration.

The analysis relating the impact of tariffs on the price index generalizes results of the classical literature about strategic trade policy. Helpman and Krugman (1989) show that in a duopoly with a foreign and a domestic firm playing Cournot in the domestic economy, the terms of trade are more likely to improve when tariffs decrease than in the case where domestic firms are perfectly competitive. The intuition is the same: opening to trade imposes competitive pressure on the domestic firm. This is not the case if the two firms play Bertrand, since the resulting increase in the foreign firm's price may cause the domestic firm to increase the price too. My setting avoids this possibility by assuming imperfect substitutability of foreign and domestic varieties. Therefore, Cournot and Bertrand assumptions deliver qualitatively similar predictions.

In Section 2 I argue that the hybrid model is a natural and practical way of extending the standard heterogeneous firms trade model to include large firms'

[17]Eaton et al. (2007) show that exporters in the top quintile at t have a probability of 90% of continuing exporting at $t+1$. This probability decreases monotonically towards the fifth quintile, where exporters at t only have a probability of 24% of surviving at $t+1$.

[18]Neary (2016) characterizes the technical difficulties of modeling oligopolistic markets and develops a general equilibrium model where a fixed number of country and sector-specific homogeneous firms that helps him overcome some of the issues. However, his model does not feature entry nor firm heterogeneity.

market power. I develop the model in Section 3 and present the main theoretical results in Sector 4, which I illustrate in Section 5 by means of a numerical exercise. Section 6 concludes by discussing future avenues for research.

1.2 A Discussion on Hybrid Competition

In international trade theory, papers employing models with monopolistic competition and models with oligopoly have followed different paths and rarely addressed the same type of questions (cf. Head an Spencer, 2017). On the one hand, recent models using oligopoly have been mostly concerned with questions related to gains from trade due to misallocation (e.g. Edmond et al., 2015). On the other hand, models with monopolistic competition have mostly addressed questions related to firm selection and productivity (e.g. Melitz, 2003). In this section, I argue that constructing a hybrid model, where a subset of firms affects industry aggregates and other subset does not, both allows me to characterize the role of industrial concentration and is in line with empirical evidence.

The basic fact that motivates having firms behaving differently depending on their size comes from evidence showing that larger, more productive firms charge higher markups (De Loecker et al., 2016). Yet this fact alone does not justify having a hybrid theory since it can be obtained by assuming consumer preferences where more productive firms face a lower elasticity of demand, even with atomistic firms (e.g. quadratic preferences as in Melitz and Ottaviano, 2008). There are two other pieces of evidence suggesting that having large firms behaving as small can be a strong assumption not suitable for addressing all trade-related research questions. First, there is evidence that the markup distribution is positively skewed. De Loecker et al. (2020) show that firms at the 90th percentile charge markups that almost double those at the median.[19] Second, concentration in export markets tends to be high. Bernard et al. (2018) show that firms in the top decile of total trade account for 96% of the total, and among them, those in the top percentile account for 82% in the US. Therefore, assuming that top 1% firms, which account for almost 80% of total trade across industries in the US, do not internalize the impact of their decisions on industry aggregates may conflict with profit maximizing behavior.

High trade concentration is not limited to the US. In order to show evidence for other countries, I use the ten largest countries in terms of exports included in the Export Dynamic Database (EDD). In Figure 1.1 I graph the export concentration distribution across exporter-importer-industries as measured by the market share of the top 1% and 25% exporting firms in terms of exports.

There are two observations to be made about this figure. First, the top 1% of firms that exports to a specific country at a given industry accounts for a third of total exports in average, and the top 25% account for more than 80%, suggesting that the so-called Pareto principle holds in average in this case.[20][21]

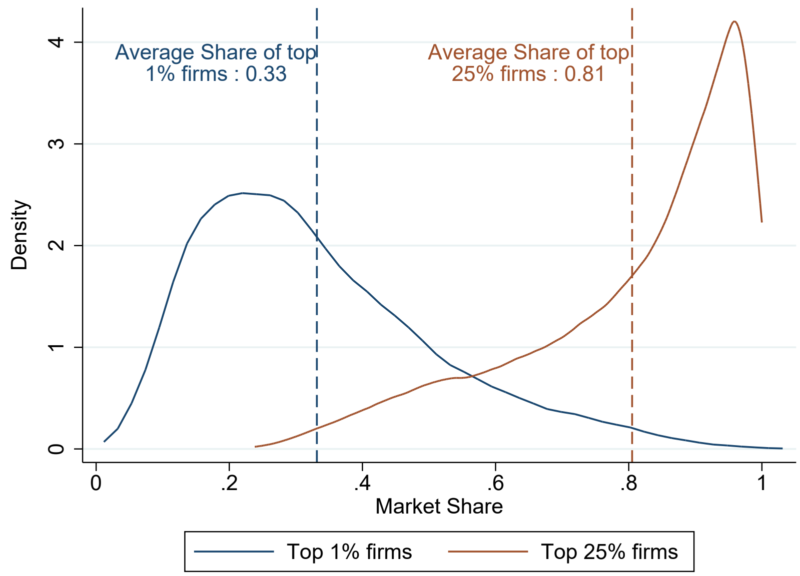
The counterpart of having top firms accounting for a high proportion of export markets is having many small firms with relatively low market shares. To illustrate

[19] This evidence is for domestic US firms.

[20] These calculations are not strictly comparable to the ones for the US, since the level of aggregation in this case is 2 digits of the Harmonized System (HS), whereas it is total trade in the case of the US.

[21] The Pareto principle states that about 80% of a phenomenon can be attributed to a 20% of the observations.

Figure 1.1: Industrial Concentration Distribution across Bilateral Flows for Selected Exporters.



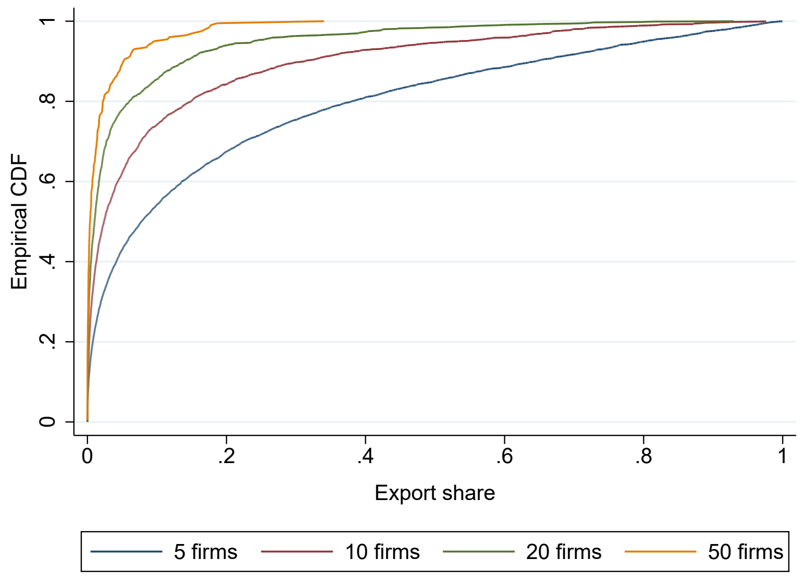
Distribution of the share of top 1% and 25% exporting firms across exporter-importer-HS2 trade flows in 2007. Ten largest exporting countries in the Export Dynamic Database (World Bank) based on the share of world exports: Bangladesh, Chile, Denmark, Spain, Morocco, Mexico, Norway, Peru, Portugal, and South Africa.

this, I employ custom export data from Colombia at the importer-product level and I estimate the empirical CDF of firm-level market shares for importer-products with 5, 10 and 20 exporters in 2007. For example, half of exporters have less than 1% export share in trade flows with 20 firms, as shown in Figure 1.2.[22] Therefore, assuming oligopolistic behavior in all firms may be a high price to pay given that oligopolistic models with heterogeneous firms cannot be analytically solved with firm entry, an important source of gains from trade.

The second feature of Figure 1.1 that I highlight is that export concentration is highly heterogeneous across industries and destinations. The most commonly used productivity distribution in the literature of firm heterogeneity in international trade

[22]Export shares are an upper bound for the real market share these firms have in import markets, since they compete with firms from other origins, including domestic ones.

Figure 1.2: Distribution of Colombian Exporters' Market Shares across Importer-Products Trade Flows with 5, 10, and 20 Colombian exporters.



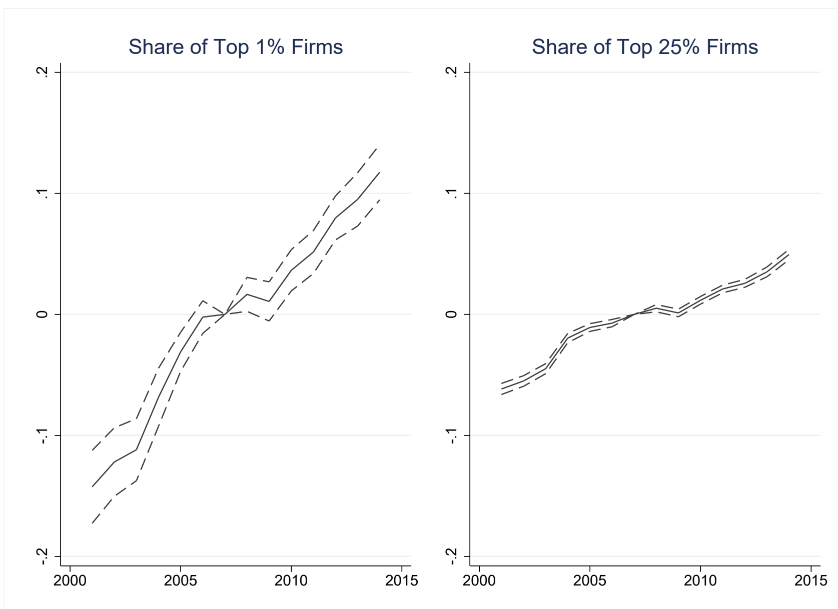
Each observation is a Colombian firm exporting a HS6 product to a specific importing country in 2007. Data from DANE Colombia.

is the unbounded Pareto distribution (cf. Head et al., 2014). Under monopolistic competition, this distribution delivers that the share of the top kth quantile of firms is constant, regardless of where the entry productivity cutoff is. This figure shows that either the Pareto distribution or monopolistic competition do not hold for these exporters, given that the distribution should be degenerate under CES preferences.

The previous result opens the door for alternative characterizations of the observed distribution of export sales. In this regard, there is evidence that the top part of the distribution is not fit well by the unbounded Pareto (e.g. Head et al., 2014; Hottman et al., 2016). In the hybrid model I assume that there is a productivity level above which firms can internalize their impact on industry aggregates. The rationale beneath is that doing so may imply spending resources and therefore only productive enough firms could afford it. Above that productivity level, predicted sales should be lower than what a model assuming an unbounded Pareto would predict, which is in line with the aforementioned evidence.

Finally, the importance of large firms has increased in export markets in the last years, suggesting that accounting for differential large firm behavior may have become more important recently. Figure 1.3 shows this evidence using the same sample of ten countries from the EDD as before. Notably, the share of top 1% exporters grew more than the share of top 25% over the 2001-2014 period.

Figure 1.3: Average Share of Top Firms Growth in Selected Exporters (in logs). 2001-2014.



The graph plots the coefficients of the regression $\log X^k_{cdpt} = \sum_{l=1}^{T} \alpha^r_t + \delta_{cdh} + u_{cdpt}$, where X is the market share of top k firms, c is the exporter, d is the importer, p is the HS2 product, and t is the year. Omitted year is 2007. Robust standard errors. Ten largest exporting countries in the Export Dynamic Database (World Bank) based on the share of world exports: Bangladesh, Chile, Denmark, Spain, Morocco, Mexico, Norway, Peru, Portugal, and South Africa.

In conclusion, developing a hybrid model allows me to exploit useful features of both oligopolistic and monopolistic competitive models, depending on the type of firm, without contradicting the empirical evidence. On the one hand, it allows me to assume that large firms have market power because they are not myopic about their size, which means that market power arises not because of a choice of consumer preferences but in spite of that. On the other hand, having small firms modeled as a continuum allows me to incorporate firm turnover on the left tail of the productivity distribution, where it is more predominant, along with oligopolistic firms on the right tail.

1.3 Model

In this section, I develop the hybrid model focusing on the role of firm concentration and its relationship with the standard international trade model with heterogeneous firms.

1.3.1 Environment

In a given industry, there are an exogenous number of domestic and foreign active firms, N_d^l and N_f^l respectively, that decide the optimal quantity they produce of different varieties of a good. These firms are granular, so they acknowledge the impact of their choices on industry aggregates, and heterogeneous in their productivity. There is also a continuum of domestic and foreign small firms in the industry. Foreign firms face an ad-valorem tariff τ in the domestic economy, so the price they receive is p/τ. In addition, these firms face an ad-valorem unit cost T_f that captures transport costs and input prices employed by foreign producers. Domestic firms face an ad-valorem unit cost T_d.

1.3.2 Consumer Preferences

Consumers have CES preferences with elasticity of substitution $\sigma > 1$, which is the same across all varieties, regardless of being produced by small or large firms; and spend an exogenous amount E on the industry. Therefore, the utility function is as follows:

$$Q = \left[(Q_d^s)^{\frac{\sigma-1}{\sigma}} + (Q_d^l)^{\frac{\sigma-1}{\sigma}} + (Q_f^s)^{\frac{\sigma-1}{\sigma}} + (Q_f^l)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{1.1}$$

where subscripts index origin (foreign or domestic), superscripts index type of firms (large or small), and Qs are the composite goods indicated by the superscripts and subscripts (e.g. Q_f^l is the composite good of large foreign firms). We have that $Q_f^s = \left[\int_{\Omega_f^s}[q_f^s(\omega)]^{\frac{\sigma-1}{\sigma}}d\omega\right]^{\frac{\sigma}{\sigma-1}}$ in the case of small foreign firms where Ω_f^s is the set of domestic available varieties (and analogously for small domestic firms); and $Q_f^l = \left[\sum_{i=1}^{N_f^l}[q_{f,i}^l]^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$ in the case of large foreign firms (and analogously for large domestic firms).[23] The industry price index has the standard CES expression:

$$P = \left[(P_d^s)^{1-\sigma} + (P_d^l)^{1-\sigma} + (P_f^s)^{1-\sigma} + (P_f^l)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{1.2}$$

where $P_f^s = \left[\int_{\Omega_f^s}[p_f^l(\omega)]^{1-\sigma}d\omega\right]^{\frac{1}{1-\sigma}}$ in the case of small foreign firms; and $P_f^l = \left[\sum_{i=1}^{N_f^l}[p_{f,i}^l]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$ in the case of large foreign firms. All firms face the inverse demand function $p_{f,i}^l = (q_{f,i}^l)^{-\frac{1}{\sigma}}Q^{\frac{1-\sigma}{\sigma}}E$ regardless of their type.

[23] I present expressions for foreign firms without loss of generality.

1.3.3 Small Firms

Small firms do not affect industry aggregates individually and charge the fixed markup $\tilde{\mu} \equiv \frac{\sigma}{\sigma-1}$. They decide whether to enter into the domestic economy by comparing the present discounting value of profits to the sunk cost of entry K. The marginal foreign firm entering into the market will equate these two:

$$\frac{\pi^s_{f,*}}{1-\beta} = K \tag{1.3}$$

where $\pi^s_{f,*} \equiv \tilde{\sigma}\tau^{-\sigma}(c^s_{f,*})^{1-\sigma}(\frac{P}{T_f})^{\sigma-1}E$, and $\beta < 1$ is the exogenous probability of exit.[24] The zero cutoff profit cost $c^s_{f,*}$ captures the expression:

$$c^s_{f,*} = \frac{P}{T_f}\Big[\frac{\tilde{\sigma}E}{(1-\beta)K}\Big]^{\frac{1}{\sigma-1}}\tau^{-\frac{\sigma}{\sigma-1}} \tag{1.4}$$

I assume that small firms draw unit costs from a bounded Pareto distribution $G^s(c^s) = \frac{(c^s)^k-(c^s_L)^k}{(c^s_H)^k-(c^s_L)^k}$ where $1/c^s_H$ is the lower productivity bound, $1/c^s_L$ is the upper productivity bound, and k is the shape parameter. In order to provide rationale for the coexistence of large and small firms, I assume that the upper productivity bound is smaller than the least productive large firm.[25] As a result, large firms cannot be less productive than small firms.[26]

[24] $\tilde{\sigma} \equiv (\sigma-1)^{\sigma-1}\sigma^{-\sigma}$

[25] If I order large firms unit costs' in descending order, this assumption implies that $c^s_L > c^l_{f,1}$. Moreover, this is in line with Hottman et al. (2016) where they show that the distribution of firms' sales does not follow an unbounded Pareto distribution due to very large top firms (log sales vs. log rank of firms is convex). My model is flexible in that regard and can accommodate any distribution of large firms' productivities.

[26] This suggests the following rationalization: ex-ante, firms decide to enter based on the bounded Pareto distribution. However, there is a sufficiently low probability of becoming granular and receiving a higher productivity. Since the probability of this event is close to zero, small firms do

Finally, note that domestic expressions are the same but with $\tau = 1$.

1.3.4 Large Firms

Domestic and foreign large firms have an arbitrary distribution of unit costs, $\{c_{d,i}\}_{i=1}^{N_d}$ and $\{c_{f,i}\}_{i=1}^{N_f^l}$ respectively.[27] All large firms compete in quantities, which means that they decide the optimal level of production by also taking into account how they impact the aggregate quantity index Q. Therefore, the first-order condition of a large foreign firm is as follows: [28]

$$p_{f,i}^l - c_{f,i}^l \tau T_f = \frac{1}{\sigma} p_{f,i}^l + \frac{\sigma - 1}{\sigma} s_{f,i}^l p_{f,i}^l \tag{1.5}$$

where the domestic expression is analogous. On the left hand side we can observe the standard marginal gain of increasing the quantity produced since it is the difference between the market price $p_{f,i}^l$ and the effective unit cost. The first term on the right hand side captures the marginal cost of increasing the quantity produced since doing so generates a movement along the demand curve that decreases the price, a mechanism that is also present in the case of small firms. However, large firms recognize that by increasing quantity, they are also increasing the quantity index and thus reducing the industry price index. This increases competition and pushes prices further down. This is captured by the extra term, $s_{f,i}^l p_{f,i}^l = (q_{f,i}^l)^{\frac{\sigma-2}{\sigma}} / Q^{\frac{\sigma-1}{\sigma}}$, which shows that increasing q increases the marginal cost

not consider that when comparing expected profits to the sunk cost of entry.

[27] We can interpret the observed distribution of unit costs as a realization of an unknown productivity distribution where large firms have a technology that allows them to retain such received productivity.

[28] Derivation in Appendix A.1.1.

of choosing a higher quantity relative to monopolistic competition the higher the σ.[29] This means that large firms produce less relative to a monopolistically competitive setting the more productive they are because the marginal cost of doing so increases with the market share.[30]

The optimality condition captured by equation 1.5 delivers the following firm-specific optimal markup:[31]

$$\mu^l_{f,i} = \tilde{\mu} \times (1 - s^l_{f,i})^{-1} \tag{1.6}$$

where $\tilde{\mu} \equiv \frac{\sigma}{\sigma-1}$ is the markup that the firm would charge under monopolistic competition.[32] Therefore, this model of competition delivers a variable markup that increases with the market share even under CES preferences. The underlying determinant of such market power is the demand elasticity ν the firm perceives, which decreases with its size:[33]

$$-\nu^l_{f,i} = (s^l_{f,i} + (1 - s^l_{f,i})/\sigma)^{-1} \tag{1.7}$$

[29] Note that given the CES demand function $q^l_{f,i} = (p^l_{f,i})^{-\sigma} P^{\sigma-1} E$, we have that $s^l_{f,i} = (p^l_{f,i}/P)^{1-\sigma} = (q^l_{f,i}/Q)^{\frac{\sigma-1}{\sigma}}$.

[30] Note that when σ is relatively small the marginal cost of increasing the quantity actually decreases when producing more because the increase in profits due to the increase in the market share offsets the negative effect of an increase in competition (i.e. the increase in market power offsets the decline in the price index). This means that even though larger firms will always produce less than under monopolistic competition, they will be closer to that level of production than smaller firms.

[31] Note that this result is analogous to the one shown by Nocke and Schutz (2018) under CES preferences when we assume that firms produce one variety.

[32] Note that it is the same expression as in Amiti et al. (2019) when the elasticity of substitution across industries is equal to 1 (η in their paper). I assume this elasticity of substitution to focus on the effect of intra-industry and cross-country reallocation of market shares.

[33] Assuming price competition delivers similar qualitative predictions.

1.3.5 Industry Equilibrium

Given the fixed distribution of productivities of large foreign and domestic firms, the unit costs shifters, T_d and T_f, the trade policy variable τ, the survival probability of small firms β, the sunk cost of entry K, and the distribution of small firms' productivity, G^s, the equilibrium conditions are defined as follows:

$$
\begin{aligned}
s^l_{r,i} &= (p^l_{r,i})^{1-\sigma}(P)^{\sigma-1} && (1.8)\\
p^l_{r,i} &= \tilde{\mu}(1-s^l_{r,i})^{-1}\tau_r c^l_{r,i}T_r && (1.9)\\
p^s_r(c) &= \tilde{\mu}\tau_r c^s_r T_r && (1.10)\\
c^s_{r,*} &= \frac{P}{T_r}\Big[\frac{\tilde{\sigma}E}{(1-\beta)K}\Big]^{\frac{1}{\sigma-1}}\tau_r^{-\frac{\sigma}{\sigma-1}} && (1.11)\\
P^l_r &= [\sum_i^{N^l_r}(p^l_{r,i})^{1-\sigma}]^{\frac{1}{1-\sigma}} && (1.12)\\
P^s_r &= [\int_{c^s_L}^{c^s_{r,*}}(p^s_{r,i})^{1-\sigma}dG^s(c^s)]^{\frac{1}{1-\sigma}} && (1.13)\\
P &= [(P^l_d)^{1-\sigma}+(P^s_d)^{1-\sigma}+(P^l_f)^{1-\sigma}+(P^s_f)^{1-\sigma}]^{\frac{1}{1-\sigma}} && (1.14)
\end{aligned}
$$

for $r \in (f,d)$ and $i = 1...N^l_r$, where $\tau_d = 1$.

Firms' market shares $s^l_{r,i}$ are defined relative to the entire market. However, we can define the following equilibrium market shares that are useful in subsequent derivations.

Definition 1 *Given firm types $\tilde{r} \in \{(d,l),(d,s),(f,l),(f,s)\}$ and the industry equilibrium defined in equations 1.8-1.14, the market share of firm i within its type is* *defined as* $z_{\tilde{r},i} \equiv \frac{(p_{\tilde{r},i})^{1-\sigma}}{(P_{\tilde{r}})^{1-\sigma}}$.

Definition 2 *Given the industry equilibrium defined in equations 1.8-1.14, aggregate equilibrium market shares are defined as:*

(i) Share of foreign firms (import penetration): $s_f \equiv \frac{(P_f^l)^{1-\sigma}+(P_f^s)^{1-\sigma}}{P^{1-\sigma}}$

(ii) Share of large firms: $h^l \equiv \frac{(P_f^l)^{1-\sigma}+(P_d^l)^{1-\sigma}}{P^{1-\sigma}}$

(iii) Share of r *firms within large firms:* $s_r^l \equiv \frac{(P_r^l)^{1-\sigma}}{(P_d^l)^{1-\sigma}+(P_f^l)^{1-\sigma}}$

(iv) Share of large firms within r *firms:* $h_r^l \equiv \frac{(P_r^l)^{1-\sigma}}{(P_r^l)^{1-\sigma}+(P_r^s)^{1-\sigma}}$

where $r \in (f, d)$.

Given definitions 1 and 2, foreign firm i's overall market share can be written either as $s_{f,i}^l = s_f h_f^l z_{f,i}^l$ or $s_{f,i}^l = h^l s_f^l z_{f,i}^l$.

1.4 Theoretical Results

In this section, I derive the main theoretical results which establish the relationship between industrial concentration, the CES industry price index, and trade liberalization. I first show that large firms' markup responses to competition can be understood as a concentration measure in the aggregate. I then show that trade liberalization decreases the CES industry price index and increases domestic concentration.

In order to do so, I define an increase in competition as follows:

Definition 3 *Any shock that decreases the CES industry price index P is a shock that increases competition.*

In this model, a decrease in P causes both downward pressure on large firms' markups and exit of less-productive small firms. These are two features present in many oligopolistic and monopolistic competitive models that are generally interpreted as characteristics of more competitive environments. Therefore, I use P to capture changes in the state of competition.

1.4.1 Industrial Concentration

1.4.1.1 Relative Market Shares

In the standard model with a continuum of monopolistically competitive firms, the role of industrial concentration is limited to reflecting the underlying productivity distribution intermediated by the elasticity of substitution conditional on the entry cutoff. Therefore, it is understandable that the international trade literature did not pay much attention to its determinants. With granular firms this is different. Changes in trade costs generate changes in the country-specific distribution of market shares due to firm-specific heterogeneous pass-throughs. Moreover, changes in trade costs do not need to directly affect firms to modify the distribution of shares since changes in competition also affect large domestic firms' markups. Therefore, industrial concentration not only reflects the underlying productivity distribution but also the state of competition in the industry.

Before formalizing the previous discussion, let's first note the following:

$$d\log s^l_{r,i} = (1-\sigma)d\log(p^l_{r,i}/P) \tag{1.15}$$

which directly follows from equation 1.8. This means that a change in the ratio of any exogenous consumer price determinant to the price index is a sufficient statistic for a change in firm-specific overall market share. The reason is that it captures both the direct impact of such effect and the overall change in competition, which aggregates all markup and entry responses, including firm's own.

The previous discussion implies that the effective impact of trade liberalization on individual foreign firms' market shares has to be measured by τ/P in the case of foreign firms, and by $1/P$ in the case of domestic firms (given that there is no direct effect of tariffs on their prices). The following proposition uses this idea to establish the relative response of market shares to trade liberalization.

Proposition 1 ***Relative Market Shares Response to Trade Liberalization.*** *A decrease in effective tariffs, τ/P, that increases competition:*

(i) decreases the market share of the relatively more productive large foreign firms,

$$\frac{d\log z^l_{f,i}/z^l_{f,j}}{d\log \tau/P} > 0 \tag{1.16}$$

where $c^l_{f,j} > c^l_{f,i}$; and

(ii) increases the market share of the relatively more productive large domestic

firms,

$$\frac{d\log z^l_{d,i'}/z^l_{d,j'}}{d\log 1/P} > 0 \tag{1.17}$$

where $c^l_{d,j'} > c^l_{d,i'}$.

Proof: See Appendix A.2.1.

In order to explore the result in Proposition 1, I define the markup pass-through as follows:

$$\psi^l_{r,i} \equiv -\frac{\partial \log \mu^l_{r,i}}{\partial \log p^l_{r,i}} = (\sigma - 1)\frac{s^l_{r,i}}{1 - s^l_{r,i}} \tag{1.18}$$

where $r \in (f, d)$.[34] Note that this elasticity is increasing in firm i market share, which indicates that larger firms react more strongly to changes in either trade costs or competition.[35] For instance, a decrease in tariffs leads to higher markup increases by relatively more productive foreign firms and thus lowers their share relative to their less productive foreign competitors.[36] Domestic firms will face more competition once tariffs go down, and as a result their markups will decrease.

[34] I follow Amiti et al. (2019) in defining a term $\psi^l_{r,i}$ as the negative of the markup elasticity.

[35] This mechanism is not present in small firms because $\frac{\partial \log \mu^l_{r,i}}{\partial \log p^l_{r,i}} = 0$.

