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Essays in Development Economics, Environmental Economics and International Trade

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorization does not, to the best of my belief, infringe the rights of any third party.

I declare that my thesis consists of approximately 28000 words.

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Abstract

This thesis consists of three chapters on international trade and environmental economics in developing countries. The first chapter examines trademarks in developing countries. I introduce a trademark as a technology to mitigate information frictions in a general equilibrium setting with firm heterogeneity. In my model, highly productive firms are more likely to use a trademark, since the revenue increase outweighs the trademark cost only for these firms. I test my theoretical predictions using Chinese exports to Africa in the tire industry. By exploiting a staggered ratification of the international trademark agreement in Africa, I find evidence of reallocation away from less productive firms. I also show that trademarks are welfare-enhancing technology in Africa. The second chapter investigates the effects of corporate environmental responsibility in global supply chains on environmental pollution by exploiting a change in an environmental tax policy in China. First, I find that Chinese firms that participate in global supply chains respond to the tax change by reducing the amount and intensity of water pollution with an increase in revenues. Second, the response to the tax is concentrated among tier 2 suppliers. Finally, the result shows that the new tax policy has a larger effect on Chinese suppliers linked to global buyers that have higher corporate environmental responsibility. These results are consistent with the notion that corporate environmental responsibility is associated with higher environmental standards, both through selection and treatment effects and potentially playing a significant role in complementing host countries' policies aimed at curbing pollution. The third chapter studies how infrastructural instability affects export practices of sellers in developing countries. By leveraging order-level export data and exploiting seasonal power outages in Myanmar, I find that exporters decrease their exports in seasons of frequent power outages. I also show that the effect is heterogeneous across orders for buyers adopting different sourcing strategies. The results suggest that infrastructural instability in developing countries is of crucial concern for linking domestic firms with foreign buyers.

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Chapter 1

The Value of Trademarks: Micro Evidence from Chinese Exports to Africa

1.1 Introduction

Imports of high-quality products play a central role in economic development (Goldberg et al., 2010). Through increased access to previously unavailable inputs, firms can increase productivity, expand the scope of their domestic products and meet the required standards to export their products. However, sourcing high-quality products in developing countries is plagued with difficulty. In settings of imperfect contract enforcement and asymmetric information, firms often struggle to credibly signal product quality, which limits their incentives to invest in quality improvements. Sellers and buyers have sought informal mechanisms and/or market-oriented behaviors to mitigate this problem, and there is empirical evidence that they rely on long-term relationships based on trust or reputation (Macchiavello and Morjaria, 2015) and on branding technologies to differentiate their products from other products (Bai, 2021). Because empirical evidence on the institutional role in quality upgrading is scarce, policymakers in developing countries are interested in how best to complement these informal institutions by building and improving the institutional context that can mitigate these problems.

For policymakers, a trademark is considered a key policy tool. This is because a trademark is capable of distinguishing the goods of one firm from those of other firms and, as a result, sellers can brand the products. Furthermore, buyers distinguish goods with a trademark from goods without a trademark, because sellers can include the special symbol "®" thorough the intellectual property system. Thus, although a trademark is not a certificate of provided quality per se, it can convey some credible signals of a seller's reputation and reliability to buyers. If sellers can build their brands and/or reputations with a trademark, they can therefore send credible signals of their quality to consumers and mitigate information friction in the market.

However, the consequences of introducing a trademark are theoretically mixed in a general equilibrium framework. One possibility is that trademark users might upgrade the quality of their products if a trademark conveys signals regarding their reputation as a signaling device (Grossman and Shapiro, 1988a). Another possibility is that a trademark could lead to changes in the market structure that allow certain firms to increase their market power and perhaps also reduce quality for trademark users, and non-users due to changes in competition (Grossman and Shapiro, 1988b, Aghion et al., 2005 and Amiti and Khandelwal, 2013). Due to these different mechanisms, empirical findings are key for understanding the welfare implications of trademarks.