[36] The underlying mechanism can be understood by examining equation 1.5: Even though the decline in tariffs increases the marginal gain of increasing production, a relatively more productive firm i, given its relatively larger size, acknowledges that it need not to increase production as much as less productive firm j to equate those gains to the marginal costs of increasing production. As a result, firm i increases production less than firm j and the decline in $p^l_{r,i}$ is lower than the decline in $p^l_{f,j}$, inducing i's markup to increase more as a consequence.

The relatively more productive firms will do so at a greater extent and therefore will gain market share.

1.4.1.2 Concentration Measures

In order to address how industrial concentration relates to the CES industry price index and trade flows, and how trade liberalization affects concentration, we need to have a general definition of industrial concentration as a benchmark.

Definition 4 *Given a set of market shares* $\{s_i\}_{i=1}^N$*, where* $\sum_{i=1}^N s_i = S$*, a function* $\mathcal{C}(\{s_i\}_{i=1}^N) = \sum_{i=1}^N m(s_i)$ *is a* ***proper industrial concentration measure*** *if a mean-preserving spread,* $\mathcal{C}(\{s_i + \Delta_i(s_i)\}_{i=1}^N)$*, where* $\sum_{i=1}^N \Delta_i = 0$ *and* $\Delta_s' \geq 0$*, increases its value.*

Definition 4 is satisfied by most of the widely used concentration measures such as the HHI, the Theil index and the share of top firms when the spread is such that shares are distributed between top and non-top firms.

In order to understand how concentration enters into the model, let's examine how the price index of large foreign firms reacts to changes in competition.

$$\Psi_r^l \equiv \frac{\partial \log P_r^l}{\partial \log P} = \sum_{i=1}^{N_r^l} z_{r,i}^l \frac{\psi_{r,i}^l}{1 + \psi_{r,i}^l} \tag{1.19}$$

The measure Ψ_r^l is the weighted average of large firms' equilibrium responses to a change in competition. In fact, each firm-specific term $\frac{\psi_{r,i}^l}{1+\psi_{r,i}^l}$ is the firm-specific equilibrium markup response to changes in determinants of its own prices (e.g. tariff in the case of foreign firms).

The importance of this object for the theoretical implications of the model is captured by the following proposition.

Proposition 2 ***Large Firms Price Index and Concentration****. The function Ψ_r^l is a proper industrial concentration measure.*

Proof: See Appendix A.2.2.

Proposition 2 establishes that concentration of firms is embedded in the industrial equilibrium because it captures the aggregate markup response to changes in competition. To fix ideas, we can further relate this measure to a widely used concentration measure, the HHI, by doing a first order approximation around $\sigma = 2$:[37]

$$\Psi_r^l \approx (\sigma - 1) s_r h_r^l HHI_r^l - (\sigma - 2)(s_r h_r^l)^2 HHI_r^l(3) \tag{1.20}$$

where $HHI(3) = \sum_{i=1}^N z_i^3$. When $\sigma = 2$, $\Psi_r^l = s_r h_r^l HHI_r^l$ and therefore $\frac{\partial \log P_r^l}{\partial \log P}$ is proportional to HHI_r^l.[38] In this sense, concentration is microfounded by the model.

1.4.2 Industry Price Index

In this section I examine how tariffs affect the CES industry price index in the hybrid model. To do so, let's first define the small firms' analogous expression to Ψ_r^l:

[37] Derivation in Appendix A.1.2.
[38] It is exactly HHI_r^l in the case of a closed economy with only oligopolistic firms.

$$\Lambda_r^s \equiv -\frac{\partial \log P_r^s}{\partial \log P} = \frac{k-(\sigma-1)}{\sigma-1} \frac{(c_{r,*}^s)^{k-(\sigma-1)}}{(c_{r,*}^s)^{k-(\sigma-1)} - (c_L^s)^{k-(\sigma-1)}} \tag{1.21}$$

In contrast to large firms, small firms do not respond individually to changes in competition since their markups are fixed. Nonetheless, when P increases, more firms enter decreasing P_r^s. Therefore, the price index of small and large firms react in opposite directions to changes in competition. The function Λ_r^s is proportional to the hazard function λ_r^s of the bounded Pareto distribution of export sales, as shown by Melitz and Redding (2015).[39]

In the following proposition I identify the new channel introduced by large firms through which trade liberalization can affect competition and thus consumers in the context of the standard model.

Proposition 3 ***Industry Price Index Elasticity***. *(a) The elasticity of the price index with respect to tariffs can be decomposed into a (i) price term (1.22), (ii) a relative large firms concentration term (1.23), (iii) relative small firms entry term (1.24), and (iv) a cross-size term (1.25):*

$$\begin{aligned}
\frac{d \log P}{d \log \tau} &= s_f & (1.22)\\
&+ (h^l)^2 \frac{s_f^l(1-s_f^l)}{H} (\Psi_d^l - \Psi_f^l) & (1.23)\\
&+ (1-h^l)^2 \frac{s_f^s(1-s_f^s)}{H} (\Lambda_f^s - \Lambda_d^s) & (1.24)\\
&+ \frac{(1-h^l)h^l}{H} \Big[s_f^s(1-s_f^l)[\Psi_d^l + b\Lambda_f^s] - (1-s_f^s)s_f^l[\Psi_f^l + \Lambda_d^s] \Big] & (1.25)
\end{aligned}$$

[39] The hazard function is exactly $\lambda_r^s = (\sigma-1)\Lambda_r^s$.

where $H \equiv 1 - h^l\Psi^l + (1-h^l)\frac{\Lambda^s}{\sigma-1} > 0$ *is the overall equilibrium response and* $b > 1$ *is a factor correcting by the difference between* $\frac{\partial \log P_r^s}{\partial \log P}$ *and* $\frac{\partial \log P_r^s}{\partial \log \tau}$.[40]

(b) The elasticity of the price index with respect to tariffs takes values between 0 *and* $\frac{\sigma}{\sigma-1}$.

Proof: See Appendix A.2.3

There are two special cases that are worth highlighting in part (a). The first one is when there are only small firms ($N_f^l = N_d^l = 0$). In that case, this expression only retains the price effect and the term 1.24, which captures the gains from trade due to product variety. In a symmetric setting, this term is positive as long as there are more small domestic firms than small foreign firms in the industry, all else equal. In the special case where the Pareto distribution is unbounded ($c_L^s = 0$), this term vanishes showing that there are no gains from trade due to product variety in the standard monopolistic model, as argued by Feenstra (2018).

The second special case is when there are no small firms ($c_L^s = c_H^s$). In this case, the gains from trade only come from the pro-competitive term, 1.23, which captures whether markups will decrease or increase depending on the relative concentration between domestic and foreign large firms. Note that its sign is not determined and depends on the specific productivity draws of granular firms. Given that this mechanism is especially important when the market is evenly distributed (i.e. $s_f^l = 1/2$), opening to trade when foreign firms are relatively more concentrated implies that pro-competitive effects can be negative.

[40] $b \equiv \frac{1-s_f^l + \frac{1}{h^l(\sigma-1)}}{1-s_f^l}$. In the case of $\frac{d\log P}{d\log T_f}$, $b=1$ because $\frac{\partial \log P_r^s}{\partial \log P} = \frac{\partial \log P_r^s}{\partial \log T_f}$. Details in the proof.

In the case where there are both large and small firms, each of the previous terms is qualified by how much more productive large firms are. This is captured by h_l: the more productive large firms are relative to small firms, the higher will be their market share, even after taking into account their higher markups. In addition, the terms 1.23 and 1.24 are not enough to capture the pro-competitive and product variety gains from trade since there are cross-effects between the two types of firms, as captured by term 1.25. For example, a decrease in tariffs will increase foreign entry by more when Λ_f^s is high, and therefore will amplify the tariff effect by further decreasing domestic markups.

In part (b) of Proposition 3 I establish that the price index elasticity is always positive and bounded above. To see this, we can write the price index as follows:

$$\frac{d\log P}{d\log \tau} = s_f \frac{\tilde{H}_f}{H} \tag{1.26}$$

where $\tilde{H}_f \equiv 1-h_f^l\Psi_f^l+(1-h_f^l)\Lambda_f^s\frac{\sigma}{\sigma-1} > 0$.[41] Given that $\frac{\tilde{H}_f}{H} > 0$, the elasticity is always positive and depends on the ratio of foreign to overall equilibrium responses.

1.4.3 Domestic Concentration

Given the evidence of an increase in domestic concentration in developed economies, it is useful to study the predictions of this model in a setting where foreign competition increases. In light of the model, such increase can be caused by

[41]Note that $\Psi_f^l \in (0,1)$ and therefore $1-h_f^l\Psi_f^l > 0$.

any factor decreasing the relative price of imports such as tariffs or an increase in foreign firms' productivities.

I analyze the relationship between competition and domestic concentration by means of the Herfindahl-Hirschman Index (HHI). In this regard, Proposition 4 decomposes and signs the elasticity of HHI with respect to the CES industry price index:

Proposition 4 ***Domestic Concentration and Competition***. *(a) The elasticity of domestic concentration as captured by the HHI with respect to the CES industry price index depends on (i) within large firms market shares reallocation (1.27), (ii) within small firms market share reallocation (1.28), and (iii) cross-size market share reallocation (1.29):*

$$\begin{aligned}\frac{d\log HHI_d}{d\log P} &= -2(\sigma-1)\sum_{i=1}^{N_d}\left[\gamma^l_{d,i}-z^l_{d,i}\right]\frac{\psi^l_{d,i}}{1+\psi^l_{d,i}} && (1.27)\\ &+ \left[\lambda^s_{2,d}-2\lambda^s_d\right] && (1.28)\\ &+ 2(1-2h^l_d)(\sigma-1)[\Lambda^s_d+\Psi^l_d] && (1.29)\end{aligned}$$

where $\lambda^s_{2,d} \equiv [k-2(\sigma-1)]\frac{c_{d,*}^{k-2(\sigma-1)}}{c_{d,*}^{k-2(\sigma-1)}-c_L^{k-2(\sigma-1)}}$ is the hazard function of a bounded Pareto distribution with shape parameter $k-2(\sigma-1)>0$, and $\gamma^l_{d,i} \equiv \frac{(z^l_{d,i})^2}{\sum_{i=1}^{N^l_d}(z^l_{d,i})^2}$ are HHI-specific weights.

(b) Any shock that increases competition increases domestic concentration when the market share of large domestic firms is no smaller than the market share of small domestic firms ($h^l_d \geq \frac{1}{2}$).

Proof: See Appendix A.2.4.

We can analyze two special cases: only small and only large firms. In the first case, the resulting expression is term 1.28 which only depends on the relationship between two Pareto distribution with different shape parameters. The term λ_d^s is the usual hazard function of the distribution of sales with bounded Pareto, which has shape parameter $k - (\sigma - 1)$ and location $c_{d,*}^s$ under the usual condition that $k > \sigma - 1$; whereas the term $\lambda_{2,d}^s$ is the hazard function of a Pareto distribution that weights individual sales differently depending on the concentration measure. In the case of the HHI, the shape parameter of such Pareto distribution is $k - 2(\sigma - 1)$.[42] The sign of this term is always negative when using a Pareto distribution, and we can gain intuition by analyzing the special case of an unbounded distribution:

$$\frac{d \log HHI_d}{d \log P} = -\frac{k}{\sigma - 1} \tag{1.30}$$

This expression captures the impact on the distribution of market shares that happens only through firm turnover. Therefore, any shock that increases competition decreases P, which causes exit and an increase of surviving firms' market shares proportional to their productivity. In terms of the magnitude of this elasticity, the higher is k, the higher will be the response of entry to competition because firms are more homogeneous. Therefore, a decrease in P will reallocate more market share towards surviving firms. When σ is high, entry is less responsive because residual demand for potential entrants is lower. Therefore, HHI_d is less responsive to P.

[42] Using this concentration measure is only valid for industries with $k > 2(\sigma - 1)$ given that the shape parameter of a Pareto distribution is restricted to be positive.

In the case with only large firms, the impact of P on HHI_d depends on the reallocation of market shares due to changes in markups. This is captured by the discrete weights that each function, P and HHI, assigns to each firm response, $z^l_{d,i}$ and $\gamma^l_{d,i}$ respectively. Its sign is always well-defined because HHI is an increasing convex function in the unit interval, which implies assigning higher weights to relatively larger firms. This means that the difference in weights, $\gamma^l_{d,i} - z^l_{d,i}$, is higher for the higher markup equilibrium responses. As a result, the impact of P on HHI_d is negative.

When there are both large and small firms, a change in P will also reallocate market shares across firm sizes as captured by term 1.29. Its sign is negative when large firms have a higher market share than small firms. The intuition is that any shock that increases competition decreases the price index of large domestic firms and increases the price index of small domestic firm, reducing the relative price of varieties produced by large firms. Hence, if $h^l_d > 1 - h^l_d$ then the set of firms that gains market share is the one that already had most of the market. Thus, concentration increases.

1.5 Numerical Exercise

In this section I provide a numerical exercise to illustrate the mechanics of the hybrid model and the role of concentration in the impact of tariffs and variable trade costs on the CES price index and concentration.

1.5.1 Large Firms' Productivities

The hybrid model does not impose any kind of restriction on the distribution of productivities of domestic and foreign large firms. In this section, I interpret the distribution of productivities of large firms as a particular draw $(\{c^l_{d,i}\}|^{N^l_d}_{i=1}, \{c^l_{f,i}\}|^{N^l_f}_{i=1})$ from an unbounded Pareto distribution G^l with shape parameter k and scale parameter $1/c^s_L$. This means that the productivity distribution of all firms, large and small, can be understood as a compound of two distributions: the one for the small firms and the distribution that generated the observed draws of large firms' productivities.[43]

1.5.2 Parameters

In Table 2.9 I list the parameter values required to conduct a numerical exercise.

Table 1.1: Parameter Values.

Parameter	Definition	Value	Source/Explanation
k	Pareto shape parameter	4.3	GI (2018)
σ	Elasticity of substitution	4.5	Average GI2018-MR2015
c^s_H	Upper bound of the unit cost distribution	1	Normalization
c^s_L	Lower bound of the unit cost distribution	0.125	Implies average large firm productivity to be 8x relative to small firms
N^l_f, N^l_d	Number of domestic and foreign large firms	4	Commonly used value to calculate concentration ratios (HS2017)
N	Number of potential entrants	1000	Normalization
$\tilde{E} \equiv \frac{E}{K(1-\beta)}$	Entry shifter	10000	Guarantees an internal solution

GI2018: Gaubert and Itshoki (2018), MR2015: Melitz and Redding (2015), HS2017: Head and Spencer (2017).

The two parameters that govern the curvature of the distribution of sales are σ and k. I set $\sigma = 4.5$, which is the average between $\sigma = 4$, the value used in Melitz and Redding (2015), which features a monopolistic competitive model and

[43]This implies that the overall productivity distribution is unbounded Pareto with scale parameter $1/c^s_H$. This is helpful to make the model potential comparable to a model with a continuum or firms over the entire cost support $(0, c^s_H)$.

truncated Pareto, and $\sigma = 5$, the one used in Gaubert and Itshoki (2018), which features a pure oligopolistic model. In the case of k, values used in the literature do not differ much and are between 4.25 and 4.5 in general. I choose 4.3 as in Gaubert and Itshoki (2018).

I set $c_L^s = 0.125$, which determines the relative productivity between small and large, given the normalization $c_H^s = 1$. This value implies that large firms are assumed to be approximately 8 times more productive than small firms in average.[44]

I assume that there are four large domestic and foreign firms serving the domestic market, N_d^l and N_f^l, given that it is a value traditionally used to measure the degree of oligopoly tightness (cf. Head and Spencer, 2017). Moreover, it is a widely used value to calculate concentration ratios.[45]

The rest of parameters/exogenous variables only affect entry directly. The number of potential entrants N captures the degree of contestability in the market given that it determines how many small firms could enter, imposing potential competition on large firms. Consumer expenditure E, the entry cost K and the discount factor β only modify the cost cutoff. I set $N = 1000$ as a normalization and construct an entry shifter $\tilde{E} \equiv \frac{E}{K(1-\beta)}$. I assume it takes a value that guarantees an internal solution ($\tilde{E} = 10000$).

---

[44]This value is derived from $\frac{\int_0^{c_L^s} c dG^l(c)}{\int_{c_L^s}^{c_H^s} c dG^s(c)} = \frac{(\frac{c_L^s}{c_H^s})(c_H^s)^{k+1} - (c_L^s)^{k+1}}{(c_H^s)^{k+1} - (c_L^s)^{k+1}}$, which using the chosen parameters is equal to 8.

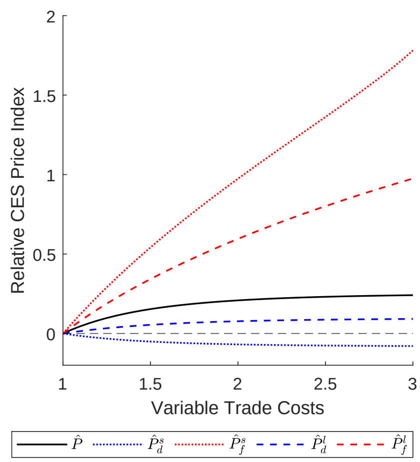
[45]The US Census uses 4, 8, 20, and 50 top firms to calculate the share of top firms.

1.5.3 Quantification

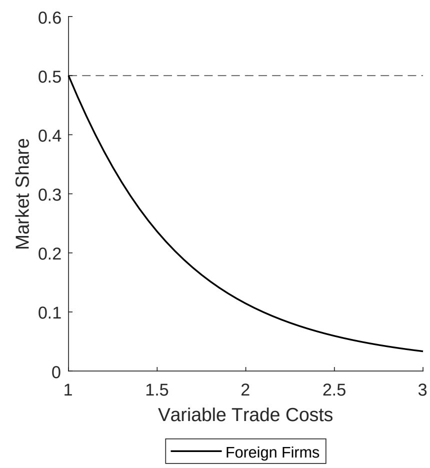
1.5.3.1 Numerical Comparative Statics

In Figure 1.4 I show the solution of the model at different variable trade costs.[46]

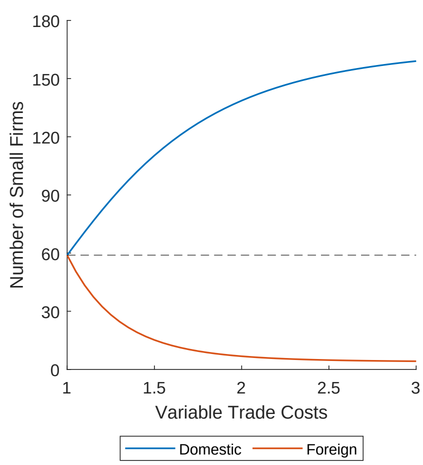
Figure 1.4: Hybrid Model Solution at Different Variable Trade Costs.



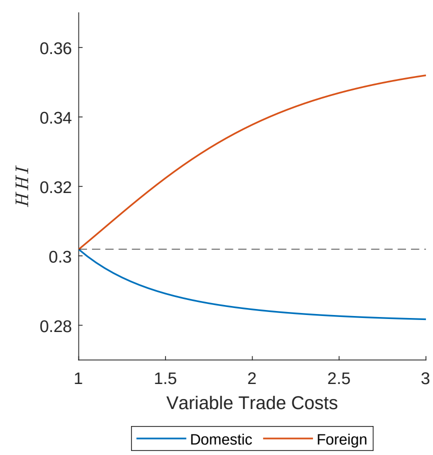
(a) Relative CES Price Index



(b) Import Penetration



(c) Number of Small Firms



(d) Industrial Concentration of Large Firms

Equilibrium solution at each level of trade costs using parameters in Table 1.1 and procedure in Appendix B.

In Panel 1.4a I plot the price index and each component relative to free trade ($\hat{P} = \log P_{T_f=\bar{T}_f} - \log P_{T_f=1}$). The increase in trade costs causes more domestic en-

[46]Details of the solution in Appendix B

try, which lowers P_d^s, but also causes large domestic firms to increase their markups, which increases P_d^l. Foreign price indices increase as expected, with the large firm price index increasing less due to markup reductions. The overall price index increases, but substitution towards domestic varieties implies that at high trade costs it is not as affected by them. This substitution can be seen in Panel 1.4b, where the share of foreign firms decreases to less than 5% at $T_f = 3$.

Panels 1.4c and 1.4d show what happens with small and large firms when trade costs increase. Given the imposed symmetry between the two countries, when $T_f = 1$ there are the same number of foreign and domestic firms selling into the industry, and the distribution of foreign and domestic market shares is the same in the case of large firms. When trade costs increase, foreign firms exit and there is more entry of domestic firms. In the case of concentration, an increase in trade costs decreases concentration of large domestic firms, as captured by the HHI, because large firms charge higher markups an therefore absorb less demand. The opposite happens with large foreign firms. This illustrates the result in Proposition 4.

1.5.3.2 Trade Liberalization

Proposition 3 decomposes the impact of tariffs on the industry price index into a price effect, a relative concentration term, a relative entry term, and a cross-size term. In Table 1.2 I show such decomposition for an impact of 10 log points decrease in tariffs at different levels of trade costs.

Table 1.2: The Impact of 10 log points Reduction in Tariffs on the Industry Price Index at Different Variable Trade Costs.

Variable Trade Costs	Total Change	Direct Effect Contribution	%	Relative Concentration Contribution	%	Relative Entry Contribution	%	Cross-size Impact Contribution	%
1	-0.0500	-0.0500	100%	0	0%	0	0%	0	0%
1.5	-0.0358	-0.0345	96.4%	-0.00213	5.97%	-0.0000369	0.103%	0.000889	-2.48%
2	-0.0256	-0.0236	92.3%	-0.00307	12.0%	-0.0000498	0.195%	0.00116	-4.54%
2.5	-0.0184	-0.0163	88.5%	-0.00315	17.1%	-0.0000481	0.261%	0.00108	-5.86%
3	-0.0134	-0.0114	85.2%	-0.00283	21.1%	-0.0000411	0.307%	0.000890	-6.64%

Equilibrium solution at each level of trade costs using parameters in Table 1.1 and procedure in Appendix B. Reduction of 10 log points in Tariff calculated using equation in Proposition 3.

At low trade costs, the decrease in the price index due to trade liberalization is mainly explained by the direct effect, given that both domestic and foreign firms have similar market shares. At high trade costs, the importance of the relative concentration term increases, reaching 21% of the total effect when $T_f = 3$. The highest economic significance is reached at $T_f = 2.5$ in this example, where the price index increases 0.3 log points due to changes in large firms' markups.[47]

1.6 Summary and Concluding Remarks

In this chapter, I argued that accounting for oligopolistic behavior in trade flows is important given the high levels of concentration we observe in export data and the evidence of an increase in domestic and foreign concentration observed in the last couple of decades. I constructed a hybrid model where two types of firms, small and large relative to the market, from two origins, domestic and foreign, compete in a given market by selling varieties of the same good. Such model allowed me to derive novel implications in which I relate industrial concentration to the CES price

[47]Note that there is almost no impact through entry. This is partially explained by the fact that the bounded Pareto distribution is similar to the unbounded Pareto distribution when the cutoff is far from the bound. Moreover, small firms only have between 20% and 30% of the market share in this example as a result of being eight times less productive in average.

index at the industry level.

I uncovered a new channel through which trade liberalization can affect consumer welfare: the relative industrial concentration between domestic and foreign firms. When domestic firms are relatively more concentrated, a reduction in tariffs has positive pro-competitive gains from trade because domestic granular firms relatively reduce their markup. The opposite is true when foreign firms are relatively more concentrated. The reason is that domestic concentration captures the aggregate partial elasticity of the domestic price index to competition, and foreign concentration in the domestic economy captures the aggregate partial elasticity of the import price index to competition. In this regard, concentration is microfounded by the state of competition through the distribution of markups. I show that this effect is especially strong when countries are highly integrated and the share of granular firms in the industry is large.

The model allowed me to construct a structural equation relating changes in domestic concentration to changes in competition. I showed that when there is a decrease in the industry price index (e.g. an increase in foreign competition), domestic concentration increases as measured by the HHI if large domestic firms have a larger market share than small domestic firms. To the best of my knowledge, this is the first theoretical equation relating concentration to international trade that can be brought to the data.

The main limitation of the model is that it does not provide an explanation nor a mechanism for the existence of large firms. In the case of small firms, a continuum of potential entrants decide to enter depending on their expected productivity, business conditions and the sunk cost of entry. On the contrary, an exogenous number of origin-specific large firms is assumed to be present. Even though the lack of entry with heterogeneous large firms is a limitation inherited from the oligopoly literature, accounting for the mechanism through which these large firms come to existence is important for future research.

In this chapter I focused on the impact of trade liberalization on both domestic welfare and concentration, but this model can be employed to study the relationship between domestic concentration and exports too. Generally, exporters are the most productive domestic firms. Therefore, changes in domestic concentration can be related to changes in their technologies due to investments made to enter foreign markets. Moreover, the difference between their domestic and export concentration can embed meaningful information about the relative state of competition across foreign import markets. I leave studying the relationship between exports and concentration for future work.

Finally, the model can be used to understand the potential relationship between the increase in import penetration from China and the increase in domestic concentration many countries have experienced. In light of the model, an increase in the productivity of Chinese firms would increase the competitive pressure firms in other countries face, causing large firms to decrease their prices and the less productive small firms to exit, increasing concentration. Even though there may be other causes behind the observed increase in concentration in countries such as the US, this model could be used to study different counterfactual scenarios and quantify the relationship between concentration and foreign competition.

Chapter 2: The Gravity Equation under Oligopolistic Behavior

2.1 Introduction

In this chapter, I explore the empirical implications of the hybrid model and the role of exporter concentration for the structural relation between bilateral trade flows and its determinants, the so-called gravity equation. The gravity equation has been labeled as "one of the most empirically successful in economics" due to its high explanatory and predicting power of trade flows with observable data (cf. Anderson and van Wincoop, 2003). Even though it was first used as an empirical relationship, many papers have developed its micro-foundations in the context of perfect and monopolistically competitive markets. I extend this framework to account for oligopolistic behavior in the context of increasing exporter concentration and integration of recent years.

I exploit the hybrid structure of the model developed in Chapter 1 to derive a novel augmented gravity equation in changes. I show that the first-order impact of a change in tariffs on trade flows is lower when exporter-specific granular firms are more concentrated and have a larger market share in the importing country. This finding makes explicit that the structural gravity equations derived from monopolistic competitive models are misspecified when there is oligopolistic behavior.

The model allows me to empirically study the heterogeneous first-order impact of trade policy through the differential market power of large firms. I study recent changes in Colombia's trade policy that differentially affected exporting countries within industries. In the 2010-2013 period, Colombia decreased its Most Favored Nation (MFN) tariffs and signed its first Free Trade Agreements (FTA) with developed countries.[1] I exploit industry and country variation arising from that differential treatment to identify both the average elasticity of imports with respect to trade costs, i.e. the trade elasticity, and the oligopolistic margin, the extra channel introduced by granular firms. Using the theory-based industrial concentration measure that captures the differential pass-through across exporters, I find that the oligopolistic margin effectively reduced the magnitude of the trade elasticity. In the preferred specification, one standard deviation increase in the theory-based concentration measure reduces the trade elasticity by 55%.

The newly identified oligopolistic margin suggests that the actual impact of tariffs on imports is highly heterogeneous across exporters and depends on their initial concentration. I find that predicted import growth is significantly lower than under monopolistic competition for the top 19% import flows in terms of concentration. Moreover, I find that the aggregate effect is higher than the average effect due to the oligopolistic margin, illustrating that this channel can have important implications for aggregate trade. In terms of trade policy, oligopolistic behavior can also have implications for the effect of preferential treatment across exporters. I estimate that imports from countries at the top decile of firm concentration have 13 log point

[1] Canada (2011), US (2012), and the European Union (2013).

lower average growth than imports from countries at the bottom decile over a period of time in which imports grew 36 log points on average. Therefore, policymakers should consider the market structure of foreign exporters when proposing changes to trade policy.

The industry model developed in Chapter 1 can be understood as a modification of Chaney (2008), where heterogeneous firms from different countries decide to enter into foreign markets based on a fixed cost of exporting and variable profits. In his setting, the trade elasticity has two margins: the intensive margin, which captures changes in firms' prices, and the extensive margin, which captures firm entry and thus an increase in varieties. In the hybrid model, the inclusion of origin-specific granular firms introduces an extra margin to the trade elasticity due to their oligopolistic behavior. The new margin reduces the trade elasticity by capturing how firms absorb part of changes in trade costs and tariffs through changes in markups. I show that this oligopolistic margin depends on the importance of the affected large firms within a given market and a measure of their concentration.[2] This result is intuitive: bilateral flows will react less to changes in trade costs if firms that are able to change their markups have a preponderant role. In conclusion, the trade elasticity is variable and initial concentration matters when there is oligopolistic behavior.

I contribute to the understanding of the gravity equation in the context of structural models. Anderson (1979) was the first to propose a theoretical framing of

[2]The model nests Chaney (2008), and therefore when the market share of these firms is zero and the productivity distribution is unbounded we return to his model.

the gravity equation. However, Anderson and van Wincoop (2003) were the first to provide a general equilibrium model to recover fundamental parameters. Recently, many papers followed their approach and found settings under which a broad spectrum of general equilibrium models can microfound the gravity equation (cf. Arkolakis et al., 2012, Arkolakis et al., 2018, Allen et al., 2020). My model abstracts from general equilibrium effects to focus on industry characteristics, which allows me to study the impact of market structure at the level at which tariffs are usually determined. Even though introducing oligopolistic behavior prevents me from finding exact changes, the first order impact of trade costs allows me to characterize the way oligopolistic behavior affects bilateral trade around the equilibrium.

There is an extensive empirical literature employing gravity equations to study the impact of trade policy on bilateral trade. Some papers study the econometric issues that arise when studying the impact of policy, such as Baier and Bergstrand (2007); whereas other papers focus on the channels through which policy affects different trade margins, such as Baier et al. (2014). I argue that the diff-in-diff empirical strategy used in this chapter provides exogenous variation that overcomes the regular issues of studying endogenous trade policy and allows me to identify the aforementioned oligopolistic margin.

I show that the heterogeneous feature of granular firms across origin countries gives exporter-specific industrial concentration an important role due to differences in firms' markups responses. In this regard, Edmond et al. (2018) decompose the welfare costs of markups in an aggregate markup, misallocation and low entry term, three channels that are present for each exporting country in my setting.

Given that I focus on the role of concentration, I do a different decomposition of the theoretical industrial concentration and identify three terms that are relevant for the first order impact of tariffs on trade flows and can be constructed with firm-level data: aggregate market power, conditional concentration, and granular extensive margin. The first one captures the relative importance of an exporting country, conditional on the distribution of market shares. A higher overall market share implies more market power, given such distribution. The second one captures market power arising from firm dispersion. In this sense, more dispersion implies a higher first-order response of markups and therefore a stronger effect on prices. The last one identifies variation from the number of large firms, which also increase the relative market power of exporting countries. Given that the oligopolistic margin depends on concentration, I decompose it into these three channels and find evidence for them.

In Section 2, I derive the oligopoly-augmented gravity equation using the model. In Section 3, I describe the empirical strategy and provide regression evidence for the oligopolistic margin. In Section 4, I argue that the hybrid model is especially important under high exporting firm concentration, and I quantitatively show that policymakers should consider the heterogeneous first order response of bilateral flows when setting tariffs. Section 5 concludes.

2.2 An Oligopoly-Augmented Gravity Equation

In this section, I employ the model developed in Chapter 1 to derive a gravity equation in changes. To do so, I generalize the model to having an arbitrary number of exporters, which are indexed by c.

In the standard international trade model of heterogeneous firms with monopolistic competition, the relation between the change in trade flows, trade costs and multilateral resistance terms takes the following form:[3]

$$d \log M_{cd}^{MC} = -\theta^{MC} d \log T_{cd} + \delta_c^G + \delta_d^G \tag{2.1}$$

where M_{cd} are d imports from c, T_{cd} are ad-valorem trade costs, θ^{MC} is the trade elasticity and δ_c^G and δ_c^G are destination and origin multilateral resistance terms that capture c supply capabilities and d market potential.

The trade elasticity θ^{MC} captures both the extensive and intensive margin effects of changes in trade costs. As shown by Chaney (2008), if we assume homogeneous firms acting under monopolistic competition, the trade elasticity is simply $\sigma - 1$ as in Krugman (1980). However, If there are heterogeneous firms whose productivity distribution follows an unbounded Pareto with shape parameter k, there is also an extensive margin elasticity that is equal to $k - (\sigma - 1)$. This means that the trade elasticity is k (the sum of the intensive and the extensive margin elasticities).

[3] In order to directly compare to Chaney (2008), in this section I consider trade costs faced by producers. Differently, tariffs are defined as the difference between the consumer and the producer price. Conclusions do not differ when using tariffs and the only difference is a fixed factor modifying the standard trade elasticity.

Given the regularity condition $k > (\sigma - 1)$, the elasticity under firm heterogeneity is higher, reflecting the fact that decreasing trade costs not only decrease the price of existing varieties but also induce entry of new varieties.

A key assumption of these models is that firms do not act strategically when setting prices or quantities. Given that the industry model I consider includes firms that do act strategically, we also need to account for changes in c's market power at d. Not accounting for it in the presence of oligopolistic behavior will lead to a misspecification of the gravity equation in changes. The hybrid model provides an interpretation of the structural change in the trade elasticity that occurs when we do not include such change in market power. This is summarized in the following proposition.

Proposition 5 ***Oligopoly-Augmented Gravity Equation and Partial Trade Elasticity***. *In the hybrid model with oligopolistic competition the gravity equation in changes is:*

$$d \log M_{cd}^{HC} = -\theta_{cd}^{HC} d \log T_{cd} + \delta_{cd}^{H}, \tag{2.2}$$

where the partial trade elasticity is:

$$\theta_{cd}^{HC} = (\sigma - 1)[1 + (1 - h_{cd}^{l})\Lambda_{cd}^{s} - h_{cd}^{l}\Psi_{cd}^{l}], \tag{2.3}$$

and δ_{cd}^{H} captures the change in multilateral resistance terms.[4]

[4]In this model, the multilateral resistance terms need to account for the imperfect pass-through

Proof: See Appendix A.2.5.

This expression shows that by including granular firms, the impact of trade costs has an extra margin, $h^l_{cd}\Psi^l_{cd}$, relative to a setting with monopolistic competition. In addition, note that θ^{HC}_{cd} is equal to k when there are no large firms, and the productivity distribution is unbounded as in Chaney (2008).[5] Moreover, $(\sigma-1)\Lambda^s_{cd}$ is the hazard function identified by Melitz and Redding (2015) and it is related to the marginal gain of adding an extra small firm. When there are few small foreign firms selling in the market, the trade elasticity increases because the marginal welfare gain is high.[6]

The novel object included in the trade elasticity is the last term, which I call the oligopolistic margin. This margin depends on two variables: the share of large foreign firms in d imports from c, h^l_{cd}, and the concentration measure, Ψ^l_{cd}. Given that $h^l_{cd}\Psi^l_{cd}$ is lower than one, the inclusion of oligopolistic firms makes trade flows less elastic to changes in trade costs but does not reverse the sign of their effect. The intuition is simple: large firms absorb changes in trade costs by modifying markups. The more important in terms of overall market shares and the more concentrated they are, the more they are able to do so.[7]

---

due to markups and bounded Pareto: $\delta^H_{cd} \equiv (1-h^l_{cd})d\log N_{cd} + \Big[1+(1-h^l_{cd})\Lambda^s_{cd}\Big]d\log E_p + (\sigma - 1)\big[1+(1-h^l_{cd})\Lambda^s_{cd} - h^l_{cd}\Psi^l_{cd}\big]d\log P$.

[5] The elasticity of imports with respect to tariffs is slightly different, given that tariffs are not paid by producers:

$$\theta^{HC,\tau}_{cd} = (\sigma-1) + (1-h^l_{cd})\frac{\sigma}{\sigma-1}\Lambda^s_{cd} - h^l_{cd}\Psi^l_{cd}$$

[6] Even though the marginal gain of new varieties decreases as more firms enter, it is always positive. In Feenstra and Weinstein (2017), the translog preferences add an extra term with a negative effect that they interpreted as crowding of the variety space.

[7] Fernandes et al. (2019) show that the intensive margin elasticity is increasing in firm size, which may seem to contradict that larger firms react less to changes in trade policy given that

2.3 Empirical Application

In this section, I apply the model to changes in trade policy in Colombia over the 2010-2013 period which led to the differential treatment of a set of countries. In this regard, I explicitly show the required identifying assumptions for obtaining the empirical equation.

2.3.1 Institutional Setting

I exploit a country-level change in the preferential treatment of exporters to Colombia from two types of events. First, Colombia implemented a unilateral trade liberalization (UTL) in 2010. The Colombian government argued that the country had a large inefficient dispersion in tariffs (cf. Torres and Romero, 2013). Next, Colombia signed significant Free Trade Agreements (FTAs) over the 2011-2013 period with Canada (2011), the US (2012), and the European Union (2013).

The UTL was a reform that covered most of the product spectrum. Exporting countries that faced this reduction were those receiving Most Favored Nation (MFN) status.[8] This reform was effective in decreasing average tariffs in approximately 5.8% from 2010 to 201.

Before 2010, Colombia only had agreements granting preferential access to

they modify their markups. However, their definition of the intensive margin elasticity refers to how much of bilateral trade can be explained by exports per firm at different percentiles. In this sense, my model assumes that the number of large firms and the share they explain can freely vary across bilateral flows, and therefore cannot be related to their setting.

[8] Latin American and Caribbean countries (LAC) were not reached by this reform given that most of them have multiple preferential schemes in place. I exclude all LAC countries from the analysis.

most Latin American and Caribbean (LAC) countries, but none to countries from the rest of world.[9] Therefore, any firm from countries outside LAC faced the MFN tariffs to sell in Colombia.[10][11] This changed at the beginning of the 2010 decade since Colombia signed FTAs with countries outside LAC that had a significant share of Colombian imports. In 2011, the Canada FTA entered into force, an agreement that represented 1% of total imports.[12] In 2012, the agreement with the US was put into force when the US Congress approved the bill after more than five years of negotiation. Imports from the US were 27% in 2010. Finally, the agreement with EU entered into force in 2013 and it represented 14% of Colombian imports in 2010. In sum, Colombia put into force FTAs with countries that represented 42% of its total imports. All these countries had MFN status before these agreements and would have faced the post-UTL tariffs were not they had the FTA. In comparison, non-LAC countries that were included in the UTL and did not end up having an agreement with Colombia represented 23% of total imports.

[9]These regional agreements are the Andean Community with Peru, Ecuador and Bolivia (founded in 1969), the ALADI with all South American countries and Mexico (1980), and with CARICOM (1994). In 2009 Colombia signed a Free Trade Agreement with Chile and the Northern Triangle (Guatemala, Honduras and El Salvador).

[10]I only consider countries that are members of the World Trade Organization (WTO) in this analysis.

[11]Colombian firms did have preferential access to developed countries such as the US and EU in subsets of products as part of the non-reciprocal tariffs schemes these countries offer to developing countries.

[12]In 2011 the agreement with EFTA countries entered into forced too. However, it was immediately effective only for Switzerland and Liechtenstein. It was effective for Iceland and Norway in 2015.

2.3.2 Identification

2.3.2.1 Estimating Sample

In order to conduct the analysis, I employ the subset of exporters that benefited from the UTL or signed an FTA with Colombia. Therefore I have two types of exporters that initially faced the same MFN tariff: those that ended up having FTAs and those that did not. For the reasons mentioned above, I do not include in the sample LAC countries, and neither do I include countries that got preferential status after 2013 to avoid heterogeneity in terms of the timing of the application.[13]

2.3.2.2 Empirical Equation

I employ the gravity equation presented in the previous section to estimate whether exporter-products with a relatively high concentration measure Ψ have a lower elasticity. To do so, I expand equation 2.2 and interpret it as a first-order approximation around an initial equilibrium:[14]

$$\begin{aligned}
\Delta \log M_{cp} &= [1 + (1 - h^l_{cp,t-1})\Lambda^s_{cp,t-1}]\Delta \log E_p - \\
&- (\sigma - 1)[1 + (1 - h^l_{cp,t-1})\frac{\sigma}{\sigma - 1}\Lambda^s_{cp,t-1} - h^l_{cp,t-1}\Psi_{cp,t-1}]\Delta \log \tau_{cp} + \\
&+ (\sigma - 1)[1 + (1 - h^l_{cp,t-1})\Lambda^s_{cp,t-1} - h^l_{cp,t-1}\Psi_{cp,t-1}]\Big[\Delta \log P_p -
\end{aligned}$$

[13]These are with EFTA (fully in force in 2015) and Korea (2016).

[14]I also include tariffs which were excluded for exposition in the previous section. Details of the derivation in Appendix A.2.5.

$$- \quad \Delta \log T_{cp} - \Delta \log w_c \Big] + (1 - h^l_{cp,t-1}) \Delta \log N^s_{cp} + v_{ip} \qquad (2.4)$$

where p indexes a products (HS at 6 digits level), T_{cp} is the ad-valorem exporter-product specific transport costs, τ_{cp} is the ad-valorem effectively applied tariff, E_p is expenditure on p, w_c are production costs in c, N^s_{cp} is the measure of potential small entrants, and v_{cp} is a mean zero approximation error.[15] Differences are taken with respect to $t-1$ which means that the initial market structure will determine how each flow reacts.

2.3.2.3 Identifying Assumptions

Including the exporter and product fixed effects implies that I use diff-in-diff variation to identify the effect. In this section I formally outline the identifying assumptions:

A1. Constant deep parameters σ and k across exporters, products and time; stationary $\Lambda^s_{cp} = \Lambda^s$ and $h^l_{cp} = h^l$.

A2. Exogenous exporter-specific production costs w_c relative to tariffs.

A3. Elasticity of substitution across products equal to one.

A4. Potential entrants are determined by a product-specific, exporter-specific and an idiosyncratic factor: $\log N^s_{cp} = \log N^s_p + \log N^s_c + \log \zeta^s_{cp}$, with $E(\log \zeta^s) = 0$.

Assumption A1 implies that variation across products does not come from different parameters but rather from different initial market structures and tariffs.

[15] Note that in Chapter 1 I used the term T_f to account for both T_{cp} and w_c.

This is a standard assumption in the literature. The stationary feature of Λ^s implies that the entry cutoff is sufficiently far from the upper productivity bound. In fact, being sufficiently far from that parameter implies that Λ tends to $\frac{k}{\sigma-1}-1$. Assuming an homogeneous h_l implies that actual variation in this variable will be captured by concentration. I show that this variable one or very close to one in most cases and test this restriction in the regression section.

Assumption A2 is done to focus on industry variables and avoid general equilibrium effects. Given the product level of aggregation I am employing, this assumption is reasonable (the HS at 6-digits includes approximately 5000 categories). Moreover, I am not including countries that are in the same region for which Colombia is potentially an important export destination.

Assumption A3 holds if the HS6 classification is identifying products that are not sufficiently close in the product spectrum. The functional form of the oligopolistic margin and therefore the augmented gravity equation depends on this assumption. However, this assumption is more likely to not hold when a single firm is close to being a monopolist within a product across all exporters. In that case, the competition the firm cares about is the one between products rather than within the same product.

In order to derive the empirical equation under the previous assumptions, note that the concentration measure affects all variables determining prices, including the price index P. This means that simply including fixed effects to control for changes in P and production costs will not be enough to account for the entire impact of the oligopolistic behavior. Therefore, we also need to allow for product and exporter-specific slopes relative to Ψ. Note that estimating the standard gravity equation in the presence of strategic behavior implies that the equation is misspecified because the original gravity equation omits the interaction between tariffs and initial market power. As a result, standard trade elasticity estimates are biased if there are oligopolistic firms.

Under the assumptions A1-A4, we get:

$$
\begin{aligned}
\Delta \log M_{cp} &= \alpha_{\tau}^{MC} \Delta \log \tau_{cp} + \alpha^{OC} \Psi_{cp,t-1} \Delta \log \tau_{cp} + \\
&+ \alpha_{T}^{MC} \Delta \log T_{cp} + \alpha^{OC} \Psi_{cp,t-1} \Delta \log T_{cp} + \\
&+ [\delta_p^I + \delta_p^S \Psi_{cp,t-1}] \\
&+ [\delta_c^I + \delta_c^S \Psi_{cp,t-1}] \\
&+ u_{cp} \qquad (2.5)
\end{aligned}
$$

where:

$$\alpha_{\tau}^{MC} = (1-\sigma)[1 + (1-h^l)\tfrac{\sigma}{\sigma-1}\Lambda^s] < 0$$

$$\alpha_{T}^{MC} = (1-\sigma)[1 + (1-h^l)\Lambda^s] < 0$$

$$\alpha^{OC} = -h^l(1-\sigma) > 0$$

$$\delta_p^I = (\sigma-1)[1 + (1-h^l)\Lambda^s \Delta \log P_p + [1 + (1-h^l)\Lambda^s] \Delta \log E_p + (1-h^l)\Delta \log N_p$$

$$\delta_p^S = (\sigma-1)h^l \Delta \log P_p$$

$$\delta_c^I = (1-\sigma)[1 + (1-h^l)\Lambda^s] \Delta \log w_c + (1-h^l)\Delta \log N_c$$

$$\delta_c^S = -h^l(1-\sigma)\Delta \log w_c$$

$$u_{cp} = (1-h^l)\Delta \log \zeta_{cp}^s + v_{cp}$$

where note that $E(u_{cp}) = 0$.[16]

To conclude the section, I explicitly show the variation I am using under this specification. For simplicity, let's define variables as differences with respect to the product average change as $\Delta \log \widetilde{M_{cp,t}} = \Delta \log M_{cp,t} - \overline{\Delta \log M_{.p,t}}$.

$$\begin{aligned}
\Delta \log \widetilde{M_{cp,t}^{FTA}} - \Delta \log \widetilde{M_{c'p,t}^{MFN}} \equiv \; & \alpha_\tau^{MC}[\Delta \log \widetilde{\tau_{cp}^{FTA}} - \Delta \log \widetilde{\tau_{c'p}^{MFN}}] - \\
- \; & \alpha^{OC}\Psi_{cp}^{FTA}[\Delta \log \widetilde{\tau_{cp}^{FTA}} - \Delta \log \widetilde{\tau_{c'p}^{MFN}}] - \\
- \; & \alpha^{OC}\Delta \log \widetilde{\tau_{cp}^{MFN}}[\Psi_{cp}^{FTA} - \Psi_{c'p}^{MFN}] \qquad (2.6)
\end{aligned}$$

The first term in equation 2.6 shows the variation that we would interpret to be capturing if we assume the standard monopolistic model. This implies a constant elasticity and therefore the pass-through is constant. The second term captures how much of the extra decrease in tariffs to FTA countries is related to an increase in markups. As a consequence, it has the opposite sign of the first term.

The last term captures initial differences in concentration that would cause a differential effect of a change in tariffs for FTA countries relative to UTL. The sign of this term depends on which set of countries is relatively more concentrated. If

[16] Some papers suggest that the level of concentration can influence the change in tariffs over a period of trade liberalization (e.g. Ferreira and Facchini, 2005). Note that if this is the case, the specification in equation 2.5 controls for that possibility as long as the initial level of concentration captures the relevant information for future changes in tariffs.

UTL countries are so, then this term is positive because the decrease in tariffs will cause the relative markups of UTL firms to increase and thus part of the demand is reallocated towards FTA countries, increasing their exports. This is the key term capturing how heterogeneous the first-order impact of tariffs can be when we have a uniform change in tariffs.

2.3.3 Descriptive Section

In this section I describe the data I employ for the empirical analysis and descriptive statistics.

2.3.3.1 Data

The main source of information is customs data from DANE (National Administrative Department of Statistics by its Spanish acronym) that covers imports from 2004 to 2018. This information is detailed since it includes all transactions recorded in administrative custom data between Colombian and foreign firms. The most relevant information it includes for this analysis are total imports in CIF and FOB terms, quantity, weight, HS10 digits product category, an importer identifier, the exporting country, the city and country of the seller, and the effectively applied tariff. This detailed data helps me to construct import data aggregated to product-exporter-year to line it up with the theoretical predictions.

Given that I do not exactly observe the foreign exporter identifier, I construct a proxy by employing information about foreign firms included in the database. To validate this information I employ the Export Dynamic Database (EDD) which provides the number of firms and other firm-based information for a subset of exporters disaggregated by importer and HS2 product levels.

I also employ the Annual Manufacturing Survey (EAM is its Spanish acronym) also collected by DANE to do robustness checks related to the definition of market shares. This data is an annual survey of all the manufacturing establishments with more than 10 employees. The database is at the establishment level and it includes the total valor of production, value added, employees, among other information.[17]

Finally, I also employed information from the WTO and Baier and Bergstrand (2007) to classify exporters based on their type of agreement it has with Colombia.

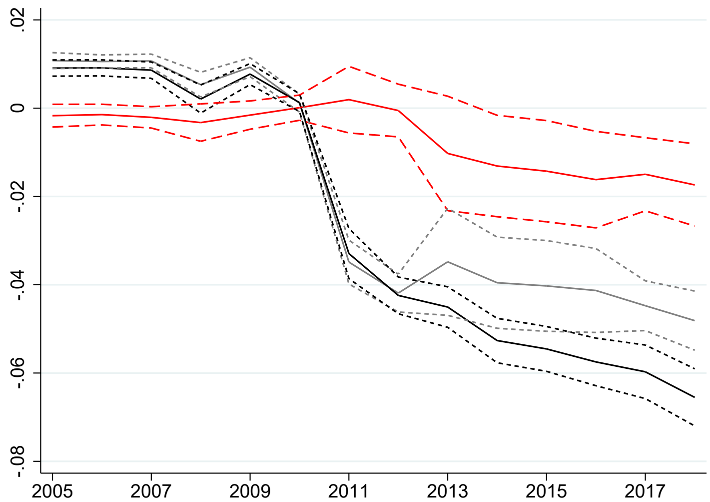
2.3.3.2 UTL and FTA Applied Tariffs and Aggregate Colombian Imports.

We can observe the UTL and FTA change in trade policy by using the effectively applied tariff included in the DANE import data. Under the UTL, all countries faced the same decrease in tariffs for each product. In addition, those with an FTA with Colombia had an extra decrease that was negotiated in each specific agreement.

In Figure 2.1 we can observe that both UTL and FTA countries faced a sig-

[17]Establishments are classified by the Colombian version of the ISIC Rev 3 and Rev 4 classification, depending the year. I match this information to the import data at the HS 6-digit level by bringing the EAM data to the international version of the ISIC Rev 3 classification. Given that ISIC is a 4-digit industry classification that is more aggregated that the HS 6-digits classification I assumed that all the HS 6-digits products within a ISIC 4-digit industry had the same import penetration ratio.

Figure 2.1: Average log Change in Tariffs Faced by UTL and FTA Exporters and Relative Change between UTL and FTA Exporters.



Black: FTA, Gray: UTL, Red: Difference

Note: FTA and UTL lines are the year-specific coefficients from the regression $\log \tau^{r}_{cpt} = \sum_{r \in UTL,FTA} \sum_{t=2007}^{2016} \beta^{r}_{t} + \delta_{cp} + \epsilon_{cpt}$ where $\log \tau^{r}_{cpt}$ is the effectively ad-valorem tariff paid by exporter c in 6-digits HS product p, where r could be the UTL and FTA regime, and $\delta_{c}p$ is a exporter-HS6 product level fixed effect. The difference line are the year-specific coefficients from the regression $\log \tau^{r}_{cpt} = \sum_{t=2007}^{2016} \beta_{t} + \sum_{t=2007}^{2016} \beta^{FTA}_{t} 1\{c \in FTA\} + \delta_{cp} + \epsilon_{cpt}$. Both regressions weighted by imports at the cpt level. Robust standard errors.

nificant decrease in average tariffs, which difference was significant after 2014.

In order to establish a benchmark for the analysis, I employ the 2007-2017 time period. First, I use 2007 to avoid using the 2008-2010 period in which global trade collapsed due to the Great Recession. As mentioned, this global crisis was the trigger for the 2010 UTL in Colombia. Moreover, FTA negotiations usually take years. Therefore, using a year that is not close to the entry into force of such agreements has the advantage that firms probably did not anticipate the future agreement. Second, I use 2017 because it is at a reasonable distance from the last considered agreement that entered into force (EU in 2013). Given that I study the effect through prices, and tariffs progressively decline under FTAs, using the first year (i.e. 2014) after the agreements may not provide the additional variation required for the analysis. This can be seen in Figure 2.1 as tariffs continued declining for FTA countries. I do robustness checks by using alternative time periods.

2.3.3.3 Firm Proxy

The import database provided by DANE does not include an identifier nor a name for the foreign firm exporting to Colombia. Given that capturing firm level decisions is important for this paper since it directly links to aggregate trade flows elasticities and flows, I construct a firm identifier from the available information in the data. I argue that the city and country of the seller can be exploited with that goal. The location of this firm can differ from the country in which production takes place. Therefore, gravity forces act as usual but I can use the extra information from the firm location to proxy for firms (i.e. trade costs are determined by the exporting and importing country since the goods have to physically be moved between these two countries, and production costs are determined by the supplier access of such exporter). The assumption is that the seller is the price-setter, not the producer.

In order to validate this proxy, I use the EDD which includes the number of firms and concentration measures such as the HHI and the share of top firms for each exporter-importer-HS2-year for all exporter-years included in the sample. The proxy firm indicator delivers high correlation between the DANE data and the EDD. Further details in Appendix C.

2.3.3.4 Descriptive Statistics

In order to contextualize the regression results, I summarize the main variables in Table 2.1.

Table 2.1: Descriptive Statistics. Baseline Sample (2007-2017).

	All		FTA		UTL	
	Average	s.d.	Average	s.d.	Average	s.d.
$\Delta \log M$	0.357	2.421	0.209	2.347	0.607	2.522
$\Delta \log \tau$	-0.066	0.045	-0.071	0.046	-0.058	0.041
$\Delta \log T$	-0.028	0.123	-0.023	0.122	-0.037	0.125
Share of Top 4 Firms (t-1)	0.930	0.134	0.935	0.128	0.922	0.145
Ψ_{t-1} (Top 4 Firms)	0.086	0.151	0.088	0.156	0.083	0.144
HHI_{t-1} (Top 4 Firms)	0.642	0.273	0.645	0.270	0.637	0.277
HHI_{t-1}	0.604	0.314	0.608	0.309	0.596	0.321
N	26,142		16,422		9,720	

Variables in changes calculated for the 2007-2017 period. Variables evaluated at $t-1$ correspond to 2007. Top and bottom 0.01% of variables in changes not considered.

The first salient result is that imports from UTL countries increased significantly more. In fact, the average growth rate is almost three times bigger for these countries. It is worth noting that China is included in this sample and imports from this country increased more than three times over the 2007-2017 period. However, not including China does not change the fact that UTL countries grew more. One potential factor explaining it may be the higher decrease in transport costs measured by the difference between CIF and FOB import valuation. In the table this is shown by $\Delta \log T$, where T is calculated as an ad-valorem trade cost. I use this measure in the regression analysis as a control.

The average extra decrease in the effectively applied tariffs for FTA countries was 1.3 percentage points. However, average transport cost decrease 1.5 percentage points more in the case of UTL. The model predicts that the relative increase in tariffs could have been neutralized by the opposite change in transport costs. Hence, this could help to explain why UTL countries grew more.

In terms of the relative market power, the unobserved behavior of firms implies that I have to assume which firms behave as large and which as small. In that regard, I define as granular firms the top four within an exporter-product.[18] Therefore, I construct the Ψ for the top four firms and assume that $\sigma = 4$, a value that is centered within the range of what other papers have estimated.

Using the Ψ constructed as explained, we can see that FTA countries had a lower pass-through overall, with an absorption of 0.088 versus 0.083 for UTL countries. This could also have helped UTL countries to increase their relative exports to Colombia. As it can be seen in equation 2.6, when $\Psi^{FTA} > \Psi^{UTL}$, the impact of a decrease in UTL tariffs is to increase UTL countries' exports relative to those from FTA countries.

Note that the HHI and the share of top four firms give mixed evidence on which set of countries was initially more concentrated. In addition, note that the average share of top firms is 0.95, which shows the high granularity of the data at the exporter-product level. In fact, if we assume that this variable is a proxy for the share of granular firms, h^l_{cp}, we would conclude that about 40% of the exporter-products have four or less firms selling to Colombia and about 75% of them would have more than 90% of sales concentrated in the top four firms.

[18] The share of top four firms is another widely used measure of concentration. For instance, Autor et al. (2017) use both the share of top four and twenty firms to characterize the increase in US concentration.

2.3.4 Regression Results

2.3.4.1 Baseline Results

The theory predicts that changes in tariffs will be partially absorbed by the industry structure of the affected exporter under A1-A4 assumptions. Without assuming oligopolistic behavior, we would estimate the effect of tariffs without considering the initial concentration. In column 1 of Table 2.2 I estimate this equation. The elasticity of imports with respect to tariffs is negative and significant as predicted by the theory and its magnitude is in line with the literature.

Table 2.2: Baseline Results. Monopolistic Competition and Hybrid Competition.

	MC model	Hybrid Model	Hybrid Model
	(1)	(2)	(3)
$\Delta \log \tau_{cp}$	-5.294***	-4.690***	-4.064***
	(0.815)	(0.959)	(0.902)
$\Delta \log \tau_{cp} \times \Psi_{cp,t-1}$			2.254**
			(1.119)
$\Delta \log T_{cp}$	-2.788***	-2.394***	-2.474***
	(0.222)	(0.232)	(0.261)
$\Delta \log T_{cp} \times \Psi_{cp,t-1}$			-0.206
			(0.336)
Exporter Fixed Effect	Yes	Yes	Yes
HS6 Fixed Effect	Yes	Yes	Yes
Exporter-specific Ψ Slopes	No	Yes	Yes
HS6-specific Ψ Slopes	No	Yes	Yes
Observations	26,142	26,142	26,142
R-squared	0.272	0.427	0.428
Adjusted R-squared	0.166	0.230	0.231
Restriction p-value hˆl = 1 ($(\sigma-1)h^l = 3$)	-	-	0.109
Restriction p-value hˆl = 0.9 ($(\sigma-1)h^l = 2.7$)	-	-	0.10

OLS Regressions. Variables in changes calculated for the 2007-2017 period. Variables evaluated at $t-1$ correspond to 2007. Top and bottom 0.01% of variables in changes not considered. Standardized Ψ. MC model: Exporter and HS6 fixed effects. Hybrid model: MC model fixed effects plus exporter and HS6-specific slopes relative to Ψ. Standard errors clustered at HS2-type of Colombian policy treatment FTA-MFN status (354 clusters). Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

However, the granular feature of exporters suggests that firms may have exploited their size to rise markups. In column 2, I interact the product and exporter fixed effects by industrial concentration as defined by the model in order to have a benchmark for the baseline result. In this case, the tariff elasticity is influenced by the underlying distribution of Ψ. Note that both the R^2 and adjusted R^2 increase by about 50%, showing that the hybrid model has more explanatory power.

Column 3 presents the baseline results where I also interact tariffs and transport costs by a demeaned Ψ. The elasticity of imports with respect to tariffs at the mean Ψ is -4.064, whereas an increase of one standard deviation of this variable decreases the elasticity by 55%. This shows that the oligopolistic margin has a strong influence on the trade elasticity.

In terms of the effect of transport costs on imports, the impact at the mean is significant and the elasticity is -2.474. However, the interaction with the standardized Ψ is insignificant. Given that there can be other factors affecting this variable and it may be observed with measurement error, I will focus on analyzing the tariff elasticity henceforth.[19][20]

Assumption A1 imposes h^l to be constant across countries. Three quarters of the flows have a share of top four firms that is higher than 90%. Therefore, I test whether this variable can be assumed to be constant using the baseline specification. Given that I assume that $\sigma = 4$ when constructing Ψ I test the restriction $\alpha^{\hat{OC}} = 3 * h_l$. I cannot reject the null hypothesis of $h_l = 1$ and $h_l = 0.9$, which means that

[19] A potential source of measurement error may be its aggregation. I aggregate this variable by taking the simple average across transactions within each exporter-product after eliminating outliers. Other ways of aggregating this variable yield similar results.

[20] As long as tariffs are not correlated with export-product specific transport costs, the tariff coefficient is unbiased.

there is no evidence of a misspecified restriction.

2.3.4.2 Robustness

In order to construct Ψ I had to assume which firms I treat as large. Therefore, I use different definitions of Ψ to assure that there is nothing specific about the way I am construction the variable. In Table 2.3 I include all the different definitions of Ψ I employ.

Table 2.3: Robustness: Concentration Measure Definition.

	Top firm	Top 20 firms	W/domestic firms	Overall share $> 1\%$	Variable σ	Simple average
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log \tau_{cp}$	-4.064***	-4.137***	-3.448***	-4.274***	-4.214***	-3.877***
	(0.898)	(0.909)	(0.962)	(0.896)	(0.946)	(0.897)
$\Delta \log \tau_{cp} \times \Psi_{cp,t-1}$	2.294**	1.929*	3.135**	1.766	2.374**	3.012**
	(1.113)	(1.091)	(1.442)	(1.081)	(1.136)	(1.303)
$\Delta \log T_{cp}$	-2.489***	-2.450***	-2.409***	-2.459***	-2.300***	-2.466***
	(0.261)	(0.258)	(0.270)	(0.256)	(0.249)	(0.264)
$\Delta \log T_{cp} \times \Psi_{cp,t-1}$	-0.226	-0.204	0.032	-0.147	0.281	-0.176
	(0.331)	(0.337)	(0.352)	(0.320)	(0.276)	(0.361)
Observations	26,142	26,142	24,486	26,142	25,299	26,142
R-squared	0.425	0.433	0.414	0.423	0.422	0.418
Mean Ψ	0.101	0.0807	0.0501	0.0825	0.0708	0.0563
s.d. of Ψ	0.172	0.146	0.106	0.151	0.146	0.104

OLS Regressions. Variables in changes calculated for the 2007-2017 period. Variables evaluated at $t-1$ correspond to 2007. Top and bottom 0.01% of variables in changes not considered. Standardized Ψ. Column 1: Ψ calculated using the top firm within the exporter-product. Column 2: Ψ calculated using the top 20 firms within the exporter-product. Column 3: Ψ calculated using the top 4 firms, including the imputed share of domestic firms. Column 4: Ψ calculated only for firms exceeding the $> 1\%$ in terms of overall market share (i.e. considering all origins). Column 5: Ψ constructed by using the HS6 level median σ from Broda and Weinstein (2006). Column 6: Constructing Ψ by simple averaging across firms rather than using the weighted average. Exporter and HS6 fixed effects and exporter and HS6-specific slopes relative to Ψ included. Standard errors clustered at HS2-type of Colombian policy treatment FTA-MFN status (354 clusters). Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Columns 1 and 2 use the top firm and top twenty firms to calculate Ψ. As expected, none of them substantially change the baseline conclusions. When I use the top firm I get a similar coefficient to the baseline, showing that the largest firm provides useful variation to identify the oligopolistic margin. Using the top twenty firms marginally decreases the coefficient and makes it noisier. The decrease in its magnitude and precision may suggest that using the top twenty firms may classify small firm as large firms. In spite of this, it is statistically the same as the baseline coefficient.

To construct Ψ, I use the firm-specific market share across all exporters. However, foreign exporters also compete with domestic firms. In column 3, I use the market share of exporters taking into account also domestic sales imputed to those products.[21] In this case, both $\alpha^{\hat{M}C}$ and $\alpha^{\hat{O}C}$ increase. As a result, the impact of an increase in a s.d. in Ψ is relatively high (90%).

Assuming that the top four firms behave oligopolistically across all exporters and products can also be a strong assumption. As a result, I alternatively define granular firms as those having more than 1% of total Colombia imports in that product across all exporters. Column 4 shows that in this case, the oligopolistic margin has the right sign and similar magnitude to the baseline but is marginally insignificant.

Another assumption I make to construct Ψ is a fixed σ. As a robustness I use the Broda and Weinstein (2006) estimation of elasticities of substitutions for the US at the HS 10 digits level and take the median within each HS 6 digits level. Column 5 shows the results using this estimated parameters. Estimates are very similar to the baseline.

[21] I employ the EAM to calculate domestic sales. However, the mismatch and different levels of classifications between the domestic industry data and the custom product level data implies that I am potentially introducing error into this measure.

Another potential issue is capturing some sort of mechanical correlation when taking the weighted average of the markup equilibrium responses. I rule this out by taking the simple average. Column 6 shows that results are robust to this.

The assumption of having exporter-specific production costs may be strong if different industries use inputs with different intensities. Therefore, I relax this assumption by controlling for exporter-HS2 fixed effects. Columns 2 of Table 2.4 shows that the oligopolistic margin is robust to such control.

Table 2.4: Robustness: Alternative Specifications.

	(1)	(2)	(3)	(4)
$\Delta \log \tau_{cp}$	-4.064***	-4.197***	-5.569***	-6.136***
	(0.902)	(1.101)	(0.974)	(1.012)
$\Delta \log \tau_{cp} \times \Psi_{cp,t-1}$	2.254**	3.992**		
	(1.119)	(1.662)		
$\Delta \log \tau_{cp} \times$ High $\Psi_{cp,t-1}$ indicator			3.282*	2.480
			(1.734)	(1.687)
$\Delta \log T_{cp}$	-2.474***	-2.155***	-2.511***	-2.485***
	(0.261)	(0.281)	(0.230)	(0.236)
$\Delta \log T_{cp} \times \Psi_{cp,t-1}$	-0.206	0.302		
	(0.336)	(0.471)		
$\Delta \log T_{cp} \times$ High $\Psi_{cp,t-1}$ indicator			-0.179	0.164
			(0.492)	(0.543)
Exporter fixed effects and Ψ slopes	Yes	No	No	No
Exporter-HS2 fixed effects and Ψ slopes	No	Yes	No	No
HS6 fixed effects and Ψ slopes	Yes	Yes	No	No
Exporter-Top Ψ indicator fixed effects	No	No	Yes	No
Exporter-HS2-Top Ψ indicator fixed effects	No	No	No	Yes
HS6-Top Ψ indicator fixed effects	No	No	Yes	Yes
Observations	26,142	25,596	24,703	23,640
R-squared	0.428	0.556	0.348	0.440

OLS Regressions. Variables in changes calculated for the 2007-2017 period. Variables evaluated at $t-1$ correspond to 2007. Top and bottom 0.01% of variables in changes not considered. Standardized Ψ. Exporter and HS6 fixed effects and exporter and HS6-specific slopes relative to Ψ included. High Ψ indicator captures the top quartile of the distribution of Ψ_{t-1}, where the 75th percentile is 0.095. Standard errors clustered at HS2-type of Colombian policy treatment FTA-MFN status (354 clusters). Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Another potential issue may be the high number of interactions in which Ψ is involved given that it could be inflating the coefficient of interest due to potentially high collinearity. To rule out such scenario I construct an indicator that takes the value of one when the exporter-product flow is in the top quartile of the distribution of Ψ.[22] I use this statistic and not the median given that the distribution of Ψ is positively skewed.[23]

In columns 3 and 4 of Table 2.4 I interact the change in tariffs and all the fixed effects by the indicator to capture the two potentially different levels of the oligopolistic margin. In column 3 I use the baseline specification and find a positive and significant effect. In column 4 I also interact the baseline fixed effects by HS2 products. The result is marginally insignificant but it has the same sign and magnitude. This shows that the magnitude of the baseline estimations are not explained by potential collinearity.

Table 2.5: Robustness: Alternative Time Periods.

	2006-2016	2007-2017	2008-2018
	(1)	(2)	(3)
$\Delta \log \tau_{cp}$	-2.012***	-4.059***	-3.837***
	(0.775)	(0.903)	(0.724)
$\Delta \log \tau_{cp} \times \Psi_{cp,t-1}$	2.570***	2.255**	2.684**
	(0.909)	(1.120)	(1.198)
$\Delta \log T_{cp}$	-2.479***	-2.474***	-2.297***
	(0.244)	(0.261)	(0.310)
$\Delta \log T_{cp} \times \Psi_{cp,t-1}$	-0.317	-0.206	-0.045
	(0.403)	(0.336)	(0.383)
Observations	24,416	26,142	26,473
R-squared	0.448	0.428	0.427

OLS Regressions. Variables in changes calculated for the period noted on the column header. Variables evaluated at $t-1$ correspond to the base period of the change. Top and bottom 0.01% of variables in changes not considered. Standardized Ψ. Exporter and HS6 fixed effects and exporter and HS6-specific slopes relative to Ψ included. Standard errors clustered at HS2-type of Colombian policy treatment FTA-MFN status (354 clusters). Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

[22] The 75th percentile of the Ψ distribution is 0.095.

[23] The average Ψ for the three lower quartiles is 0.019 whereas in the case of the top quartile it is 0.29. Its skewness is 2.7.

Another potential issue may be the chosen baseline period. In Table 2.5 I show that I get similar estimates when I use the 2006-2016 and 2008-2018 time periods.

2.3.4.3 Endogenous Trends

Initial concentration as captured by Ψ can be correlated with import growth. For instance, young firms can find more ground for growth in foreign markets in relatively less concentrated and protected industries. As a result, the coefficients can be capturing a different relationship not necessarily related to the oligopolistic margin.

In this regard, finding a valid instrument would be the first best for addressing such endogeneity. However, the theoretical model shows that we need to account for all the different product and exporter-specific absorption caused by oligopolistic behavior, which is the reason why I include the product and exporter-specific slopes. This means that in the case of finding an instrument for Ψ we need to instrument all the slopes as well. This is unfeasible given the number of interaction it implies.

I follow a different approach to deal with potential endogeneity. I assume that product and exporter-specific import growth is linear over the 2004-2017 period of time and stack two annualized differences, 2004-2007 and 2007-2017. Doing so allows me to control for exporter-product fixed effects.

Table 2.6: Deviations from Linear Trends. Monopolistic Competition and Hybrid Competition.

	MC model	Hybrid model	Hybrid model
	(1)	(2)	(3)
$\Delta \log \tau_{cpt}$	-6.058***	-4.719***	-2.199*
	(0.966)	(1.069)	(1.259)
$\Delta \log \tau_{cpt} \times \Psi_{cp,t-1}$			5.816***
			(2.053)
$\Delta \log T_{cpt}$	-2.038***	-1.072***	-0.465
	(0.263)	(0.232)	(0.359)
$\Delta \log T_{cpt} \times \Psi_{cp,t-1}$			1.219*
			(0.680)
Observations	39,436	39,436	39,436
R-squared	0.568	0.782	0.783

OLS Regressions. Variables in changes stacked calculated and annualized for the 2007-2017 and 2004-2007 period. Variables evaluated at $t-1$ correspond to 2004 and 2007. Top and bottom 0.01% of variables in changes not considered. Standardized Ψ. MC model: Exporter-year, HS6-year and exporter-HS6 fixed effects. Hybrid model: MC model fixed effects plus exporter-year and HS6-year specific slopes relative to Ψ. Standard errors clustered at HS2-type of Colombian policy treatment FTA-MFN status (354 clusters). Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In Table 2.6 I reproduce Table 2.2 with this specification. In column 1, I show that both the tariff and transport cost elasticity we would get in the standard specification are marginally higher although statistically the same as in Table 2.2. In column 3 I confirm that the oligopolistic margin is not explained by differential exporter-product linear trends. In addition, there is also evidence for the oligopolistic margin in the transport cost elasticity, which may suggest that controlling for these trends is especially relevant on a potentially endogenous variable.

2.3.4.4 Channels

The identified effect captures the total exporter-specific pass-through. However, I can decompose this variable to identify the different channels that play a role in the first order impact of tariffs on imports due to oligopolistic behavior. Note that the measure Ψ is a function of large firms' market share, $s^l_{cp} = s_{cp}h^l_{cp}$, and the distribution of shares, $\{z_{cp,i}\}$. Hence, we can decompose it as follows:

$$\Psi = \Psi_{\mathcal{M}} + \Psi_{\mathcal{C}} + \Psi_{\mathcal{N}} \tag{2.7}$$

where:

- $\Psi_{\mathcal{M}} \equiv \Psi(s^l_{cp}, \{z_{cp,i}\}) - \Psi(1, \{z_{cp,i}\})$ accounts for the *market power shifter*,
- $\Psi_{\mathcal{C}} \equiv \Psi(1, \{z_{cp,i}\}) - \Psi(1, 1/N_{cp})$ accounts for the *conditional firm concentration*,
- $\Psi_{\mathcal{N}} \equiv \Psi(1, 1/N_{cp})$ accounts for the *granular extensive margin.*

Table 2.7: Oligopolistic Channels.

	(1)
$\Delta \log \tau_{cp}$	-2.567**
	(1.116)
$\Delta \log \tau_{cp} \times \Psi_{\mathcal{M},cp,t-1}$	8.896***
	(2.746)
$\Delta \log \tau_{cp} \times \Psi_{\mathcal{C},cp,t-1}$	3.846**
	(1.641)
$\Delta \log \tau_{cp} \times \Psi_{\mathcal{N},cp,t-1}$	8.533***
	(2.763)
$\Delta \log T_{cp}$	-2.090***
	(0.374)
$\Delta \log T_{cp} \times \Psi_{\mathcal{M},cp,t-1}$	-0.509
	(0.915)
$\Delta \log T_{cp} \times \Psi_{\mathcal{C},cp,t-1}$	-0.147
	(0.501)
$\Delta \log T_{cp} \times \Psi_{\mathcal{N},cp,t-1}$	-0.264
	(0.859)
Observations	26,609
R-squared	0.612
$\Psi_{\mathcal{M}}$ average	-0.695
$\Psi_{\mathcal{M}}$ s.d.	0.233
$\Psi_{\mathcal{C}}$ average	0.115
$\Psi_{\mathcal{C}}$ s.d.	0.119
$\Psi_{\mathcal{N}}$ average	0.666
$\Psi_{\mathcal{N}}$ s.d.	0.204

OLS Regressions. Variables in changes calculated for the 2007-2017 period. Variables evaluated at $t-1$ correspond to 2007. Top and bottom 0.01% of variables in changes not considered. Standardized Ψ. Exporter and HS6 fixed effects and exporter and HS6-specific slopes relative to all Ψ included. Standard errors clustered at HS2-type of Colombian policy treatment FTA-MFN status (354 clusters). Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In Table 2.7 I show the results when I interact the tariff and transport cost change with the variables capturing the different oligopolistic channels. The three channels are significant and imply a larger effect than in the baseline. A potential reason is multicollinearity given that the number of interactions significantly increased due to the interactions with the exporter and product fixed effects. However, the sign and magnitudes are stable across alternative specifications, which indicates that they may be capturing the fundamental channels behind overall industrial concentration.

2.4 Quantitative Implications

In this section, I analyze the quantitative impact of the oligopolistic margin through industrial concentration. First, I show that employing the hybrid model is especially relevant in cases of high concentration. Second, I calculate the average and aggregate effect of tariffs to show the aggregate importance of the oligopolistic margin. Third, I focus on the differential concentration across countries to draw policy implications.

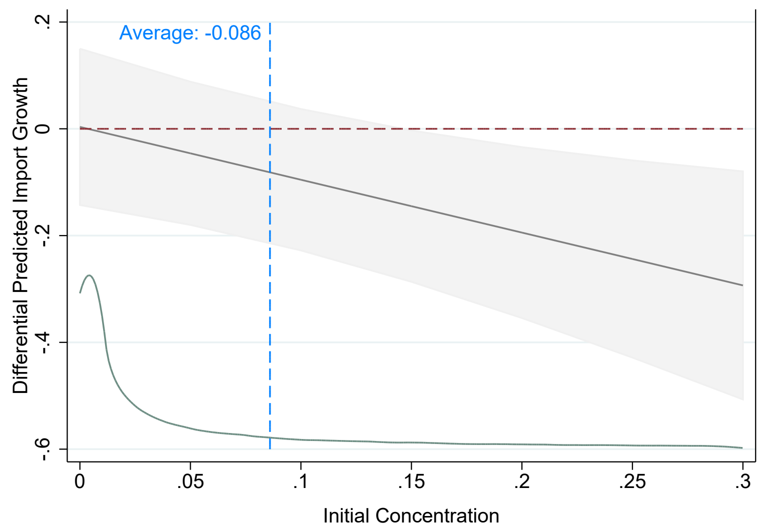
2.4.1 Monopolistic Competitive Model vs. Hybrid Model

The trade elasticity is constant in the standard monopolistic competitive model where firms are sizeless and their distribution follows an unbounded Pareto. On the contrary, the trade elasticity can be potentially heterogeneous when there are granular firms and their country-specific distribution of market shares differ. To test if the hybrid model predictions differ from the standard model, I construct the following:

$$\Delta \widehat{\log M}^{HC} - \Delta \widehat{\log M}^{MC} = \left[\left[\widehat{\alpha_\tau^{HC,I}} - \widehat{\alpha_\tau^{MC}}\right] + \widehat{\alpha_\tau^{HC,S}}\Psi_{cp}\right]\overline{\Delta \log \tau} \tag{2.8}$$

This equation delivers a distribution of predicted import growth that depends on the underlying distribution of industrial concentration. In Figure 2.2, I include both the distribution of Ψ and the differential predicted import growth at different levels of Ψ and the average log tariff change (-0.066). Specifically, I put the difference between predicted import growth in the hybrid model and predicted growth in the monopolistic model, in the y-axis, and initial concentration as measured by Ψ in the x-axis.

Figure 2.2: Predicted Import Growth Differential Due to Granularity by Initial Concentration.



Relationship between the differential predicted import growth due to changes in tariffs using baseline estimates from Table 2.2, Column 3 (monopolistically competitive model with no granular firms minus hybrid model with granular firms). Calculations at average $\Delta \log \tau = -0.066$. Confidence intervals at 90%. Kernel density of Ψ truncated at $\Psi < 0.3$ for clarity of exposition (the 91th percentile).

Figure 2.2 shows that at average $\bar{\Psi}$ (0.086), both models yield the same predicted import growth. This is consistent with the extensive literature showing the goodness of fit of the gravity equation since it suggests we could ignore this channel in some settings. When initial concentration is higher than 0.147, the hybrid model delivers significantly lower import growth. In terms of the sample employed, it means that for the top 19% exporter-industry import flows, the impact of trade liberalization will be lower than what a standard gravity equation microfounded by perfect and monopolistic competitive models would estimate. In a context where export concentration seems to be growing, considering the differential behavior of large firms may become increasingly necessary.

2.4.2 Average and Aggregate Effect

In this section I calculate the partial average and aggregate effect of changes in tariffs over the 2007-2017 period. In doing so, I separate the effect attributed to the extensive and intensive margin, and the effect attributed to the oligopolistic margin.

The average effect is calculated as follows:

$$\overline{\Delta \log M^{HC,ave}} = \widehat{\alpha_\tau^{HC,I}} \overline{\Delta \log \tau} + \widehat{\alpha_\tau^{HC,S}} \overline{\Psi \Delta \log \tau} \tag{2.9}$$

where the first term captures the average intensive and extensive margin, and the second term the average oligopolistic margin. In Table 2.8 I show that the oligopolistic margin reduces predicted import growth by about 8 log points, which is 24% less than what the intensive and extensive margins predict.

Table 2.8: Impact of Tariffs Reduction in the Hybrid Model (log points).

	Intensive and Extensive Margins	Oligopolistic Margin	Total Effect
Average	35.5	-8.44	27.1
Aggregate	28.0	-18.1	9.91

Calculations made by using baseline results in Table 2.2, Column 3 using non-standardized coefficients.

To calculate the aggregate effect, I use initial exporter-product imports weights in 2007, $\rho_{cp} = \frac{M_{cp,2007}}{\sum_{cp=1}^{n} M_{cp,2007}}$, where n is the number of included observations:

$$\overline{\Delta \log M^{HC,agg}} = \widehat{\alpha_\tau^{HC,I}} \sum_{cp=1}^{n} \rho_{cp} \Delta \log \tau_{cp} + \widehat{\alpha_\tau^{HC,S}} \sum_{cp=1}^{n} \rho_{cp} \Psi_{cp} \Delta \log \tau_{cp} \tag{2.10}$$

where the first term captures the aggregate intensive and extensive margin, and the second term the aggregate oligopolistic margin. As shown in Table 2.8, the aggregate total affect is a third part of the average effect. This difference is mostly explained by the importance of the oligopolistic margin, which reduces the predicted import growth by 18 log points in this case.

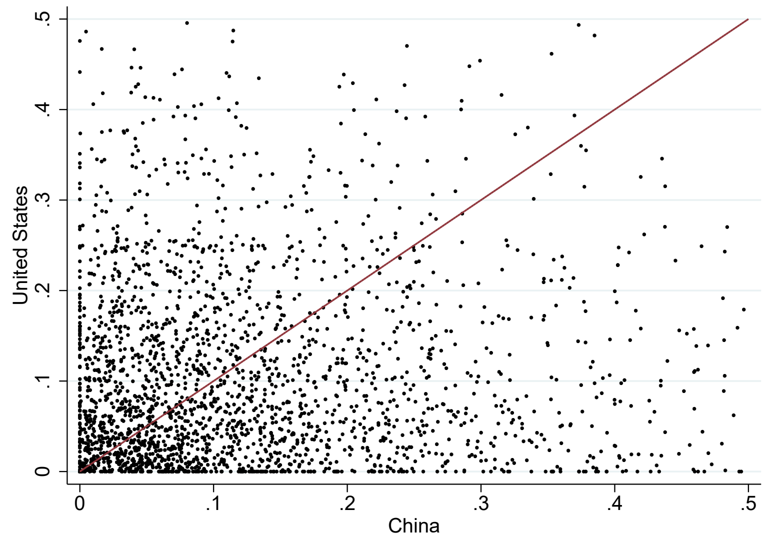
2.4.3 Differential Impact Due to Concentration

When tariffs uniformly decrease for all exporters, the model predicts that the impact will be heterogeneous depending on the initial aggregate market power of exporters. In this section I quantify the differential trade elasticity and import growth between exporters with high and low concentration.

In Figure 2.3, I plot the relationship between product-specific industrial concentration in exports from China and the US to Colombia in 2007. The figure shows that this variable has substantial variation as most dots are scattered along the entire plane and do not seem to cluster around the 45 degree line.

In order to compare differences in industrial concentration, recall that the change in imports can be written as follows based on the decomposition of the oligopolistic margin presented in the previous section:

Figure 2.3: Industry-level Conditional Industrial Concentration in Colombia. China vs. USA (2007).



Scatter plot of HS6-specific $\Psi_{p,CH}$ (China) and $\Psi_{p,US}$ (US) in 2007. The US has more market power in products above the 45 degree line and China does in products below the 45 degree line.

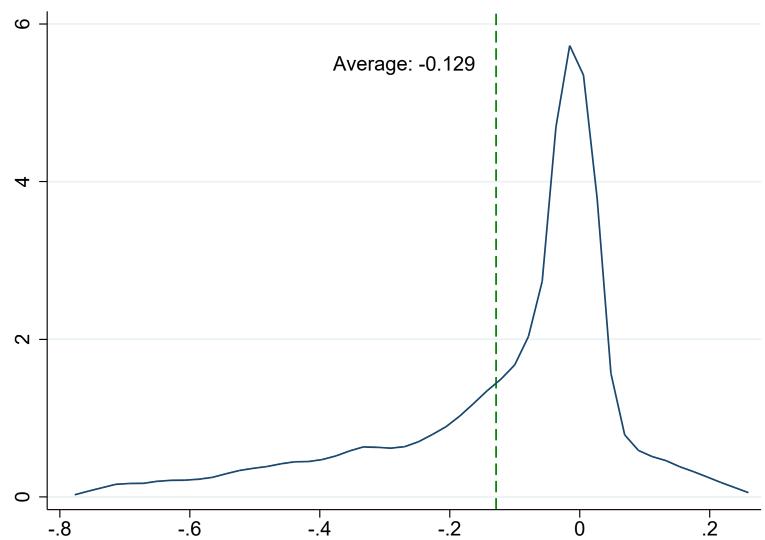
$$\widehat{\Delta \log M} = \Delta \log \tau_p \Big[\widehat{\alpha^{MC}} + \widehat{\alpha^{OC}} [\Psi_{\mathcal{M}} + \Psi_{\mathcal{C}} + \Psi_{\mathcal{N}}] \Big] \tag{2.11}$$

To isolate the heterogeneous impact of trade policy when there are differences in the market structure of exporters, I calculate the product-specific differential elasticity between high and low concentration exporters using the conditional concentration term $\Psi_{\mathcal{C}}$. I calculate the elasticity of exporters at the 90th percentile of $\Psi_{\mathcal{C}}$ (high concentration, HC) and the elasticity of exporters at the 10th percentile of the same variable (low concentration, LC). In order to account for potential correlation across the different components of Ψ and tariff changes, I also consider the associated $\Psi_{\mathcal{M}}$ and $\Psi_{\mathcal{N}}$, and changes in applied $\Delta \log \tau_p$ of the high and low concentration exporters.[24]

[24]Note that if HC countries have low $\Psi_{\mathcal{M}}$ and $\Psi_{\mathcal{N}}$, the increase in the trade elasticity could be offset.

In Figure 2.4 I graph the empirical distribution of the differential import growth between LC and HC exporters. As it can be seen, there is a lot of heterogeneity across products and the average differential is 13 log points. This implies that the model predicts about 13% lower import growth in the case of exporters that are highly concentrated.

Figure 2.4: Differential Import Growth Distribution.



Distribution of $\Delta \widehat{\log M}^{HC} - \Delta \widehat{\log M}^{LC}$ across HS6 products using baseline estimates from Table 2.2, Column 3.

In Table 2.9 I present detailed statistics of the distribution in Figure 2.4 along with the distribution of trade elasticities. In Panel A I present product-level statistics showing the average and range of the differential trade elasticity due to the HC-LC country differences. The average trade elasticity differential due to firm concentration is 1.962. In addition, there is substantial heterogeneity across products as it can be seen by the range and standard deviation.

The average elasticity considers also how $\Psi_{\mathcal{C}}$ relates to $\Psi_{\mathcal{M}}$ and $\Psi_{\mathcal{N}}$. However, we can isolate the impact of $\Psi_{\mathcal{C}}$, which is shown in the third row of the same panel.

Table 2.9: High-Low Concentration Differential in Trade Elasticity and Predicted Import Growth.

High-Low Concentration Differential Trade Elasticity				
Panel A. All Products				
	Mean	s.d.	Min	Max
Total	1.962	3.891	-13.861	14.741
Aggregate Market Power ($\mathcal{M}$)	3.368	5.037	-14.502	14.902
Concentration ($\mathcal{C}$)	3.527	1.734	0.000	7.431
Extensive Margin ($\mathcal{N}$)	-4.934	3.067	-7.451	3.726
Panel B. Products with five or more exporters				
	Mean	s.d.	Min	Max
Total	1.699	2.989	-8.069	14.029
Aggregate Market Power ($\mathcal{M}$)	3.100	4.189	-10.413	14.538
Concentration ($\mathcal{C}$)	4.189	1.335	0.352	7.431
Extensive Margin ($\mathcal{N}$)	-5.589	2.670	-7.451	3.726
High-Low Concentration Differential Import Growth				
Panel C. All Products				
	Mean	s.d.	Min	Max
Total	-0.129	0.343	-2.354	1.751
Aggregate Market Power ($\mathcal{M}$)	-0.224	0.642	-2.716	2.632
Concentration ($\mathcal{C}$)	-0.238	0.220	-1.336	0.658
Extensive Margin ($\mathcal{N}$)	0.333	0.576	-2.374	2.810
Panel D. Products with five or more exporters				
	Mean	s.d.	Min	Max
Total	-0.115	0.261	-2.354	0.989
Aggregate Market Power ($\mathcal{M}$)	-0.203	0.582	-2.713	2.632
Concentration ($\mathcal{C}$)	-0.280	0.217	-1.336	0.658
Extensive Margin ($\mathcal{N}$)	0.368	0.511	-2.169	2.717

Calculations made by using baseline results in Table 2.2, Column 3 using non-standardized coefficients. Panels A and C include all 3102 HS6 products in sample and Panel B and D include the 1843 products with five or more exporting firms.

Given that the comparison has been set in terms of high and low $\Psi_{\mathcal{C}}$, the difference in the trade elasticity due to concentration is higher (3.527 at the average). This means that the differential impact on imports due to concentration alone can be almost doubled at 23 log points (3.527×-0.066).

In 40% percent of products there are less than five exporters selling into Colombia. Given that I use the 10th and 90th percentiles to compare high and low concentration, the low number of exporters may be understating the relevant heterogeneity. In Panel B I show the same information but only for products in which there are five or more exporters. Results show that the total differential elasticity is not higher bur rather lower (1.699).

Finally, the magnitude of the decrease in tariffs could be systematically associated to high and low exporters. In fact, countries that signed the FTA had an initially higher Ψ. If that is the case, then we may find that the actual predicted change in imports differ for high and low concentration countries. In Panel C I show that this is not the case since the average change in imports for HC exporters is 13 log points lower than for LC exporters, the same as the average change in imports when the average change in tariffs is used. Panel D replicates results for products with five or more exporters and conclusions do not differ.

2.5 Summary and Concluding Remarks

In this chapter, I employed the hybrid model to derive a gravity equation in changes and showed that granular firms introduce an extra margin of adjustment into the trade cost elasticity. On top of the intensive and extensive margin, the model implies an oligopolistic margin that depends on both exporter-specific concentration and the bilateral importance of exporter-specific granular firms. This extra margin comes from large firm's markup adjustments when trade costs change. The higher exporter concentration, the lower is the impact of trade costs on import growth.

I tested the model using changes in discriminatory trade policy in Colombia. I exploited diff-in-diff variation in tariffs due to both a unilateral trade liberalization and the signature of free trade agreements over the 2010-2013 period and found robust evidence for the oligopolistic margin. Using the preferred specification, I derived quantitative implications relative to the standard gravity equation, which is microfounded under monopolistic and competitive behavior. I found that import growth is predicted to be significantly lower for the top 19% of import flows in terms of initial exporter concentration. Moreover, I found that the aggregate effect of the decrease in tariffs was lower than the average effect due to oligopolistic behavior, which suggests that further exploring the aggregate implications of this model can be an avenue for future research.

I found that imports from countries at the top decile in terms of firm concentration were predicted to have 13 log points lower growth on average than imports from countries at the bottom decile. This implies that accounting for oligopolistic behavior may be important for trade policy when there is high concentration, since gains may be lower when signing agreements with less competitive countries. Given the usual political constraints this kind of policies face, policy makers should account for this mechanism when signing trade agreements and lowering tariffs, potentially focusing on signing agreements with more competitive partners.

This chapter only addresses changes in policy of a single importer, but future research should consider extending the analysis to a multi-importer setting. The main difficulty of doing that may be obtaining firm level data to construct concentration measures for different bilateral trade flows. On this regard, using exporter concentration data such as the included in the EDD may be the way to move the understanding of gravity equations under different forms of competition forward.

Chapter 3: Trade Policy Uncertainty and Firm Concentration

3.1 Introduction

In this chapter, I explore the implications of the hybrid model in a setting with trade policy uncertainty (TPU). One of the main goals of preferential trade agreements has been to secure preferences among their members (cf. Limão, 2016). However, recent work has shown that current trade policy disagreements may be undermining that goal by increasing the probability of policy reversals. In this chapter, I extend the hybrid model developed in Chapter 1 by introducing TPU in a setting with both oligopolistic and monopolistic competitive firms. I characterize industries based on how oligopolistic behavior modifies the standard framework through industrial concentration. I also propose an strategy for future empirical research.

I characterize the relationship between TPU and oligopolistic behavior by constructing a model that features both. I apply the Handley-Limão framework (HL framework henceforth), where an increase in either the probability of policy reversals or tail risk lowers the entry cost cutoff of exporters, reducing the number of available varieties for consumers and thus consumer welfare. I find that exporter concentration amplifies the negative impact of TPU on entry by allowing oligopolistic firms to offset part of the increase in tariffs by reducing markups. On the contrary, domestic concentration mitigates the impact of TPU because higher tariffs are expected to be offset by higher domestic markups.

The model predicts an augmented gravity equation in changes that accounts for both a variable trade cost elasticity and an uncertainty factor that reduces export growth. This feature of the model can be useful to evaluate ongoing and recent trade policy disagreements in the context of concerns about increasing industrial concentration.[1] I propose applying the model to the United Kingdom (UK) exit process from the European Union (EU), the so-called Brexit. The model extends Graziano et al. (2018), a paper that applies the HL framework in this setting. Given that different sectors faced different threats, they exploit the time-varying probability and the sector-varying threat to identify the effect of Brexit uncertainty. I propose an additional channel that provides extra industry variation: the concentration of large firms.

This chapter relates and extends the TPU literature by allowing for oligopolistic behavior. In recent years, a number of papers applied the HL framework to different settings. Handley and Limão (2015) apply this framework to the accession of Portugal to the EU, whereas Handley and Limão (2017) study the impact of China's World Trade Organization accession on US's imports from that country. In both cases, the authors show the impact of a decrease in TPU on exporter entry and export flows. Carballo et al. (2018), Graziano et al. (2018), and Graziano et

[1] Examples are the US withdrawal from Trans-Pacific Partnership, the US-China Trade War, and the Argentinian withdrawal from MERCOSUR's current FTA negotiations.

al. (2020), study the impact of an increase in uncertainty. In the first case, they study how the increase in demand and policy uncertainty caused by the Great Recession negatively impacted export investments. Moreover, they show that trade agreements can provide insurance against tail risk. Graziano et al. (2018), GHL henceforth, study the negative impact of an increase in the probability of tail risk due to Brexit uncertainty in the case of EU-UK trade, whereas Graziano et al. (2020) extend the analysis to countries that have a FTA with the EU. In this chapter, I follow the GHL setting but allow firms to have an impact on the counterfactual, higher-tariffs industry price index. Handley and Limão (2017) allowed for this type of general equilibrium effects. In my case, I exploit the fact that the hybrid model delivers a variable elasticity that depends on both large and small firms' behavior to characterize such effect.

To the best of my knowledge, this is the first attempt to characterize the impact of TPU when there is oligopolistic behavior. Doing so can provide a valuable tool for analyzing trade policy in a context of increasing concentration and tariffs threats. Even though the model inherits a series of technical limitations from the oligopolistic literature (cf. Head and Spencer, 2017), it provides a strategy to partially overcome them. I assume that the entry cutoff only affects monopolistic competitive firms and not larger, oligopolistic firms, which in the context of the hybrid model means that there will be surviving non-granular exporters, had the worst state is realized. A key object to link the theory with the data in the HL framework is the "uncertainty factor" that modifies the gravity equation. As shown in Chapter 2, the hybrid model also provides a gravity equation in changes that is augmented along the oligopolistic dimension. In this chapter, I put both extensions together and show that we can use a gravity equation to identify the interaction between the two. The key intuition is that the price index elasticity resulting from the hybrid model modifies the uncertainty factor, providing an additional source of variation.

In Section 2 I show how the hybrid model can be merged with the HL framework. In Section 3 I propose an empirical strategy to derive the empirical equation and bring the model to the data by employing the Brexit case as an illustrative application. Section 4 concludes and suggests future applications and extensions.

3.2 Model

3.2.1 Environment

The environment is the same as in Chapter 2, with exporter-specific large and small firms selling differentiated varieties in a given importing country. I explain below how I merge this setting with the HL framework.

3.2.2 Entry Decisions under Trade Policy Uncertainty

Firms know their productivity and only enter into the market if their expected profits net of the entry cost, $\Pi_e - K$, are higher than the expected value of waiting, Π_w. As before, I assume that large firms are present in the market over the period of time we consider and do not exit.[2] Therefore, only small firms face the entry

[2] As discussed in Chapter 1, even though the probability of exit of large firms is not zero, the probability of exit of the top quintile of firms is substantially lower than the probability of exit of smaller firms (Eaton et al., 2007).

decision. Given that small and large firms only interact with each other through the price index, we can use the HL framework to derive a cost cutoff at which small firms are indifferent between entering into export markets by paying the sunk cost K and waiting:

$$\Pi_e^s(a_{ct}^s, c_{ct}^U, r_c) - K = \Pi_w^s(c_{ct}^U, r_c) \tag{3.1}$$

where a_{ct}^s captures business conditions in state s faced by c at t, c_{ct}^U is the small firms' cost cutoff, and $r_c = \{\gamma, \bar{H}_c(a_c)\}$ is the trade policy regime, with γ being the probability of a trade policy shock. Given that I use a bounded Pareto distribution for small firms with lower bound c_L^s, I assume $c_{ct}^U > c_L^s$ in equilibrium. This implies that worsening business conditions still allow for a fraction of small firms to enter.

Equation 3.1 allows me to solve for the cutoff as in GHL, which delivers the following uncertainty cutoff:[3]

$$c_{ct}^{Us} = c_{ct}^{Ds} \times \frac{P}{P^D} \times U_{ct}^h = \left[\frac{a_{ct}\tilde{\sigma}}{(1-\beta)K}\right] \times \left[1 + \frac{\beta\gamma_c(\bar{\omega}_{ct}^h - 1)}{1 + \beta(1-\gamma_c)}\right]^{\frac{1}{\sigma-1}} \tag{3.2}$$

$$(\bar{\omega}_{ct}^h - 1) = -\bar{H}_c(a_{ct})\frac{a_{ct} - E(a'_{ct} \leq a_{ct})}{a_{ct}} \in (-1, 0] \tag{3.3}$$

Equation 3.2 differs from the expression in GHL in a fundamental way. The existence of large exporting firms implies they can affect the overall price index. This introduces the ratio of $\frac{P}{P^D}$ as an additional term in the entry cutoff, which captures how much higher is the current price index relative to the price index

[3] Details in Appendix A.1.3.

under certain future conditions.[4] That term can be eliminated by noting that c_{ct}^{Ds} would not be capturing the deterministic cutoff. Other than that, the derivation is identical to GHL, since large firms will be modifying small firm behavior through their expected profits conditional on the shock, $\bar{\omega}_{ct}^{h} - 1$, which captures the different tail risk scenarios they face.

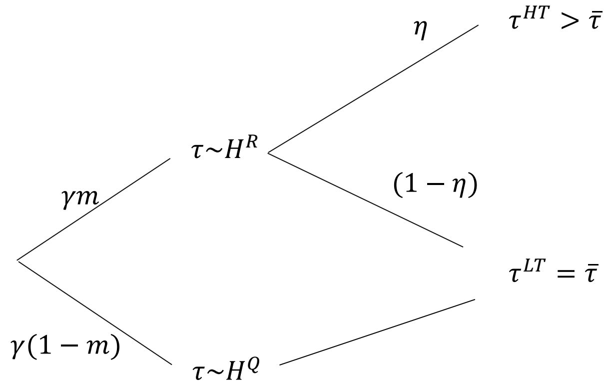
3.2.3 Policy Risk

I assume there are two potential trade policy distributions. One of them is H^R, which assigns probability η to an absorbing state with high import tariffs (HT), and $1 - \eta$ to an absorbing state with low tariffs (LT). Other trade policies, such as non-tariff barriers, and trade costs are assumed to be certain. An example of such setting is a FTA member that is uncertain about its future preferential status. The other distribution is H^Q, which assigns the low tariffs absorbing state with certainty. I assume policy is drawn from H^R with probability m and from H^Q with probability $1 - m$, and also that firms are facing low tariffs currently. I illustrate this in Figure 3.1.[5]

[4] This term is also present in Handley and Limão (2017) when they analyze the general equilibrium implications of TPU.

[5] If current tariffs are higher than in the LT state, then small domestic firms would also face TPU. This means that there would be another cutoff of interest that can be modified by the industry's market structure.

Figure 3.1: Event Space and Probability Tree for Trade Policy Distributions.



The probability tree and event space in Figure 3.1 imply the following for the expected profit loss $\bar{\omega}^h_{ct} - 1$:

$$\bar{\omega}^h_{ct} = m\omega^{h,R}_{ct} + (1-m)\omega^{h,Q}_{ct} \tag{3.4}$$

$$\omega^{h,R}_{ct} - 1 = \Big[\eta(\tau^{HT})^{-\sigma}[\frac{P^{HT}}{P_{ct}}g^{HT}_{ct}]^{\sigma-1} + (1-\eta)[\frac{P^{LT}}{P_{ct}}g^{LT}_{ct}]^{\sigma-1} - 1\Big] \tag{3.5}$$

$$\omega^{h,Q}_{ct} - 1 = \Big[[\frac{P^{LT}}{P_{ct}}g^{LT}_{ct}]^{\sigma-1} - 1\Big] \tag{3.6}$$

$$g^{HT}_{ct} \equiv (1-\beta)\sum_{\tilde{t}=0}^{\infty}\beta^{\tilde{t}}\frac{P^{HT}_{\tilde{t}}}{P^{HT}} \tag{3.7}$$

$$g^{LT}_{ct} \equiv (1-\beta)\sum_{\tilde{t}=0}^{\infty}\beta^{\tilde{t}}\frac{P^{LT}_{\tilde{t}}}{P^{LT}} \tag{3.8}$$

Given that the impact of exporters is not negligible, Equation 3.3 also has to account for the transition from the current state to either absorbing state LT or HT.[6] This is an unavoidable issue given the existence of large firms: all scenarios potentially involve some degree of risk for a subset of small firms. If policy is drawn

[6]The transition takes time because incumbent firms above the entry cutoff remain profitable (costs are sunk) and thus exit only after a death shock, after which point they do not re-enter.

from the Q distribution, then there will be more entry of foreign firms and a decrease in large firms' markups. Given that tariffs would not change and domestic firms were already facing the lowest level of protection, this causes a decrease in the price index relative to the uncertain state. The R distribution has tail risk because it assigns positive probability to the HT state, which involves an increase in tariffs. In that scenario, the price index would increase, allowing large firms to modify markups, potentially offsetting part of the direct effect.

Factors g_{ct}^{HT} and g_{ct}^{LT} capture the transition process caused by the exit of firms towards the new stationary state via exogenous death and non-reentry. In the first case, exit will happen on the foreign side, whereas in the second case on the domestic side.

3.2.4 Uncertainty Factor

To characterize the change in entry due to uncertainty we have to understand how the uncertainty factor differs across industries and exporters facing the same trade policy regime. To do so, I derive a second order approximation of $\log U$ with respect to $u = (\log m, \tau)$ around no tail risk and no import tariffs, $u_0 = (0, 0)$:[7][8]

$$\log U \approx -\tilde{\beta}\eta\Big[\frac{\sigma}{\sigma-1} - \varepsilon_{\bar{c}}\Big] m \log \tau^{HT} \tag{3.9}$$

where $\frac{\partial \log P^{HT}}{\partial \log \tau_{\bar{c}}^{HT}}|_{u_0} \equiv \varepsilon_{\bar{c}}$ is the price index elasticity with respect to tariffs from

[7] Derivation and details in Appendix A.1.4. I omit time subscripts for clarity.

[8] $\tilde{\beta} \equiv \frac{\beta\gamma}{2(1-\beta(1-\gamma))}$

all countries that could face higher tariffs ($\bar{c}$), evaluated at u_0. The approximation point implies that the effect is only explained by the cross-elasticity of uncertainty and risk, $\frac{\partial^2 \log U}{\partial \log \tau_{\bar{c}}^{HT} \partial m}$. Having large firms implies that such elasticity is heterogeneous across sectors not only due differential trade policy, but also due to differences in their industry characteristics.

In order to characterize how the heterogeneous effect across industries, let's write the price index elasticity as derived in Chapter 1:

$$\varepsilon_{\bar{c}} = s_{\bar{c}} \frac{\tilde{H}_{\bar{c}}}{H} \tag{3.10}$$

where $\tilde{H}_{\bar{c}} = 1 - h_{\bar{c}}^l \Psi_{\bar{c}}^l + (1 - h_{\bar{c}}^l) \Lambda_{\bar{c}}^s \frac{\sigma}{\sigma-1}$.[9] Equation 3.10 shows that $\varepsilon_{\bar{c}}$ captures the direct impact of the potential increase in tariffs, $s_{\bar{c}}$, modified by a factor that corrects by the relative importance of $\bar{c}$ countries firms' equilibrium responses through entry and markups.

Given that $\varepsilon_{\bar{c}} < \frac{\sigma}{\sigma-1}$ as shown in Chapter 1, the sign of the cross-elasticity and thus the uncertainty factor around no uncertainty is well-defined. This implies that the higher the R probability m and the HT tariff threat $\log \tau^{HT}$, the lower the uncertainty factor and thus entry. On the contrary, the higher $\varepsilon_{\bar{c}}$ the lower the impact of uncertainty on export entry. In GHL, this last term is not present because they assume that exporters are small relative to the domestic market. However, that assumption is not compatible with having oligopolistic firms. As a result,

[9] Recall that $H = s_{\bar{c}} H_{\bar{c}} + (1 - s_{\bar{c}}) H_{-\bar{c}}$, where $H_{\bar{c}} = 1 - h_{\bar{c}}^l \Psi_{\bar{c}}^l + (1 - h_{\bar{c}}^l) \Lambda_{\bar{c}}^s$.

higher $\varepsilon_{\bar{c}}$ implies a larger increase in the price index, which partially offsets the eventual impact of tariffs. Thus, industry heterogeneity acts through the price index's response.

Finally, note that the LT absorbing state does not have a direct impact on the uncertainty factor because there that state does not imply an increase in tariffs.

3.2.5 Industry Characteristics

The price index elasticity depends on different industry characteristics. I discuss below potentially observable variables that provide intuition for the impact of TPU and can be linked to underlying parameters of the model.

Proposition 6 ***Trade Policy Uncertainty and Industry Characteristics****. In the hybrid model with oligopolistic competition the impact of TPU shocks in reducing firm entry and exports is:*

(i) mitigated by the market share of exporters facing TPU,

(ii) amplified by the market share of large firms within countries facing TPU,

(iii) amplified by the concentration of large firms within countries facing TPU,

(iv) mitigated by the concentration of large firms within countries not facing TPU.

Proof: See Appendix A.2.6.

Proposition 6 summarizes under which observable industry characteristics we should expect a higher or lower uncertainty factor, all else equal. Point (i) says that, conditional on the HT tariff, surviving exporting firms in industries where the market share of exporting countries facing TPU is higher should face lower uncertainty because the price index is expected to increase more, partially offsetting the direct tariff effect.

Point (ii) implies that the share of large oligopolistic firms in export flows facing TPU has a negative effect on entry. The intuition is that in flows where large firms have a higher share and thus oligopolistic competition is relatively more important, the increase in the price index as a result of an increase in tariffs is mitigated by changes in markups. As a result, the offsetting effect is lower and there is less entry.

Point (iii) says that firm concentration as captured by $\Psi^{l}_{\bar{c}}$ within all countries facing TPU will amplify the impact of TPU relative to a monopolistic competitive setting. The reason is that high concentration implies a low tariff pass-through and therefore the price index would not increase as it would otherwise, implying a relatively tougher competitive environment. The opposite is true for firm concentration within all countries not facing TPU in point (iv).

The following corollaries identify a special case that can be of particular interest.

Corollary 1 *Import penetration mitigates the impact of uncertainty shocks in reducing firm entry and exports when all exporters face TPU.*

Proof: By defining $\bar{c}$ as domestic firms and relying on the proof of Proposition 6.

When all foreign exporters face TPU in the domestic economy, the only firms not facing TPU are domestic firms. Therefore, high import penetration implies that the price index will increase at a greater extent offsetting a higher fraction of the negative impact through lower entry.

Corollary 2 *Domestic concentration mitigates the impact of uncertainty shocks in reducing firm entry and exports when all exporters face TPU.*

Proof: By defining $\bar{c}$ as domestic firms and relying on the proof of Proposition 6.

Similarly, a high Ψ_d^l implies that when protection increases, large domestic firms will increase markups at a greater extent, which will further increase the price index leaving more residual demand for small exporting firms. Both corollaries suggest that the increase in import penetration and domestic concentration observed in developed countries in recent years could have decreased the cost of TPU for consumers.

3.2.6 Oligopoly-Augmented Gravity Equation under Trade Policy Uncertainty

The uncertainty factor modifies the entry cutoff of the hybrid model and therefore the augmented gravity equation in changes derived in Chapter 2 is incomplete to capture oligopolistic behavior under uncertainty. The following proposition captures both mechanisms relative to a standard model without TPU and oligopolistic behavior:

Proposition 7 ***Oligopoly-Augmented Gravity Equation under Trade Policy Uncertainty***. *In the hybrid model with oligopolistic competition and trade* *policy uncertainty, the gravity equation in changes is:*

$$d\log M_{ct}^{U} = d\log M_{ct}^{D} + d\log\frac{\overline{M}_{ct}^{U}}{M_{ct}^{D}} + \mathbb{1}\Big[c\in\bar{c}\Big](1-h_{ct}^{U,l})\Lambda_{ct}^{s}d\log U_{t} \tag{3.11}$$

where $\bar{c}$ identifies exporters facing trade policy uncertainty, M_{ct}^{U} is imports from country c at t, M_{ct}^{D} is imports under deterministic tariffs, and $\frac{\overline{M}_{ct}^{U}}{M_{ct}^{D}}$ is the change in imports due to firms equilibrium responses to trade policy uncertainty.

Proof: See Appendix A.2.7.

Proposition 7 shows that trade growth is reduced by the direct impact of TPU given that $U < 1$. The (log) ratio of $\overline{M}_{cpt}^{U}$ to M_{cpt}^{D} captures at which extent other firms will respond to the impact of uncertainty on entry and may be either positive or negative depending on the importance of small firms. In addition, note that the extent at which TPU directly affects trade flows is lower than in the standard HL framework because large firms are not affected by exit in the short run. Finally, the pass-through from changes in trade and production costs need to be accounted for as with deterministic policy.

3.3 Empirical Discussion

In this section I discuss a potential empirical application for this model. I extend the analysis of Brexit uncertainty in the context of GHL using a similar empirical strategy to the one in Chapter 2.

3.3.1 Trade Policy Uncertainty under Brexit

The UK referendum held to decide whether to leave the EU, the so-called Brexit process, reduced UK-EU bilateral trade through lower exporter entry because of TPU, as shown by GHL. In 2015, after the Conservative Party UK general election victory, Prime Minister Cameron delivered in the campaign promise of holding a referendum to decide UK's EU membership status. By opening a formal channel for exiting the EU, the Prime Minister introduced a tangible mechanism through which UK and EU firms could lose their reciprocal preferential treatment. In other words, that election introduced a TPU shock that induced firms to consider the alternative scenarios they could face depending on the referendum outcome. The referendum took place in June 2016, when the Brexit option won.

In GHL, the authors characterize the event space firms faced before the referendum by interpreting the referendum probability as the probability of drawing policy from a riskier policy distribution H^{BR}, instead of the less risky H^{EU}. Conditional on drawing policy from H^{BR}, they identified alternative states: renegotiation, FTA, MFN, and a trade war, where FTA refers to duty-free trade under a Free Trade Agreement, and MFN refers to having Most Favored Nation status, as WTO members not holding an agreement with the EU do. We can map their setting to the model presented in this chapter as follows. The MFN is the HT state, whereas renegotiation, FTA and EU states can be grouped into the LT state, assuming away uncertain non-tariff barriers for simplicity of exposition. GHL showed that firms did not believe trade war was likely so I disregard this possibility.

3.3.2 Empirical Equation

In order to transform equation 3.11 into an empirical equation, I follow the same approach as in Chapter 2. In that chapter, I switched the gravity equation from marginal changes with respect to a steady state setting to an equation in discrete changes. Such transformation can be interpreted as a first order approximation around the equilibrium. Below I show the full equation:[10]

$$\begin{aligned}
\Delta_0 \log M_{cpt} &= (1-h^l_{cp,0})\Lambda^s_{cp,0}\Delta_0 \log U_{cp,t} + \\
&+ [1+(1-h^l_{cp,0})\Lambda^s_{cp,0}]\Delta_0 \log E_{p,t} - \\
&- (\sigma-1)[1+(1-h^l_{cp,t-1})\frac{\sigma}{\sigma-1}\Lambda^s_{cp,0} - h^l_{cp,0}\Psi_{cp,0}]\Delta_0 \log \tau_{cp,t} + \\
&+ (\sigma-1)[1+(1-h^l_{cp,0})\Lambda^s_{cp,0} - h^l_{cp,0}\Psi_{cp,0}]\Big[\Delta_0 \log P_{p,t} - \\
&- \Delta_0 \log T_{cp,t} - \Delta_0 \log w_{c,t}\Big] + (1-h^l_{cp,0})\Delta_0 \log N^s_{cp,t} + v_{ip,t} \qquad (3.12)
\end{aligned}$$

where Δ_0 refers to differences against the steady state.

3.3.2.1 Identifying Assumptions

In Chapter 2 I made identifying assumptions that helped me to construct an empirical equation that could be applied in that setting. In this case, I slightly modify them to allow variation across different trade flows along the dimensions

[10] I omit the superscript U, but note that all are equilibrium responses under U since $d\log M^D_{cpt} + d\log \frac{\overline{M}^U_{cpt}}{M^D_{cpt}} = d\log \overline{M}^U_{cpt}$.

addressed by Proposition 6.

A1a. Constant deep parameters σ and k across importers, exporters, products and time.

A1b. Two types of products in steady state: products with high concentration, Ψ^H, and products with low concentration, Ψ^L.

A2. Exogenous exporter-specific production costs w_c.

A3. Elasticity of substitution across products equal to one.

A4. Potential entrants are determined by a product-specific, exporter-specific and an idiosyncratic factor: $\log N^s_{cp} = \log N^s_p + \log N^s_c + \log \zeta^s_{cp}$, with $E(\log \zeta^s) = 0$.

A5. Transport cost and tariffs are constant over this period of time ($\Delta \log T_{cp,t} = 0$ and $\Delta \log \tau_{cp,t} = 0$)

The key difference is that I assume there are two types of sectors in steady state: those with high and low firm concentration. A way of understanding this in light of the model is assuming different upper productivity bound across sectors.

3.3.2.2 Estimating Equation

The previous identifying assumptions deliver the following estimating equation:

$$\log M_{cp,t} \quad = \quad (1 - h^{l,X})\Lambda^{s,X} \log U_{cp,t} +$$

$$+ \quad \delta_{cp}^{0,X} + [\delta_{p}^{I,X} + \delta_{pt}^{S,X}\Psi_{cp,0}] + [\delta_{ct}^{I,X} + \delta_{c}^{S,X}\Psi_{cp,0}^{X}] + u_{cp_t} \tag{3.13}$$

where $X \in (L, H)$ identifies the type of sector in terms of exporter concentration.

Figure 3.1 shows the trade policy stochastic process, and equation 3.9 shows the second order approximation capturing the impact of changes in the probability of drawing from the riskier distribution, m, and the MFN tariff threat, $\log \tau^{MFN}$, in the case of Brexit. The following equation shows the uncertainty factor in the context of the steady state approximation:

$$\log U_{cp,t}^{X} \approx -\tilde{\beta}\eta\Big[\frac{\sigma}{\sigma-1} - \varepsilon^{X}\Big] m \log \tau^{MFN} \tag{3.14}$$

The key difference with respect to GHL is that there are two conditional uncertainty factors that depend on ε^{X}, one for high and another for low concentration.

Under the conditions presented in this section, the coefficient will have the following structural interpretation:

$$\alpha^{X} = -(1 - h^{l,X})\Lambda^{s,X}\frac{\tilde{\beta}\eta}{2}\Big[\frac{\sigma}{\sigma-1} - \varepsilon^{X}\Big] \tag{3.15}$$

This coefficient differs from the one in GHL in three ways. First, ε^{X} lowers the cross-elasticity magnitude as long as TPU modifies the overall price index, but does not fully offset it. This result is in line with Handley and Limão (2017), where they prove that this effect cannot offset the direct effect. Second, the fact that TPU only impacts entry of small firms implies that the coefficient will be lower when the share of exports of large firms is high. Therefore, if sectors with high concentration of large firms are correlated with sectors where the share of large firms is high, the impact on exports may not be as high as predicted by Proposition 6. Third, the hazard function also amplifies the effect. If there are few varieties sold in the market, the impact will be larger.

3.4 Summary and Concluding Remarks

In this chapter, I merged the HL framework with the hybrid model developed in Chapter 1 in order to characterize how TPU impacts export flows when there are firms that behave oligopolistically. I showed that when there are small monopolistic competitive firms and granular oligopolistic firms competing in a market, an increase in TPU modifies the cross-elasticity of uncertainty and risk due to large firms' markup responses. When foreign exporters are highly concentrated, the aggregate pass-through of tariffs to large firms' prices is reduced and therefore the effect of TPU on small firms is amplified. On the contrary, when large domestic firms are highly concentrated, the impact of TPU is partially offset by an increase in domestic markups, which reduces the magnitude of the cross-elasticity.

This way of modeling oligopolistic behavior helps in characterizing the impact of TPU but also has limitations. First, this model is valid mostly in the short run since large firms are not assumed to make sunk investments. Second, properly bringing this model to the data can be demanding since it requires having firm-level bilateral export values and concentration for the trade flows included in the sample.

The model as is has implications for policy in the short run. Given that the impact on consumer welfare is expected to be milder in sectors with high domestic concentration and low foreign concentration, policy makers may be inclined to threaten sectors with these characteristics. In this sense, high domestic concentration may offset the impact of high markups by providing more room for foreign exporters in contexts with policy uncertainty.

This model provides an extra channel through which TPU can have a testable differential impact. Future research may want to exploit this dimension in the context of generalized tariff hikes threats. For instance, a threat of an increase in x% in tariffs across many sectors may impact them differently, depending on their market structures. This type of threats have been common in the last years, during the 45th US president tenure. Moreover, many proposed tariff hikes did materialize, providing credibility to his threats.

Appendix A: Proofs and Analytic Derivations

A.1 Analytic Derivations

A.1.1 Markups and Elasticity of Demand of Large Firms

Firms maximize the their profits by choosing quantities taking into account their effect on aggregates (I omit industry subscripts).

Firms' i in r problem:

$$\max_{q^l_{r,i}} (p^l_{r,i}/\tau - c^l_{f,i}T_r)q^l_{f,i} \tag{A.1}$$

subject to $p^l_{r,i} = (q^l_{r,i})^{-\frac{1}{\sigma}} Q^{\frac{1-\sigma}{\sigma}} E$.

First order condition (FOC):

$$(p^l_{r,i})'_q q^l_{r,i} + p^l_{r,i} - c^l_{r,i} T_r \tau = 0 \tag{A.2}$$

where $(p^l_{r,i})'_q = -\frac{1}{\sigma}\frac{p^l_{r,i}}{q^l_{r,i}} - \frac{\sigma-1}{\sigma}\frac{p^l_{r,i}}{Q}Q'_q$ and $Q'_q = \frac{Q}{Q^{\frac{\sigma-1}{\sigma}}}(q^l_{r,i})^{-\frac{1}{\sigma}}$.

Therefore, the FOC is:

$$-\frac{1}{\sigma}p^l_{r,i} - \frac{\sigma-1}{\sigma}\frac{p^l_{r,i}}{Q^{\frac{\sigma-1}{\sigma}}}(q^l_{r,i})^{\frac{\sigma-1}{\sigma}} + p^l_{r,i} = c^l_{r,i}T_r\tau \tag{A.3}$$

Given that $s^l_{r,i} = \frac{p^l_{r,i}q^l_{r,i}}{PQ} = \frac{(q^l_{r,i})^{\frac{\sigma-1}{\sigma}}}{Q^{\frac{\sigma-1}{\sigma}}}$, we can write the markup as a function of the market share:

$$\begin{aligned} p^l_{r,i}[1 - \frac{1}{\sigma} - \frac{\sigma-1}{\sigma}s^l_{r,i}] &= c^l_{r,i}T_r\tau \\ \frac{p^l_{r,i}}{c^l_{r,i}T_r\tau} &= \frac{\sigma}{(\sigma-1)(1-s^l_{r,i})} \end{aligned} \tag{A.4}$$

The firm-specific elasticity of demand $-\nu^l$ can be derived by using the Lerner Index:

$$\begin{aligned} \frac{1}{-\nu^l_{r,i}} &= \frac{p^l_{r,i} - c^l_{r,i}T_r\tau}{p^l_{r,i}} \\ -\nu^l_{r,i} &= \frac{1}{s^l_{r,i} + (1-s^l_{r,i})/\sigma} \end{aligned} \tag{A.5}$$

where it can be seen that $-\nu^l_{r,i}$ is decreasing in $s^l_{r,i}$ and therefore large firms face a more inelastic demands.

A.1.2 First Order Approximation of Ψ

The concentration measure Ψ_r can be written as follows:

$$
\begin{aligned}
\Psi_r &= \sum_{i=1}^{N_r} z_f^l \frac{(\sigma-1)\frac{s_{r,i}^l}{1-s_{r,i}^l}}{1+(\sigma-1)\frac{s_{r,i}^l}{1-s_{r,i}^l}} \\
&= \sum_{i=1}^{N_r} z_f^l \frac{(\sigma-1)s_{r,i}^l}{1+(\sigma-2)s_{r,i}^l} \qquad \text{(A.6)}
\end{aligned}
$$

To construct the first order approximation around $\sigma = 2$ we need the following:

$$
\begin{aligned}
\Psi_r|_{\sigma=2} &= s_f h_r^l \sum_{i=1}^{N_r} (z_f^l)^2 \qquad \text{(A.7)} \\
\frac{\partial \Psi_r}{\partial \sigma}|_{\sigma=2} &= \sum_{i=1}^{N_r} z_f^l \left[\frac{\partial\left(\frac{(\sigma-1)s_{r,i}^l}{1+(\sigma-2)s_{r,i}^l}\right)}{\partial\sigma} \right]|_{\sigma=2} \\
&= \sum_{i=1}^{N_r} z_f^l s_f^l (1 - s_f^l) \\
&= s_f h_r^l \sum_{i=1}^{N_r} (z_f^l)^2 - s_f h_r^l \sum_{i=1}^{N_r} (z_f^l)^3 \qquad \text{(A.8)}
\end{aligned}
$$

where I used $s_{r,i}^l \equiv s_f h_r^l z_f^l$. Putting all together:

$$
\begin{aligned}
\Psi_r &\approx \Psi_r|_{\sigma=2} + \frac{\partial \Psi_r}{\partial \sigma}|_{\sigma=2}(\sigma-2) \\
&\approx s_f h_r^l \sum_{i=1}^{N_r} (z_f^l)^2 + \left[s_f h_r^l \sum_{i=1}^{N_r} (z_f^l)^2 s_f^l - (s_f h_r^l)^2 \sum_{i=1}^{N_r} (z_f^l)^3 \right] (\sigma-2) \\
&\approx (\sigma-1) s_f h_r^l \sum_{i=1}^{N_r} (z_f^l)^2 - (\sigma-2)(s_f h_r^l)^2 \sum_{i=1}^{N_r} (z_f^l)^3 \qquad \text{(A.9)}
\end{aligned}
$$

A.1.3 Entry Cutoff under Uncertainty

This derivation is adapted from Carballo et al. (2018) as used in Graziano et al. (2018). I need the following value functions to derive the cutoff:

(i) the value of exporting

$$\Pi_e(a_t, c, r) = \pi(a_t, c) + \beta(1-\gamma)\Pi_e(a_t, c, r) + \gamma\mathbb{E}\Pi_e(a', c, r)], \tag{A.10}$$

(ii) the value of waiting

$$\Pi_w(c, r) = 0 + \beta\left(1 - \gamma + \gamma\bar{H}(a_t)\right)\Pi_w(c, r) + \beta\gamma\left(1 - \bar{H}(a_t)\right)(\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) - K), \tag{A.11}$$

and (iii) the conditional expected value of exporting if $a' \geq \bar{a}$

$$\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) = \mathbb{E}\pi(a' \geq \bar{a}, c, r) + \beta(1-\gamma)\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) + \beta\gamma\mathbb{E}\Pi_e(a', c, r). \tag{A.12}$$

I obtain the cutoff expression by using the entry condition in (3.1); the value functions in (A.10), (A.11) and (A.12), and the expression for $\mathbb{E}\Pi_e(a', c, r)$. In contrast to GHL, a will be affected by large firm behavior.

A.1.4 Second Order Approximation of the Uncertainty Factor

Let's define the ratio of the price index under absorbing state HT to the current price index times the transition factor as $\Gamma^{HT} \equiv \frac{P^{HT}}{P} g^{HT}$.

The general form to derive the second order approximation with respect to $\mathbf{u} = \left(m, \log \tau^M\right)$ around $\mathbf{u}_0 = (0,0)$ is:

$$\log U(\mathbf{u}) \approx \log U(\mathbf{u}_0) + (\mathbf{u} - \mathbf{u}_0) \cdot \bigtriangledown \log U(\mathbf{u}_0) + \frac{1}{2}(\mathbf{u} - \mathbf{u}_0)^T (\mathbf{H} \log U(\mathbf{u}_0))(\mathbf{u} - \mathbf{u}_0), \tag{A.13}$$

where $\bigtriangledown$ is the gradient function and $\mathbf{H} \log U(\mathbf{u}_0)$ is the Hessian matrix.

As shown in GHL, only the second order cross-derivatives are not zero in the case of high tariffs around no uncertainty. Given that ω is a function of both τ and Γ, this means we can use their result and simplify to the following expression:

$$(\sigma - 1)\log U \approx \left[\frac{\partial^2 \log U^{\sigma-1}}{\partial \log \tau^{HT} \partial m} + \frac{\partial^2 \log U^{\sigma-1}}{\partial \log \Gamma^{HT} \partial m}\frac{\partial \log \Gamma^{HT}}{\partial \log \tau^{HT}}\right]\Big|_{u_0} \log \tau^{HT} m \tag{A.14}$$

The U derivatives are as follows:

$$(\sigma-1)\frac{\partial^2 \ln U}{\partial \log \tau^{HT} \partial m}|_{u_0} = -\frac{\tilde{\beta}(\Gamma^M)^{\sigma-1}\sigma(\tau^M)^\sigma}{\left(\left(\tilde{\beta}\tau^\sigma - \tilde{\beta}(\Gamma^M)^{\sigma-1}\right)m - \tau^\sigma\right)^2}|_{u_0} = -\tilde{\beta}\sigma \tag{A.15}$$

$$(\sigma-1)\frac{\partial^2 \ln U}{\partial \log \Gamma^{HT} \partial m}|_{u_0} = \frac{\tilde{\beta}(\sigma-1)(\tau^M)^\sigma(\Gamma^M)^{\sigma-1}}{\left((\tilde{\beta}(\Gamma^M)^{\sigma-1} - \tilde{\beta}(\tau^M)^\sigma)m + \tau^\sigma\right)^2}|_{u_0} = \tilde{\beta}(\sigma-1) \tag{A.16}$$

where $\tilde{\beta} \equiv \frac{\beta\gamma}{1-\beta(1-\gamma)}$.

I only need to calculate the partial derivatives of $\log \Gamma$ with respect to $\log \tau^{HT}$:

$$\begin{aligned} d\log\Gamma^{HT} &= d\log P^{HT} - d\log P + d\log g^{HT} && \text{(A.17)} \\ &= \Big[\frac{\partial \log P^{HT}}{\partial \log m} - \frac{\partial \log P}{\partial \log m} + \frac{\partial \log g^{HT}}{\partial m}\Big] d\log m + \\ &+ \Big[\frac{\partial \log P^{HT}}{\partial \log \tau^{HT}} - \frac{\partial \log P}{\partial \log \tau^{HT}} + \frac{\partial \log g^{HT}}{\partial \log \tau^{HT}}\Big] d\log \tau^{HT} && \text{(A.18)} \end{aligned}$$

Given that the expression only requires the derivatives with respect to $\log \tau^{HT}$:

$$\begin{aligned} \frac{\partial \log P^{HT}}{\partial \log \tau^{HT}}\Big|_{u_0} &= \varepsilon^{HT}\Big|_{u_0} = \varepsilon && \text{(A.19)} \\ \frac{\partial \log P}{\partial \log \tau^{HT}}\Big|_{u_0} &= (1-h^l) s_c^s \lambda_c^s \frac{\tilde{u}}{H^U} \bar{\omega} [\varepsilon^{HT} - \frac{\sigma}{\sigma - 1}]\Big|_{u_0} = 0 && \text{(A.20)} \end{aligned}$$

where ε is the price index elasticity, and $\tilde{u}|_{u_0} \equiv \frac{\tilde{\beta} m}{1+\tilde{\beta} m(\bar{\omega}-1)}|_{u_0} = 0$.

Regarding g^{HT}, we have:

$$g^{HT} = (1-\beta) \sum_{t=0}^{\infty} \beta^t \frac{P_t^{HT}}{P^{HT}} = (1-\beta) \sum_{t=0}^{\infty} \beta^t \Big[1 + \frac{\int_{c_c^{U,s}}^{c_{ct}^{HT,s}} p_c^s dG^s(c)}{P^{HT}}\Big] \quad \text{(A.21)}$$

The key observation is that both c^{Us} and $c_t^{HT,s}$ are the same under the approximation point and therefore this term is zero when taken the derivative because $m = 0$.

Therefore:

$$\frac{\partial \log \Gamma^{HT}}{\partial \log \tau^{HT}}\Big|_{u_0} = \Big[\frac{\partial \log P^{HT}}{\partial \log \tau^{HT}} - \frac{\partial \log P}{\partial \log \tau^{HT}} + \frac{\partial \log g^{HT}}{\partial \log \tau^{HT}}\Big]\Big|_{u_0} = \varepsilon \tag{A.22}$$

Let's replace back into the U approximation and rearranging:

$$\begin{aligned}
(\sigma - 1) \log U &\approx \Big[\frac{\partial^2 \log U^{\sigma-1}}{\partial \log \tau^{HT} \partial m} + \frac{\partial^2 \log U^{\sigma-1}}{\partial \log \Gamma^{HT} \partial m}\frac{\partial \log \Gamma^{HT}}{\partial \log \tau^{HT}}\Big]\Big|_{u_0} \log \tau^{HT} m \\
&\approx \Big[-\tilde{\beta}\sigma + \Big[\tilde{\beta}(\sigma-1)\Big]\varepsilon\Big] \log \tau^{HT} m \\
&\approx -(\sigma-1)\tilde{\beta}\Big[\frac{\sigma}{\sigma-1} - \varepsilon\Big] \log \tau^{HT} m
\end{aligned} \tag{A.23}$$

A.2 Proofs

A.2.1 Proposition 1. Relative Market Shares Response to Trade Liberalization.

The first point of the proposition implies we need to prove the following:

$$\frac{d \log z^l_{f,i}/z^l_{f,j}}{d \log \tau/P} > 0 \tag{A.24}$$

where $c^l_{f,j} > c^l_{f,i}$. Note that by proving for τ it can be extended to any change in the relative price of imports.

The market shares within large foreign firms are: $z^l_{f,i} = (p^l_{f,i})^{1-\sigma}/(P^l_f)^{1-\sigma}$, therefore $d\log z^l_{f,i} = d\log(p^l_{f,i})^{1-\sigma} - d\log(P^l_f)^{1-\sigma}$. Given that, we only need to derive $d\log(p^l_{f,i})^{1-\sigma}$ since $d\log z^l_{f,i} - d\log z^l_{f,j} = d\log(p^l_{f,i})^{1-\sigma} - d\log(p^l_{f,j})^{1-\sigma}$.

$$\begin{aligned} d\log p^l_{f,i} &= d\log[\tilde{\mu}(1-s^l_{f,i})^{-1}c^l_{f,i}T_f\tau] \\ &= \frac{s^l_{f,i}}{1-s^l_{f,i}}d\log s^l_{f,i} + d\log\tau \end{aligned} \tag{A.25}$$

where I assumed fixed $c^l_{f,i}$ and T_f. Note that $d\log s^l_{f,i} = (1-\sigma)d\log p^l_{f,i} - (1-\sigma)d\log P$. Therefore:

$$\begin{aligned} d\log p^l_{f,i} &= \frac{s^l_{f,i}}{1-s^l_{f,i}}(1-\sigma)[d\log p^l_{f,i} - d\log P] + d\log\tau \\ &= -\psi^l_{f,i}[d\log p^l_{f,i} - d\log P] + d\log\tau \\ &= \frac{\psi^l_{f,i}}{1+\psi^l_{f,i}}d\log P + \frac{1}{1+\psi^l_{f,i}}d\log\tau \end{aligned} \tag{A.26}$$

where I used the definition $\psi^l_{f,i} \equiv -\frac{\partial\log\mu^l_{f,i}}{\partial\log p^l_{f,i}} = (\sigma-1)\frac{s^l_{r,i}}{1-s^l_{r,i}}$.

Subtract the price of the two large foreign firms:

$$\begin{aligned} d\log p^l_{f,i} - d\log p^l_{f,j} &= \frac{\psi^l_{f,i}}{1+\psi^l_{f,i}}d\log P + \frac{1}{1+\psi^l_{f,i}}d\log\tau - \frac{\psi^l_{j,i}}{1+\psi^l_{j,i}}d\log P - \\ &- \frac{1}{1+\psi^l_{f,j}}d\log\tau \\ &= \frac{\psi^l_{f,i}}{1+\psi^l_{f,i}}d\log P - \frac{\psi^l_{f,i}}{1+\psi^l_{f,i}}d\log\tau - \frac{\psi^l_{j,i}}{1+\psi^l_{j,i}}d\log P + \end{aligned}$$

$$
\begin{aligned}
&+ \quad \frac{\psi^l_{f,i}}{1+\psi^l_{f,j}} d\log\tau \\
&= \quad -\frac{\psi^l_{f,i}}{1+\psi^l_{f,i}} d\log\tau/P + \frac{\psi^l_{f,j}}{1+\psi^l_{f,j}} d\log\tau/P
\end{aligned} \tag{A.27}
$$

where in the second line I used $\frac{1}{1+\psi^l_{f,i}} - 1 = -\frac{\psi^l_{f,i}}{1+\psi^l_{f,i}}$. Finally:

$$
\begin{aligned}
d\log z^l_{f,i} - d\log z^l_{f,j} &= (\sigma-1)[\frac{\psi^l_{f,i}}{1+\psi^l_{f,i}} d\log\tau/P - \frac{\psi^l_{f,j}}{1+\psi^l_{f,j}} d\log\tau/P] \\
&= \frac{\sigma-1}{(1+\psi^l_{f,i})(1+\psi^l_{f,j})}\left[\psi^l_{f,i} - \psi^l_{f,j}\right] d\log\tau/P
\end{aligned} \tag{A.28}
$$

Given that $\frac{\sigma-1}{(1+\psi^l_{f,i})(1+\psi^l_{f,j})} > 0$, we need $\psi^l_{f,i} - \psi^l_{f,j} > 0$ which follows from the fact that $z^l_{f,i} > z^l_{f,j}$.

The second point holds symmetrically by comparing two domestic firms and noting that $\tau = 1$. The decrease in τ decreases P and then increases the ratio $z^l_{d,i'}/z^l_{d,j'}$, where $c^l_{d,j'} > c^l_{d,i'}$.

A.2.2 Proposition 2. Large Firms Price Index and Concentration.

To prove that Ψ^l_f is a proper concentration measure it suffices to show that $m(z_{f,i}; s_f) = z^l_{f,i}\frac{(\sigma-1)\frac{s_f h^l_f z^l_{f,i}}{1-s_f h^l_f z^l_{f,i}}}{1+(\sigma-1)\frac{s_f h^l_f z^l_{f,i}}{1-s_f h^l_f z^l_{f,i}}}$ is convex in $z^l_{f,i}$, since $\Psi^l_f = \sum_{i=1}^N m(z_{f,i})$:

$$
m'_{\Psi_f} = \frac{(\sigma-1)\, s_f z_{f,i}\left((\sigma-2)\, s_f z_{f,i} + 2\right)}{\left((\sigma-2)\, s_f z_{f,i} + 1\right)^2} \tag{A.29}
$$

$$
m''_{\Psi_f} = \frac{2\,(\sigma-1)\, s_f}{\left((\sigma-2)\, s_f z_{f,i} + 1\right)^3} > 0 \tag{A.30}
$$

Which proves that a mean preserving spread of Ψ^l_f increases its value and therefore it is a proper firm concentration measure.

A.2.3 Proposition 3. Industry Price Index Elasticity.

A.2.3.1 Decomposition

Totally differentiating the price index I get:

$$d\log P = h^l d\log P^l + (1-h^l) d\log P^s \tag{A.31}$$

where $h^l = \frac{(P^l)^{1-\sigma}}{(P^l)^{1-\sigma}+(P^s)^{1-\sigma}}$. Hence, I can derive the impact on each subset of firms and then add them up.

Large Firms. Rewriting the price index of domestic and foreign large firms directly as a function of the individual firms' prices we get:

$$\begin{aligned} d\log P^l &= s^l_f d\log P^l_f + (1-s^l_f) d\log P^l_d && \text{(A.32)} \\ &= s^l_f \sum_{k=i}^{N^l_f} z^l_{f,k} d\log p^l_{f,k} + (1-s^l_f) \sum_{k=i}^{N^l_d} z^l_{d,k} d\log p^l_{d,k} && \text{(A.33)} \end{aligned}$$

where $s^l_f = \frac{(P^l_f)^{1-\sigma}}{(P^l_f)^{1-\sigma}+(P^l_d)^{1-\sigma}}$.

We already derived $d\log p^l_{f,k} = \frac{\psi^l_{f,k}}{1+\psi^l_{f,k}} d\log P - \frac{\psi^l_{f,k}}{1+\psi^l_{f,k}} d\log\tau$ when proving Proposition 1, thus:

$$\begin{aligned}
d\log P^l &= s^l_f \sum_{k=i}^{N^l_f} z^l_{f,k}[\frac{\psi^l_{f,k}}{1+\psi^l_{f,k}} d\log P + \\
&+ \frac{1}{1+\psi^l_{f,k}} d\log\tau] + (1-s^l_f)\sum_{k=i}^{N^l_d} z^l_{d,k}\frac{\psi^l_{d,k}}{1+\psi^l_{d,k}} d\log P \\
&= s^l_f \Psi^l_f \log P + s^l_f(1-\Psi^l_f) d\log\tau + (1-s^l_f)\Psi^l_d d\log P \\
&= \Psi^l \log P + s^l_f(1-\Psi^l_f) d\log\tau \qquad \text{(A.34)}
\end{aligned}$$

where I used the definition $\Psi^l_f \equiv \sum_{k=i}^{N^l_f} z^l_{f,k}\frac{\psi^l_{f,k}}{1+\psi^l_{f,k}}$, the fact that $1-\Psi^l_f = \sum_{k=i}^{N^l_f} z^l_{f,k}\frac{1}{1+\psi^l_{f,k}}$, and I defined $\frac{\partial \log P^l}{\partial \log P} \equiv s^l_f \Psi^l_f + (1-s^l_f)\Psi^l_d \equiv \Psi$.

Small Firms. We can analogously write the change in small firms' price index as follows:

$$d\log P^s = s^s_f d\log P^s_f + (1-s^s_f) d\log P^s_d \qquad \text{(A.35)}$$

where $s^s_f = \frac{(P^s_f)^{1-\sigma}}{(P^s_f)^{1-\sigma}+(P^s_d)^{1-\sigma}}$.

The foreign price index for small firms is as follows:

$$\begin{aligned}
(P^s_f)^{1-\sigma} &= N\int_{c^s_L}^{c^s_{f,*}} p(c)^{1-\sigma} dG^s(j) \\
&= kN\frac{\tilde{\mu}^{1-\sigma}T_f^{1-\sigma}\tau^{1-\sigma}}{(c^s_H)^k-(c^s_L)^k}\int_{c^s_L}^{c^s_{f,*}} (c^s)^{k-\sigma} d(c^s) \\
&= kN\frac{\tilde{\mu}^{1-\sigma}T_f^{1-\sigma}\tau^{1-\sigma}}{(c^s_H)^k-(c^s_L)^k}\Big[\frac{(c^s)^{k-(\sigma-1)}}{k-(\sigma-1)}\Big]\Big|_{c^s_L}^{c^s_{f,*}}
\end{aligned}$$

$$= \quad kN\frac{\tilde{\mu}^{1-\sigma}T_f^{1-\sigma}\tau^{1-\sigma}}{(c_H^s)^k-(c_L^s)^k}\Big[\frac{(c_{f,*}^s)^{k-(\sigma-1)}-(c_L^s)^{k-(\sigma-1)}}{k-(\sigma-1)}\Big] \tag{A.36}$$

where I need that $k-(\sigma-1)>0$ to have a well-defined Pareto distribution of sales.

Differentiating this expression yields:

$$d\log(P_f^s)^{1-\sigma} \quad = \quad (1-\sigma)d\log\tau+\lambda_f^s d\log c_{f,*}^s \tag{A.37}$$

where $\lambda_f=(k-(\sigma-1))\frac{(c_{f,*}^s)^{k-(\sigma-1)}}{(c_{f,*}^s)^{k-(\sigma-1)}-(c_L^s)^{k-(\sigma-1)}}$ is the hazard function of foreign sales distribution under bounded Pareto. Since $c_{f,*}^s=\frac{P}{T_f}\Big[\frac{\tilde{\sigma}E}{(1-\beta)K}\Big]^{\frac{1}{\sigma-1}}\tau^{-\frac{\sigma}{\sigma-1}}$ we have:

$$\begin{aligned}
d\log(P_f^s)^{1-\sigma} &= (1-\sigma)d\log\tau+\lambda_f^s d\log\Big[\frac{P}{T_f}\Big[\frac{\tilde{\sigma}E}{(1-\beta)K}\Big]^{\frac{1}{\sigma-1}}\tau^{-\frac{\sigma}{\sigma-1}}\Big]\\
&= (1-\sigma)d\log\tau+\lambda_f^s d\log P-\lambda_f^s\frac{\sigma}{\sigma-1}d\log\tau\\
&= \lambda_f^s d\log P-(\sigma-1)\Big[1+\frac{\lambda_f^s}{\sigma-1}\frac{\sigma}{\sigma-1}\Big]d\log\tau
\end{aligned} \tag{A.38}$$

where I assumed exogenous T_f and E. The small domestic firms price index is analogous but without the direct tariff impact. Therefore, both effects are:

$$d\log P_f^s=-\Lambda_f^s d\log P+\Big[1+\Lambda_f^s\frac{\sigma}{\sigma-1}\Big]d\log\tau \tag{A.39}$$

$$d\log P_d^s=-\Lambda_d^s d\log P \tag{A.40}$$

where I defined $\Lambda_f^s \equiv \frac{\lambda_f^s}{\sigma-1}$ as in the text.

Therefore, the total impact of small firms is:

$$\begin{aligned} d\log P^s &= s_f^s\Big[-\Lambda_f^s d\log P + \Big[1+\Lambda_f^s\frac{\sigma}{\sigma-1}\Big]d\log\tau\Big] + (1-s_f^s)\Big[-\Lambda_d^s d\log P\Big] \\ &= -\Lambda^s d\log P + s_f^s\Big[1+\Lambda_f^s\frac{\sigma}{\sigma-1}\Big]d\log\tau \end{aligned} \tag{A.41}$$

where $\Lambda^s \equiv s_f^s\Lambda_f^s + (1-s_f^s)\Lambda_d^s$.

Total Impact. To derive the total impact of τ on P we put together previous derivations:

$$\begin{aligned} d\log P &= h^l\Big[\Psi^l d\log P + s_f^l(1-\Psi_f^l)d\log\tau\Big] + \\ &+ (1-h^l)\Big[-\Lambda^s d\log P + s_f^s(1+\Lambda_f^s\frac{\sigma}{\sigma-1})d\log\tau\Big] \\ &= \Big[h^l\Psi^l - (1-h^l)\Lambda^s\Big]d\log P + \\ &+ \Big[h^l s_f^l(1-\Psi_f^l) + (1-h^l)s_f^s(1+\Lambda_f^s\frac{\sigma}{\sigma-1})\Big]d\log\tau \end{aligned} \tag{A.42}$$

Defining $H \equiv 1 - h^l\Psi^l + (1-h^l)\Lambda^s$ yields:

$$\frac{d\log P}{d\log\tau} = \frac{h^l s_f^l(1-\Psi_f^l) + (1-h^l)s_f^s(1+\Lambda_f^s\frac{\sigma}{\sigma-1})}{H} \tag{A.43}$$

Decomposition. We can write the pride index elasticity as follows:

$$\frac{d\log P}{d\log\tau} = \Theta^l + \Theta^s \tag{A.44}$$

where $\Theta^l \equiv \frac{h^l s_f^l(1-\Psi_f^l)}{H}$ and $\Theta^s \equiv \frac{(1-h^l)s_f^s(1+\tilde{\Lambda_f^s})}{H}$, and $\tilde{\Lambda_f^s} \equiv \Lambda_f^s \frac{\sigma}{\sigma-1}$. Then, we can work on each term of the elasticity:

$$\begin{aligned}
\Theta^l &= \frac{h^l s_f^l}{H} - \frac{h^l s_f^l \Psi_f^l}{H} \\
&= h^l s_f^l + \frac{h^l s_f^l}{H}(1-H) - \frac{h^l s_f^l \Psi_f^l}{H} \\
&= h^l s_f^l + \frac{h^l s_f^l}{H}(h^l\Psi^l - h^l\Psi_f^l + h^l\Psi_f^l - (1-h^l)\Lambda^s) - \frac{h^l s_f^l \Psi_f^l}{H} \\
&= h^l s_f^l + (h^l)^2 \frac{s_f^l(1-s_f^l)}{H}(\Psi_d^l - \Psi_f^l) - s_f^l \frac{h^l(1-h^l)}{H}(\Psi_f^l + \Lambda^s) \qquad \text{(A.45)} \\
\Theta^s &= \frac{(1-h^l)s_f^s(1+\tilde{\Lambda_f^s})}{H} \\
&= (1-h^l)s_f^s + \frac{(1-h^l)s_f^s}{H}(1-H) + \frac{(1-h^l)s_f^s\tilde{\Lambda_f^s}}{H} \\
&= (1-h^l)s_f^s + \frac{(1-h^l)^2 s_f^s}{H}(\Lambda_f^s - \Lambda^s) - \frac{(1-h^l)s_f^s}{H}(1-h^l)\Lambda_f^s + \\
&+ \frac{(1-h^l)s_f^s}{H}h^l\Psi^l + \frac{(1-h^l)s_f^s\tilde{\Lambda_f^s}}{H} \\
&= (1-h^l)s_f^s + \frac{(1-h^l)^2 s_f^s}{H}(\Lambda_f^s - s_f^s\Lambda_f^s - (1-s_f^s)\Lambda_d^s) + \\
&+ \frac{(1-h^l)s_f^s}{H}(\tilde{\Lambda_f^s} - (1-h^l)\Lambda_f^s + h^l\Psi^l) \\
&= (1-h^l)s_f^s + (1-h^l)^2\frac{s_f^s(1-s_f^s)}{H}(\tilde{\Lambda}_f^s - \tilde{\Lambda}_d^s) + \\
&+ s_f^s\frac{(1-h^l)h^l}{H}(a\Lambda_f^s + \Psi^l) \qquad \text{(A.46)}
\end{aligned}$$

where $a \equiv \frac{h^l(\sigma-1)+1}{h^l(\sigma-1)}$. Adding both terms yields the final result:

$$\frac{d\log P}{d\log\tau} = s_f + (h^l)^2\frac{s_f^l(1-s_f^l)}{H}(\Psi_d^l - \Psi_f^l) + (1-h^l)^2\frac{s_f^s(1-s_f^s)}{H}(\Lambda_f^s - \Lambda_d^s) +$$
$$+ \frac{(1-h^l)h^l}{H}\Big[s_f^s(1-s_f^l)[\Psi_d^l + b\Lambda_f^s] - (1-s_f^s)s_f^l[\Psi_f^l + \Lambda_d^s]\Big] \quad (A.47)$$

where $b \equiv \frac{a-s_f^l}{1-s_f^l}$. Note that $b=1$ in the case of $\frac{d\log P}{d\log T_f}$ because the cost cutoff elasticity with respect to the price index and trade costs is the same.

A.2.3.2 Sign

This result follows directly from equation A.43. We can further reduced it by noting that $h^l s_f^l = s_f h_f^l$ and hence $h^l s_f^l + (1-h^l)s_f^s = s_f$:

$$\frac{d\log P}{d\log\tau} = s_f\frac{\tilde{H}_f}{H} \quad (A.48)$$

where $\tilde{H}_f \equiv 1 - h_f^l\Psi_f^l + (1-h_f^l)\Lambda_f^s\frac{\sigma}{\sigma-1}$.

Given that $1-h^l\Psi^l$ and $1-h_f^l\Psi_f^l$ are both positive because both h^l and Ψ^l are between zero and one, this expression is always negative.

In terms of the upper bound, note that we can be write the elasticity as follows:

$$\frac{d\log P}{d\log\tau} = \frac{s_f H_f}{s_f H_f + (1-s_f)H_d} + \frac{(1-h_f^l)\Lambda_f^l}{(\sigma-1)H} \quad (A.49)$$

where $H_r \equiv 1 - h_r^l \Psi_r^l + (1 - h_r^l)\Lambda_r^s$ and the last term corrects for the fact that tariffs are paid by consumers, not producers. In the potential extreme case in which there are only foreign small firms we have that:

$$1 + \frac{\Lambda_f^l}{(\sigma - 1)(1 + \Lambda_f^l)} = \frac{\sigma}{\sigma - 1} - \frac{1}{(\sigma - 1)(1 + \Lambda_f^l)} \tag{A.50}$$

because in this case $H = H_f = 1 + \Lambda_f^l$ and $h_f^l = 0$. Given that $\Lambda_f^l \in (0, +\infty)$, then $\frac{d \log P}{d \log \tau}$ cannot take values higher than $\frac{\sigma}{\sigma - 1}$.

Note that in the case of the price index elasticity relative to trade costs paid by producers, T_f, the upper bound is 1 because the last term in equation A.49 is not present.

A.2.4 Proposition 4. Domestic Concentration and Competition.

A.2.4.1 Decomposition

In order to prove part (a) of this proposition, I will employ any proper concentration measure increasing in market shares $\mathcal{C}$, noting the special case of homogeneous concentration functions $\mathcal{C}_h = \sum_{i=1}^{N_d^l} (z_{d,i}^l)^t$, with $t > 1$. When $t = 2$ then $\mathcal{C}_h = HHI$.

Let's start by the general definition of $\mathcal{C}$:

$$\mathcal{C}^l(\{z_{d,i}\}_{i=1}^N) = \sum_{i=1}^{N} m(z_{d,i}; W_d) \tag{A.51}$$

where $m(z_{d,i}; W_d)$ is a function of internal market shares $z_{d,i}$ and can contain other factors, which I summarize in W_d. The theoretical version of it needs to consider the continuum of small firms. Hence, the full concentration measure is:

$$\mathcal{C}(\{z_{d,i}\}_{i=1}^N) = \sum_{i=1}^{N_d} m[h_d^l z_{d,i}^l] + \int_{c_L^s}^{c_{d,*}^s} m[(1-h_d^l) z^s(j)] dG^s(j) \tag{A.52}$$

Large Firms.

$$\begin{aligned} d\log\left[\sum_{i=1}^{N} m[h_d^l z_{d,i}^l]\right] &= \sum_{i=1}^{N} \gamma_{d,i}^l \iota_i^l [d\log z_{d,i}^l + d\log h_d^l] \\ &= \sum_{i=1}^{N_d} \gamma_{d,i}^l \iota_i^m d\log z_{d,i}^l + \iota^{m,l} d\log h_d^l \end{aligned} \tag{A.53}$$

where $\gamma_{d,i}^l = \frac{m[h_d^l z_{d,i}]}{\sum_{k=1}^{N_d} m[h_d^l z_{d,k}]}$ are $\mathcal{C}$-specific weights and $\iota_i^m = \frac{m_i' h_d^l z_{d,i}}{m_i}$ is the elasticity of m with respect to the domestic market share of i, where I define $\iota^{m,l} = \sum_{i=1}^{N_d} \gamma_{d,i}^l \iota_i^m$ to be the weighted elasticity of changes in the large firm aggregate market share.

The first term captures reallocation within large firms:

$$
\begin{aligned}
\sum_{i=1}^{N_d} \gamma_{d,i}^l \iota_i^m d\log z_{d,i}^l &= \sum_{i=1}^{N_d} \gamma_{d,i}^l \iota_i^m \Big[d\log(p_{d,i}^l)^{1-\sigma} - d\log(P_d^l)^{1-\sigma} \Big] \\
&= (1-\sigma)\sum_{i=1}^{N_d} \gamma_{d,i}^l \iota_i^m d\log p_{d,i}^l - \iota^{m,l}(1-\sigma)\sum_{i=1}^{N_d} z_{d,i}^l d\log p_{d,i}^l \\
&= (1-\sigma)\iota^{m,l} \sum_{i=1}^{N_d} \Big[\tilde{\gamma}_{d,i}^l - z_{d,i}^l \Big] d\log p_{d,i}^l \qquad \text{(A.54)}
\end{aligned}
$$

where $\tilde{\gamma}_{d,i}^l \equiv \gamma_{d,i}^l \frac{\iota_i^m}{\iota^{m,l}} \in (0,1)$.

Assuming that the concentration function is homogeneous of degree t simplifies this expression due to the following:

$$
\iota_i^m = \frac{m_i' h_d^l z_{d,i}}{m_i} = \frac{(h_d^l z_{d,i})^{t-1} h_d^l z_{d,i}}{(h_d^l z_{d,i})^t} = t
$$

and implies $\iota^{m,l} = t$ and $\tilde{\gamma}_{d,i}^l = \gamma_{d,i}^l = \frac{z_{d,i}^t}{\sum_{k=1}^{N_d} z_{d,i}^t}$. As a result, the term for large firms is $t(1-\sigma)\sum_{i=1}^{N_d} \Big[\gamma_{d,i}^l - z_{d,i}^l \Big] d\log p_{d,i}^l$ in the case of $\mathcal{C}_h$.

Small Firms. Small firms are atomistic so the effect of competition on concentration acts through changes in the productivity distribution of firms that enter.

$$
\begin{aligned}
&\int_{c_L^s}^{c_{d,*}^s} m[(1-h_d^l)z(j)]dG^s(j) = \\
&= \int_{c_L^s}^{c_{d,*}^s} m[(1-h_d^l)z(j)]d\Big[\frac{(c^s)^k - (c_L^s)^k}{(c_H^s)^k - (c_L^s)^k} \Big]
\end{aligned}
$$

$$= \frac{k}{(c_H^s)^k - (c_L^s)^k} \int_{c_L^s}^{c_{d,*}^s} m[(1-h_d^l)\frac{p(c)^{1-\sigma}}{(P_d^s)^{1-\sigma}}](c^s)^{k-1} d(c^s) \tag{A.55}$$

At this point I assume that m is homogeneous of degree t, which means that $m[\frac{p(c)^{1-\sigma}}{P_d^{1-\sigma}}] = \left[\frac{p(c)^{1-\sigma}}{P_d^{1-\sigma}}\right]^t$.

$$\begin{aligned}
\int_{c_L^s}^{c_{d,*}^s} m[(1-h_d^l)z(j)]dG^s(j) = \\
= \frac{k}{(c_H^s)^k - (c_L^s)^k} \int_{c_L^s}^{c_{d,*}^s} m[\frac{p(c)^{1-\sigma}}{P_d^{1-\sigma}}](c^s)^{k-1} d(c^s) \\
= \frac{k}{(c_H^s)^k - (c_L^s)^k} \frac{(1-h_d^l)^t}{(P_d^s)^{t(1-\sigma)}} \int_{c_L^s}^{c_{d,*}^s} p(c)^{t(1-\sigma)}(c^s)^{k-1} d(c^s) \\
= \frac{k(1-h_d^l)^t}{(c_H^s)^k - (c_L^s)^k} \frac{\tilde{\mu}^{t(1-\sigma)} T_d^{t(1-\sigma)}}{(P_d^s)^{t(1-\sigma)}} \int_{c_L^s}^{c_{d,*}^s} (c^s)^{t(1-\sigma)+k-1} d(c^s) \\
= \frac{k(1-h_d^l)^t}{(c_H^s)^k - (c_L^s)^k} \frac{\tilde{\mu}^{t(1-\sigma)} T_d^{t(1-\sigma)}}{(P_d^s)^{t(1-\sigma)}} \Big[\frac{(c_{d,*}^s)^{k-t(\sigma-1)} - (c_L^s)^{k-t(\sigma-1)}}{k-t(\sigma-1)}\Big]
\end{aligned} \tag{A.56}$$

where I need that $k - t(\sigma-1) > 0$ to have a well-defined Pareto distribution of sales to the power of t.

Taking logs and differentiating this expression yields:

$$\begin{aligned}
d\log \int_{c_L^s}^{c_{d,*}^s} m[(1-h_d^l)z(j)]dG^s(j) &= td\log(1-h_d^l) + \lambda_{t,d}^s d\log P + \\
&+ t(\sigma-1)d\log P_d^s
\end{aligned} \tag{A.57}$$

where $\lambda_{t,d}^s \equiv [k-t(\sigma-1)]\frac{c_{d,*}^{k-t(\sigma-1)}}{c_{d,*}^{k-t(\sigma-1)} - c_L^{k-t(\sigma-1)}}$ and I used that $d\log c_{d,*}^s = d\log P$. Given that $(1-\sigma)d\log P_d^s = \lambda_d^s d\log c_{d,*}^s$ we get:

$$d\log\int_{c_L^s}^{c_{d,*}^s} m[(1-h_d^l)z(j)]dG^s(j) = td\log(1-h_d^l) + [\lambda_{t,d}^s - t\lambda_d^s]d\log P \qquad \text{(A.58)}$$

Total Impact. Adding up both derivations in the case of homogeneous concentration functions yields:

$$\begin{aligned} d\log\mathcal{C}_h &= t(1-\sigma)\sum_{i=1}^{N_d}\Big[\gamma_{d,i}^l - z_{d,i}\Big]\frac{\psi_{d,i}^l}{1+\psi_{d,i}^l}d\log P + \\ &+ [\lambda_{t,d}^s - t\lambda_d^s]d\log P + t\frac{1-2h_d^l}{1-h_d^l}d\log h_d^l \end{aligned} \qquad \text{(A.59)}$$

where I used $d\log p_{d,i}^l = \frac{\psi_{d,i}^l}{1+\psi_{d,i}^l}d\log P$.

The change in $\log h_d^l$ captures the reallocation of market share between large and small firms and is as follows:

$$\begin{aligned} d\log h_d^l &= (1-\sigma)\Big[\sum_{i=1}^{N_d} z_{d,i}d\log p_{d,i} - d\log P_d\Big] \\ &= (1-\sigma)\Psi_d^l d\log P - (1-\sigma)h_d^l d\log P_d^l - (1-\sigma)(1-h_d^l)d\log P_d^s\Big] \\ &= (1-h_d^l)(1-\sigma)[\Psi_d^l + \Lambda_d^s]d\log P \end{aligned} \qquad \text{(A.60)}$$

Replacing this last derivation into the main expression and rearranging yields the result:

$$
\begin{aligned}
\frac{d\log \mathcal{C}_h}{d\log P} &= t(1-\sigma)\sum_{i=1}^{N_d}\left[\gamma^l_{d,i} - z_{d,i}\right]\frac{\psi^l_{d,i}}{1+\psi^l_{d,i}} + [\lambda^s_{t,d} - t\lambda^s_d] + \\
&+ t(1-2h^l_d)(1-\sigma)[\Psi^l_d + \Lambda^s_d] \qquad (A.61)
\end{aligned}
$$

Setting $t = 2$ yields $\frac{d\log HHI}{d\log P}$ in text.

A.2.4.2 Sign

I follow the same approach than in the proof of Proposition 4 where I use any concentration measure homogeneous of degree t and note that the HHI is a special case when $t = 2$.

Sign of the Large Firms Effect. I need to prove that $\sum_{i=1}^{N_d}\left[\gamma^l_{d,i} - z_{d,i}\right]\frac{\psi^l_{d,i}}{1+\psi^l_{d,i}} > 0$ which means that the sign of the large firms effect is negative (since it is multiplied by $(1-\sigma)$).

(1) First, I need to show that there exists a firm $i*$ above which $\gamma_i - z_i > 0$. For any i, we can write it as follows:

$$
\begin{aligned}
\gamma_i - z_i &= \frac{z_i^t}{\sum_{j=1}^N z_j^t} - z_i \\
&= \frac{\omega_i z_i}{\sum_{j=1}^N \omega_j z_j} - z_i \qquad (A.62)
\end{aligned}
$$

where $\omega_i = \frac{z_i^{t-1}}{\sum_{j=1}^N z_j^{t-1}}$ are weights that put more weight on larger firms given that $t > 1$. Define $\bar{\omega} = 1/N$ as the particular case for which all shares are equally weighted. Given that $\sum_{j=1}^{N} z_j = 1$, we can write it as:

$$\gamma_i - z_i = \frac{\omega_i z_i}{\sum_{j=1}^{N} \omega_j z_j} - \frac{\bar{\omega} z_i}{\sum_{j=1}^{N} \bar{\omega} z_j} \tag{A.63}$$

This expression shows that it is the difference of the contribution of observation i between using ω_i and $\bar{\omega}$ weights.

I claim there is a i^* such that:

(i) $\gamma_i - z_i \geq 0$ if $i^* \geq i$

(ii) $\gamma_i - z_i < 0$ if $i^* < i$

To prove claim (i), assume that $i \geq i^*$ and $\gamma_i - z_i < 0$:

$$\frac{\omega_i z_i}{\sum_{j=1}^{N} \omega_j z_j} < \frac{\bar{\omega} z_i}{\sum_{j=1}^{N} \bar{\omega} z_j} \tag{A.64}$$

but given that ω_i is increasing in z_i, then the contribution of $i > i^*$ has to be higher for these weights. Thus, $\gamma_i - z_i > 0$ for $i > i^*$.

To prove claim (ii), we can follow the same logic assuming that $l < i^*$ and $\gamma_l - z_l \geq 0$:

$$\frac{\omega_l z_l}{\sum_{j=1}^{N} \omega_j z_j} \geq \frac{\bar{\omega} z_l}{\sum_{j=1}^{N} \bar{\omega} z_j} \tag{A.65}$$

but given that ω_l is increasing in z_l, then the contribution of $i < i^*$ has to be lower for these weights. Thus, $\gamma_l - z_l \leq 0$ for $i < i^*$.

(2) Define $X_i = \frac{\psi^l_{d,i}}{1+\psi^l_{d,i}}$ and $Z_i = \gamma^l_{d,i} - z^l_{d,i}$. Define two sets of firms: A for firms such as $i^* \geq i$ and B for firm such as $i^* > i$. Since X_i is increasing in z_i then $X^B_i > X^A_j$ for any $i \in A$ and $j \in B$. Lets assume that the expression is negative:

$$Z^A \sum_{i \in A} Z^A_i X_i + Z^B \sum_{i \in B} Z^B_i X_i < 0 \tag{A.66}$$

where $Z^A = \sum_{i \in A} Z_i$, $Z^B = \sum_{i \in B} Z_i$, and $Z^A_i = Z_i / Z^A$ and $Z^B_i = Z_i / Z^B$. Note that $Z^A + Z^B = 0$ and thus:

$$\begin{aligned} -Z^B \sum_{i \in A} Z^A_i X_i + Z^B \sum_{i \in B} Z^B_i X_i &< 0 \\ Z^B \sum_{i \in B} Z^B_i X_i &< Z^B \sum_{i \in A} Z^A_i X_i \\ \sum_{i \in B} Z^B_i X_i &< \sum_{i \in A} Z^A_i X_i \end{aligned} \tag{A.67}$$

The left hand side is a weighted average of all X_i in B and the right hand side is a weighted average of all X_i in A. Since we assumed that $X^B_i > X^A_j$ for any $i \in A$ and $j \in B$ we arrived to a contradiction. Therefore:

$$Z^A \sum_{i \in A} Z^A_i X_i + Z^B \sum_{i \in B} Z^B_i X_i > 0 \tag{A.68}$$

which proves that $(1-\sigma)t\sum_{i=1}^{N_d}\left[\gamma^l_{d,i}-z_{d,i}\right]\frac{\psi^l_{d,i}}{1+\psi^l_{d,i}}<0$.

Sign of the Small Firms Effect. Assume the sign is positive:

$$\begin{aligned}
\lambda^s_{t,d}-t\lambda^s_d &> 0\\
t\lambda^s_d\left(\frac{\lambda^s_{t,d}}{t\lambda^s_d}-1\right) &> 0\\
\frac{\lambda^s_{t,d}}{t\lambda^s_d}-1 &> 0\\
\frac{\frac{(c^s_{d,*})^{k-t(\sigma-1)}}{(c^s_{d,*})^{k-t(\sigma-1)}-(c^s_L)^{k-t(\sigma-1)}}}{\frac{(c^s_{d,*})^{k-(\sigma-1)}}{(c^s_{d,*})^{k-(\sigma-1)}-(c^s_L)^{k-(\sigma-1)}}}\frac{k-t(\sigma-1)}{tk-t(\sigma-1)} &> 1\\
\frac{1-v^{k-(\sigma-1)}}{1-v^{k-t(\sigma-1)}}\frac{k-t(\sigma-1)}{tk-t(\sigma-1)} &> 1 \qquad \text{(A.69)}
\end{aligned}$$

where $v\equiv\frac{c^s_L}{c^s_{d,*}}\in(0,1)$. This means we can define the LHS as the function $\mathcal{F}(t;\sigma,k,v)$ and given that $t\in(1,\infty)$, check the limit of $\mathcal{F}$ at both boundaries:

$$\begin{aligned}
\lim_{t\to\infty}\mathcal{F}(t;\sigma,k,v) &= \lim_{t\to\infty}\left[\frac{1-v^{k-(\sigma-1)}}{1-v^{k-t(\sigma-1)}}\frac{k-t(\sigma-1)}{tk-t(\sigma-1)}\right]\\
&= \lim_{t\to\infty}\left[\frac{1-v^{k-(\sigma-1)}}{1-v^{k-t(\sigma-1)}}\right]\lim_{t\to\infty}\left[\frac{\frac{k}{t}-(\sigma-1)}{k-(\sigma-1)}\right]\\
&= \frac{1-v^{k-(\sigma-1)}}{k-(\sigma-1)}\frac{\lim_{t\to\infty}\frac{k}{t}-(\sigma-1)}{\lim_{t\to\infty}(1-v^{k-t(\sigma-1)})}\\
&= 0 \qquad \text{(A.70)}
\end{aligned}$$

where the last result follows from $\lim_{t\to\infty}\frac{k}{t}=0$ and $\lim_{t\to\infty}v^{k-t(\sigma-1)}=\infty$. This means that as t increases the impact of P on small firms concentration is negative because the inequality A.69 is a contradiction.

When $t \to 1^+$, we have:

$$\lim_{t\to 1^+} \mathcal{F}(t;\sigma,k,v) \;=\; 1 \tag{A.71}$$

Therefore, if $\frac{d\mathcal{F}}{dt} < 0$ for all $t \in (1,\infty)$, the inequality A.69 is contradiction for all t in its support:

$$\frac{d\mathcal{F}}{dt} \;=\; \frac{1-v^{k-(\sigma-1)}}{k-(\sigma-1)} \frac{d\left[\frac{\frac{k}{t}-(\sigma-1)}{(1-v^{k-t(\sigma-1)})}\right]}{dt} < 0 \tag{A.72}$$

where the sign follows from $\frac{1-v^{k-(\sigma-1)}}{k-(\sigma-1)} > 0$ and $\frac{d\left[\frac{\frac{k}{t}-(\sigma-1)}{(1-v^{k-t(\sigma-1)})}\right]}{dt} < 0$. Therefore, A.69 is a contradiction for all the support and hence the sign of the small firms effect is negative. Note that this includes $t = 2$, the HHI particular case.

Sign of the Cross-Effect. The sign of the cross-size effect depends on the relative market share between small domestic and large firms. If we assume that large domestic firms have more than half of the market ($h_d^l > \frac{1}{2}$), then this term is negative because both Ψ_d^l and Λ_d^s are positive.

Overall sign. The large and small firms' effects are negative. Given that the cross-size effect is positive if $h_d^l < \frac{1}{2}$, then having $h_d^l \geq \frac{1}{2}$ is sufficient to have a negative overall effect.

A.2.5 Proposition 5. Oligopoly-Augmented Gravity Equation and Partial Trade Elasticity.

We can write total exports from c to d as follows:

$$M_{cd} = M^l_{cd} + M^s_{cd} \tag{A.73}$$

Log-differentiating this equation yields:

$$d\log M_{cd} = h^l_{cd} d\log M^l_{cd} + (1 - h^l_{cd}) d\log M^s_{cd} \tag{A.74}$$

I proceed by deriving each term separately.

Large Firms. The change in total imports of large firms' varieties can be calculated as the change in the expenditure share given the exogeneity of E:

$$\begin{aligned} d\log M^l_{cd} &= (1-\sigma)\Big[\frac{\partial \log P^l_{cd}}{\partial \log \tau_{cd}} d\log \tau_{cd} + \frac{\partial \log P^l_{cd}}{\partial \log T_{cd}} d\log T_{cd} + \frac{\partial \log P^l_{cd}}{\partial \log P_d} d\log P\Big] - \\ &- d\log P_d^{1-\sigma} + d\log E_d \\ &= (1-\sigma)(1-\Psi^l_{cd})\Big[d\log \tau_{cd} + d\log T_{cd} - d\log P_d\Big] + d\log E_d \end{aligned} \tag{A.75}$$

given that $\frac{\partial \log P^l_{cd}}{\partial \log \tau_{cd}} = \frac{\partial \log P^l_{cd}}{\partial \log T_{cd}} = (1 - \Psi^l_{cd})$ and $\frac{\partial \log P^l_{cd}}{\partial \log P_d} = \Psi^l_{cd}$ as shown in

Proposition 1.

Small Firms. To derive total imports of small firms' varieties, which includes entry, we need to calculate M_f^s by integrating over the support of c.

$$
\begin{aligned}
M_{cd}^s &= N_{cd}^s \int_{c_L^s}^{c_{cd*}^s} E_d P_d^{\sigma-1} (p^s(c))^{1-\sigma} dG^s(c^s) \\
&= k \frac{N_{cd}^s E_d P_d^{\sigma-1} \tau_{cd}^{1-\sigma} T_{cd}^{1-\sigma} \tilde{\mu}^{1-\sigma}}{(c_H^s)^k - (c_L^s)^k} \int_{c_L^s}^{c_{cd*}^s} (c^s)^{k-\sigma} dc \\
&= k \frac{N_{cd}^s E_d P_d^{\sigma-1} \tau_{cd}^{1-\sigma} T_{cd}^{1-\sigma} \tilde{\mu}^{1-\sigma}}{k-\sigma+1} \Big[\frac{(c_{cd*}^s)^{k-\sigma+1} - (c_L^s)^{k-\sigma+1}}{(c_H^s)^{k-\sigma+1} - (c_L^s)^{k-\sigma+1}} \Big] \qquad \text{(A.76)}
\end{aligned}
$$

Differentiating this equation and using $c_{cd*}^s = \frac{P_d}{T_{cd}} \left[\frac{\tilde{\sigma} E_d}{(1-\beta)K} \right]^{\frac{1}{\sigma-1}} \tau_{cd}^{-\frac{\sigma}{\sigma-1}}$ we get:

$$
\begin{aligned}
d\log M_{cd}^s &= (1-\sigma)\Big[1 + \Lambda_{cd}^s\Big]\Big[d\log T_{cd} + \frac{\sigma}{\sigma-1} d\log \tau_{cd} - d\log P_d\Big] + \\
&+ \Big[1 + \Lambda_{cd}^s\Big] d\log E_d + d\log N_{cd} \qquad \text{(A.77)}
\end{aligned}
$$

All Firms. Using equation A.74 I get:

$$
\begin{aligned}
d\log M_{cd} &= (1-\sigma)\Big[1 + (1-h_{cd}^l)\Lambda_{cd}^s - h_{cd}^l \Psi_{cd}^l\Big]\Big[d\log T_{cd} + \frac{\sigma}{\sigma-1} d\log \tau_{cd} - \\
&- d\log P_d\Big] \\
&+ \Big[1 + (1-h_{cd}^l)\Lambda_{cd}^s\Big] d\log E_d + (1-h_{cd}^l) d\log N_{cd} \qquad \text{(A.78)}
\end{aligned}
$$

Where it can be seen that:

$$\theta_{cd}^{HC} \equiv \frac{\partial \log M_{cd}}{\partial \log T_{cd}} = (1-\sigma)\Big[1+(1-h_{cd}^{l})\Lambda_{cd}^{s} - h_{cd}^{l}\Psi_{cd}^{l}\Big] \quad (A.79)$$

$$\theta_{cd}^{HC,\tau} \equiv \frac{\partial \log M_{cd}}{\partial \log \tau_{cd}} = (1-\sigma)\Big[1+(1-h_{cd}^{l})\Lambda_{cd}^{s}\frac{\sigma}{\sigma-1} - h_{cd}^{l}\Psi_{cd}^{l}\Big] \quad (A.80)$$

A.2.6 Proposition 6. Trade Policy Uncertainty and Industry Characteristics.

The approximation of the uncertainty factor is written as follows:

$$\log U \approx -\tilde{\beta}\eta\Big[\frac{\sigma}{\sigma-1} - \varepsilon^{M}\Big]\log \tau^{M} m \quad (A.81)$$

Therefore, deriving the sign of the impact of variable y can be done as follows:

$$\begin{aligned} sign(\frac{\partial \log U}{\partial y}) &= sign(\frac{\partial \varepsilon}{\partial y}) \\ &= sign(\frac{\partial s_{\bar{c}}\frac{\tilde{H}_{\bar{c}}}{H}}{\partial y}) \\ &= sign(\frac{\partial s_{\bar{c}}\frac{H_{\bar{c}}+\frac{(1-h_{\bar{c}}^{l})\Lambda_{\bar{c}}^{s}}{\sigma-1}}{H}}{\partial y}) \end{aligned} \quad (A.82)$$

Using the previously defined equilibrium responses for countries facing and not facing uncertainty, $H_{\bar{c}} = 1 - h_{\bar{c}}^{l}\Psi_{\bar{c}}^{l} + (1+h_{\bar{c}}^{l})\Lambda_{\bar{c}}^{s} > 0$ and $H_{-\bar{c}} = 1 - h_{-\bar{c}}^{l}\Psi_{-\bar{c}}^{l} + (1-h_{-\bar{c}}^{l})\Lambda_{-\bar{c}}^{s} > 0$, and the overall equilibrium response $H = s_{\bar{c}}H_{\bar{c}} + (1-s_{\bar{c}})H_{-\bar{c}}$, I get the following derivatives:

$$
\begin{aligned}
\frac{\partial \varepsilon}{\partial s_{\bar{c}}} &= \frac{H_{-\bar{c}}\tilde{H}_{\bar{c}}}{H^2} > 0 & \text{(A.83)}\\
\frac{\partial \varepsilon}{\partial h^l_{\bar{c}}} &= \frac{\partial \varepsilon}{\partial \tilde{H}_{\bar{c}}} \times \frac{\partial \tilde{H}_{\bar{c}}}{\partial h^l_{\bar{c}}} + \frac{\partial \varepsilon}{\partial H_{\bar{c}}} \times \frac{\partial H_{\bar{c}}}{\partial h^l_{\bar{c}}} & \\
&= -(\Psi^l_{\bar{c}} + \Lambda^s_{\bar{c}}\frac{\sigma}{\sigma-1})\frac{s_{\bar{c}}}{H} + (\Psi^l_{\bar{c}} + \Lambda^s_{\bar{c}})\frac{s^2_{\bar{c}}\tilde{H}_{\bar{c}}}{H^2} & \\
&= -\Psi^l_{\bar{c}}\frac{s_{\bar{c}}}{H^2}(H - s_{\bar{c}}\tilde{H}_{\bar{c}}) - \Lambda^s_{\bar{c}}\frac{s_{\bar{c}}}{H^2}(\frac{\sigma}{\sigma-1}(1-s_{\bar{c}})H_{-\bar{c}} + & \\
&+ s_{\bar{c}}(\frac{1}{\sigma-1}(1 - h^l_{\bar{c}}\Psi^l_{\bar{c}})) < 0 & \text{(A.84)}\\
\frac{\partial \varepsilon}{\partial \Psi^l_{\bar{c}}} &= \frac{\partial \varepsilon}{\partial H_{\bar{c}}} \times \frac{\partial H_{\bar{c}}}{\partial \Psi^l_{\bar{c}}} & \\
&= \frac{s_{\bar{c}}}{H^2}\Big[H - s_{\bar{c}}\tilde{H}_{\bar{c}}\Big] \times (-h^l_{\bar{c}}) < 0 & \text{(A.85)}\\
\frac{\partial \varepsilon}{\partial \Psi^l_{-\bar{c}}} &= \frac{\partial \varepsilon}{\partial H_{-\bar{c}}} \times \frac{\partial H_{-\bar{c}}}{\partial \Psi^l_{-\bar{c}}} & \\
&= -\frac{s_{\bar{c}}(1-s_{\bar{c}})\tilde{H}_{\bar{c}}}{H^2} \times (-h^l_{-\bar{c}}) > 0 & \text{(A.86)}
\end{aligned}
$$

where I am assuming that $H - s_{\bar{c}}\tilde{H}_{\bar{c}} = (1-s_{\bar{c}})H_{-\bar{c}} - s_{\bar{c}}(\tilde{H}_{\bar{c}} - H_{\bar{c}}) > 0$, which is the small difference that arises in the case of foreign firms due to the difference in the cutoff elasticity between τ and P (if I use $T_{\bar{c}}$, which is paid by producers, this difference goes away).

A.2.7 Proposition 7. Oligopoly-Augmented Gravity Equation under Trade Policy Uncertainty

Trade policy uncertainty modifies the cutoff when we condition on the overall price effect, so we can write the change in imports as follows (where U captures the uncertainty state):

$$d\log M_{cd}^{U} = h_{cd}^{U,l} d\log M_{cd}^{U,l} + (1-h_{cd}^{U,l}) d\log M_{cd}^{U,s} \tag{A.87}$$

In the case of large firms, the equilibrium responses to small firms entry remain the same:

$$d\log M_{cd}^{U,l} = (1-\sigma)(1-\Psi_{cd}^{U,l})\Big[d\log \tau_{cd} + d\log T_{cd} - d\log P_d^U\Big] + d\log E_d \tag{A.88}$$

In the case of small firms, we have an additional term capturing uncertainty that comes from the uncertainty factor multiplying the cost cutoff in equation 3.2:

$$\begin{aligned} d\log M_{cd}^{U,s} &= (1-\sigma)\Big[1+\Lambda_{cd}^{U,s}\Big]\Big[d\log T_{cd} + \frac{\sigma}{\sigma-1} d\log \tau_{cd} - d\log P_d\Big] + \\ &+ \frac{\Lambda_{cpt}^{U,s}}{\sigma-1} d\log U \\ &+ \Big[1+\Lambda_{cd}^{U,s}\Big] d\log E_d + d\log N_{cd} \end{aligned} \tag{A.89}$$

Therefore, the total change in imports is the sum of the two:

$$d\log M_{cd}^{U} = (1-\sigma)\Big[1+(1-h_{cd}^{U,l})\Lambda_{cd}^{U,s} - h_{cd}^{U,l}\Psi_{cd}^{U,l}\Big]\Big[d\log T_{cd} + \frac{\sigma}{\sigma-1} d\log \tau_{cd} -$$

$$
\begin{aligned}
&- \quad d\log P_d^U\Big] + (1-h_{cd}^{U,l})\Lambda_{cd}^{U,s} d\log U_{cd} \\
&+ \quad \Big[1+(1-h_{cd}^{U,l})\Lambda_{cd}^{U,s}\Big] d\log E_d + (1-h_{cd}^{U,l}) d\log N_{cd} \qquad \text{(A.90)}
\end{aligned}
$$

This equation has the same structure but has an additional term capturing uncertainty. Therefore, we can capture the full expression as follows

$$
\begin{aligned}
d\log M_{cd}^U &= d\log \bar{M}_{cd}^U + (1-h_{cd}^{U,l})\Lambda_f^s d\log U_{cd} \\
&= d\log M_{cd}^D + d\log \frac{M_{cd}^U}{M_{cd}^D} + (1-h_{cd}^{U,l})\Lambda_f^s d\log U_{cd} \qquad \text{(A.91)}
\end{aligned}
$$

where the term $d\log \frac{\bar{M}_{cd}^U}{M_{cd}^D}$ captures how different imports are due to the equilibrium response of all firms to lower small firm entry.

Appendix B: Numerical Solution

The model is characterized by the set of equilibrium conditions defined in equations 1.8-1.14. In order to solve it numerically, I nest the equilibrium condition related to large firms into the conditions related to small firms. Specifically, I propose a cutoff for domestic and foreign firms and calculate the price index for small firms. Then I solve the oligopoly game played by large firms, conditional on the price index of small firms' varieties. With both indices, I construct the overall price index and the resulting entry cutoffs. I compare the latest with the initially proposed cutoffs and if the distance is outside the established tolerance, I iterate.

Formally, let's define the set of parameters $\Theta \equiv \{\sigma, k, K, \beta, c_L, c_H\}$, and the set of exogenous variables $\Xi \equiv \{E_d, N^e, N_d^l, N_f^l, \{c_{d,i}^l\}|_{i=1}^{N_d^l}, \{c_{f,i}^l\}|_{i=1}^{N_f^l}\}$, where $\{N_d^l, N_f^l\} \in \mathbb{Z}^+$, and a policy variable τ.[1]

Endogenous variables are $S \equiv \{c_{d,*}^s, c_{f,*}^s, P^s, \{z_{d,i}^l\}|_{i=1}^{N_d^l}, \{z_{f,i}^l\}|_{i=1}^{N_f^l}, s^l\}$.

Therefore, I conduct the following steps:

1. I propose an initial set of cutoffs $c^0 \equiv \{[c_{d,*}^s]^0, [c_{f,*}^s]^0\}$ and calculate $[P^s]^0 \equiv P^s(c^0; \tau, \Xi, \Theta)$.

[1]Note that by choosing N_d^l and c_{Ld}, and conditioning on c_H, the number of domestic potential entrants is determined and does not need to be added to the set of exogenous variables. The same holds for the number of potential foreign entrants.

2. I solve for large firm's internal market shares: $[z^l_{r,i}]^0 = z^l_{r,i}([P^s]^0; \tau, \Xi, \Theta)]$, for $i = 1...N^l_r$, $r \in (d, f)$, and their overall share $[s^l]^0 = s^l([P^s]^0; \tau, \Xi, \Theta)]$ conditional on the small firms' price index $[P^s]^0$.

3. I construct the large firm's price index:

   $[P^l]^0 \equiv P^l([\{z^l_{d,i}\}]^0|^{N^l_d}_{i=1}, [\{z^l_{f,i}\}]^0|^{N^l_f}_{i=1}\}, [s^l]^0; \tau, \Xi, \Theta)$.

4. I construct the overall price index $P^0 = [(([P^s]^0)^{1-\sigma} + ([P^l]^0)^{1-\sigma}]^{1/(1-\sigma)}$.

5. Derive the new cutoffs $c^1 \equiv \{[c^s_{d,*}(P^0; \tau, \Xi, \Theta)], [c^s_{f,*}(P^0; \Xi, \Theta)]\}$

6. If $|c^1 - c^0| < \epsilon$, then the problem is solved, otherwise I use c^1 to iterate the process.

This iterative process delivers a solution $S(\tau_0, T_{f0})$ conditional on the value of the trade policy variable τ_0. Given that each solution depends on the specific draw of large firms productivities, I solve the model U times in each case and average the result. Therefore, I use for each endogenous variable $S^y \in S$ the following: $S^y(\tau_0, T_{f0}) = \frac{\sum_{u=1}^{U} S^y_u(\tau_0, T_{f0})}{U}$, where $U = 1000$.

In the numerical exercise, I vary either τ and T_{f0}, depending the case, such that I get a set of solutions for the R values of these variables, τ: $\bar{S} \equiv \{S_1(\tau_1), ..., S_R(\tau_R)\}$, or T_f: $\bar{S} \equiv \{S_1(T_{f1}), ..., S_R(\tau_{fR})\}$.

Appendix C: Firm Proxy

In this appendix I employ an ANOVA approach to choose a proxy for foreign firms based on the available information included in the DANE custom data.

C.1 Databases

The custom database from DANE contains information about the seller but does not have an id number nor a name. Therefore, I consider the following information included: the country and city of origin of the seller, which can differ from the country of origin of the producer due to offshoring. The assumption is that the agent that is deciding the optimal quantity produced is the firm that is selling the product, no the one that is producing.

I consider different alternative combination of information to proxy for the firm: 1) city and country of the seller (C), 2) city and country of the seller interacted by the HS10 product category (CH), 3) country of the seller (N), 4) country of the seller interacted by the HS10 product category (NH), 5) HS10 category alone (H).

In order to choose the optimal proxy, I employ the Export Dynamic Database (EDD) which provides HS2-importer-exporter-year aggregate statistics related to exports, number of firms and the distribution of trade. This database includes 53 exporters, mostly developing countries, for different time periods ranging from 1997 to 2004. I keep all flows between 2004 and 2014 in which the importer is Colombia to compare with DANE information regarding trade value, number of firms and the HHI, the latter to capture information about the distribution of firms.

The EDD does not contains all imports from Colombia given that the reporters are the exporters. Therefore, the comparison below is for trade flows that are present in both samples (about 20%).

C.2 Descriptive Statistics for Different Proxies

In Table C.1 I show the average log imports across exporter-HS2 products by year for both DANE and EDD for trade flows included in both samples. The average is similar in terms of levels, showing that both databases are capturing the same information.

Table C.1: Average log Imports for Comparable Flows in EDD and DANE.

Year	EDD	s.d.	DANE	s.d.
2004	12.851	0.120	12.658	0.136
2005	12.865	0.111	12.594	0.124
2006	12.942	0.106	12.543	0.117
2007	13.191	0.108	12.928	0.120
2008	13.258	0.104	12.937	0.119
2009	13.091	0.107	12.756	0.124
2010	13.349	0.109	13.090	0.121
2011	13.572	0.109	13.348	0.117
2012	13.431	0.104	13.223	0.117
2013	13.570	0.140	13.301	0.154
2014	13.617	0.170	13.485	0.179

Average and standard deviation (s.d.) of the log imports at the exporter-HS2 product level for observations in both EDD and DANE databases.

Tables C.2 and C.3 show the average log number of firms and HHI for the

EDD and the DANE database using the alternative firm proxies. Proxies can either over or underestimate the average both variables. For instance, if there are more than one firm per city then the proxy could be lower than the actual number of firms. On the other hand, city variables are noisy even after cleaning. In this sense, I could be counting a city more than once if the cleaning process did not exhaust all possibilities. Note that errors that are related to specific cities and are constant over time are not a problem for the regression analysis, given the fixed effect structure of the empirical equation 2.5. Nonetheless, both the proxy number of firms and HHI are close to the levels in the EDD.

Table C.2: Average log Number of Firms for Comparable Flows in EDD and DANE by Type of Firm Proxy.

Year	EDD	s.d.	C	s.d.	H	s.d.	HC	s.d.	HP	s.d.	P	s.d.
2004	1.514	0.050	1.506	0.048	1.588	0.048	2.030	0.058	1.705	0.050	0.615	0.027
2005	1.697	0.048	1.634	0.046	1.722	0.045	2.204	0.054	1.865	0.047	0.706	0.027
2006	1.710	0.046	1.529	0.043	1.583	0.043	2.037	0.052	1.717	0.045	0.653	0.025
2007	1.710	0.047	1.646	0.044	1.679	0.044	2.182	0.054	1.833	0.047	0.722	0.027
2008	1.649	0.045	1.578	0.042	1.626	0.042	2.099	0.051	1.771	0.044	0.706	0.025
2009	1.706	0.046	1.576	0.044	1.630	0.043	2.114	0.053	1.780	0.046	0.705	0.026
2010	1.750	0.048	1.639	0.044	1.659	0.043	2.177	0.054	1.824	0.047	0.749	0.027
2011	1.849	0.049	1.688	0.045	1.710	0.043	2.235	0.054	1.886	0.047	0.815	0.028
2012	1.864	0.047	1.750	0.044	1.721	0.042	2.272	0.053	1.917	0.047	0.843	0.028
2013	2.110	0.068	1.825	0.062	1.828	0.060	2.395	0.076	2.038	0.067	0.915	0.042
2014	2.241	0.087	2.078	0.082	1.976	0.076	2.661	0.099	2.243	0.085	1.067	0.055

Average and standard deviation (s.d.) of the log number of firms at the exporter-HS2 product level for observations in both EDD and DANE databases.

Table C.3: Average HHI for Comparable Flows in EDD and DANE by Type of Firm Proxy

Year	EDD	s.d.	C	s.d.	H	s.d.	HC	s.d.	HP	s.d.	P	s.d.
2004	-0.877	0.030	-1.077	0.035	-0.772	0.029	-1.097	0.035	-0.841	0.030	-0.809	0.029
2005	-0.912	0.028	-1.129	0.032	-0.828	0.026	-1.151	0.033	-0.906	0.027	-0.874	0.027
2006	-0.936	0.028	-1.084	0.032	-0.797	0.026	-1.109	0.032	-0.866	0.028	-0.833	0.027
2007	-0.946	0.028	-1.115	0.033	-0.813	0.028	-1.145	0.034	-0.895	0.029	-0.855	0.028
2008	-0.915	0.028	-1.080	0.031	-0.807	0.026	-1.114	0.032	-0.880	0.028	-0.837	0.027
2009	-0.927	0.027	-1.069	0.033	-0.785	0.027	-1.097	0.033	-0.864	0.029	-0.824	0.028
2010	-0.985	0.028	-1.145	0.033	-0.814	0.028	-1.176	0.034	-0.905	0.029	-0.862	0.028
2011	-0.982	0.029	-1.143	0.032	-0.834	0.026	-1.178	0.033	-0.921	0.028	-0.874	0.027
2012	-1.004	0.028	-1.156	0.031	-0.830	0.026	-1.185	0.032	-0.931	0.028	-0.888	0.027
2013	-1.036	0.040	-1.169	0.044	-0.845	0.036	-1.196	0.045	-0.957	0.039	-0.918	0.038
2014	-1.125	0.050	-1.281	0.054	-0.899	0.044	-1.304	0.055	-1.033	0.047	-0.993	0.046

Average and standard deviation (s.d.) of the log HHI at the exporter-HS2 product level for observations in both EDD and DANE databases.

C.3 ANOVA

Although average indicators are useful to illustrate that aggregate trade and the alternative proxies are similar to the true data in terms of levels, they are not the relevant information for capturing the variation in the number of firms and their internal distribution of market shares. Therefore, I do an ANOVA to compare which proxy explains more variation of the true data for the exporter-product-year observations that are present in both samples.

Table C.4: Proportion of Variance Explained by Each Firm Proxy for each Variable (R^2).

Proxy	Imports		Number of Firms		HHI	
	Unconditional	Conditional	Unconditional	Conditional	Unconditional	Conditional
C	0.731	0.221	0.615	0.054	0.400	0.079
H	0.731	0.221	0.630	0.048	0.315	0.053
HC	0.731	0.221	0.681	0.071	0.401	0.076
HP	0.731	0.221	0.632	0.051	0.324	0.056
P	0.731	0.221	0.368	0.006	0.316	0.059

Variance explained by each proxy (C, H, HC, HP, P) and each variable (imports, number of firms and HHI). Unconditional: R^2 of regression $\ln X_{cpt}^{EDD} = \beta^u \ln X_{pct}^{proxy} + v_{cpt}$. Conditional: R^2 of regression $\ln u_{cpt}^{EDD} = \beta^u \ln u_{pct}^{proxy} + v_{cpt}$, where $\ln u_{cpt}^{y}$ is the residual of the regression $\ln X_{cpt}^{y} = \delta_{cp} + \delta_{pt} + \delta_{ct} + \epsilon_{pct}$ (δ_{cp}, δ_{pt} and δ_{ct} are exporter-product, product-year and exporter-year fixed effects).

Table C.4 contains the proportion of the variance explained by each proxy across products, exporters and years (R^2). The unconditional columns show the R^2 of the proxy alone, whereas the conditional columns show the R^2 of the proxy after conditioning by exporter-product, product-year and exporter-year fixed effects. The latter captures the true variation used in the Chapter 2 regression results, given the set of fixed effects used.

Given that the proxy is not needed to calculate imports, the first two columns are the same across proxies. The unconditional R^2 is 0.730, showing that the EDD explains about three quarters of Colombian imports. Part of the unexplained variance may come from the fact that the origin of these databases are different and valuations can differ. In this sense, the DANE database is collected by this single agency, whereas the EDD is collected by each individual exporters. Moreover, the World Bank does a cleaning process that may differ from the one I did for DANE given their different goal. The conditional R^2 is quite lower, at 0.22. Given that the proxy does not modify this variable, I will use these values as benchmarks for the number of firms and the HHI.

Columns 3 and 4 show the information for the number of firms. The unconditional R^2 is quite similar toe the one for imports and across proxies with the exception of P. The one that explains more is HC. The conditional R^2 is lower than the one for imports in all cases, capturing the fact that the fixed effects capture some of the relevant information that the proxy can use. The HC is again the one that explains the most. Columns 5 and 5 do the same for the case of the HHI, and conclusions do not differ, with C also doing a relatively good job.

As a conclusion, the proxy that performs better in capturing conditional and unconditional variation in the number of firms and HHI is the CH. Therefore, I employ this in the empirical analysis and proxy firms by city of the seller and 10-digit HS products.

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