In this paper, I study whether a trademark improves market efficiency and welfare. Identifying the role of a trademark is key to public policy but empirical evidence on this question is scarce due to several distinct challenges. First, the institutional setting regarding a trademark is endogenously determined. Second, the role of trademarks requires transaction-level data combined with information about which products are trademarked. Third, within-firm variation in trademark usage is rarely observed and it is hard to isolate its effect from the effects of other firm-specific factors.

I tackle these challenges by studying an international trademark for Chinese exporters in the African tire industry. This context presents several features that allow my analysis. First, 17 African countries suddenly ratified an agreement on an international trademark in 2015. Second, Chinese exporters in the tire industry are leading exporters not only within one country but also across different countries in Africa. This allows me to investigate how exports of the same firm with and without a trademark are different. Third, information frictions between sellers and buyers were widespread in the industry, and it is appropriate to analyze the role of a trademark in developing countries.

The empirical setting is the African tire market after 17 countries unexpectedly ratified an international trademark agreement in 2015. This market is served almost entirely by Chinese exports, with 400 Chinese firms accounting for about 60% of the market share across the whole continent in 2014. More than 90% of total exports were from firms exporting to both countries that ratified the 2015 trademark agreement and to those that did not. The main estimation method used in this paper is a Difference-in-Differences (DID) design, comparing country- and firm-level outcomes in ratifying and non-ratifying countries before and after the agreement came into force.

Exploiting this sudden change of the member countries, I examine how exporters change their behavior. At an aggregate level, countries that become member countries in 2015 import fewer tires and total expenditure falls in the subsequent years. Next, since more micro-level study is needed to evaluate welfare, I also look at the details of these results at the firm level. At the extensive margin, fewer Chinese firms export tires to the ratifying countries. On the intensive margin, an exporter increases the probability of trademark usage as well as the unit price, but reduces its sales. Then, I investigate whether the effect of an international trademark agreement varies across African countries and between Chinese exporters. I find that the effect is more pronounced in a competitive market, and that the intensive margin effect depends on an exporter's position in each country. A large Chinese exporter in a given country increases the probability of trademark usage and its sale by upgrading products' quality, while a small Chinese exporter decreases its sales and does not use a trademark. These results, when considered together, suggest a reallocation of total market shares to larger Chinese firms who have upgraded product quality in ratifying countries.

My interpretation of the empirical results is that sellers sell more and earn more revenue because they mitigate information frictions with a trademark and upgrade the quality of their products. In the above empirical analyses, I use several outcomes as proxies of product quality by country-year. Unit prices contain information about quality because they reflect changes in marginal cost, as well as in markup. Second, quality is reflected in the lifespan of the tires: higher-quality tires last longer and need to be replaced less frequently. Less frequent replacement decreases the total number of tires demanded and, hence, product quantities are also informative about quality. Since prices and quantities are equilibrium outcomes that reflect other changes to demand and supply, a combination of results is needed to distinguish evidence of quality upgrading from the role played by other possible effects. Furthermore, to further strengthen my empirical results, I infer quality of the products following Khandelwal et al. (2013) and check whether estimated quality is different between exporters. The results indicate that large exporters upgrade the quality of their products in the ratifying countries after 2015.

An alternative hypothesis appears less plausible. It is that a firm uses a trademark not to differentiate its product from others but rather, to protect it from counterfeits. If it can protect its genuine products with a trademark, it means that it faces less competition and increases its market power by excluding counterfeit products from the market. Then, it does not have an incentive to offer high quality with a trademark due to less competition in the market. Thus, when the cost of applying for a trademark declines, the reallocation away from a less productive firm forces this firm to downgrade quality, to decrease the unit price, to sell fewer quantities, and to earn less revenue. These predictions are at odds with my empirical findings. Furthermore, downgraded quality of the product with a trademark is not consistent, because my estimated quality increases when a trademark is added to a product.

Another concern is that a firm uses a trademark to exclude products from the market and to change its markup. If this holds, the increase in the unit price is not from an increase in provided quality but from an increase in markups due to the change in the market size (Melitz and Ottaviano, 2008). To check whether a Chinese exporter changes its mark up after a country ratified the international trademark agreement, I follow Corsetti et al. (2019) and estimate the destination-specific markup elasticity to the exchange rate. The results show that the effect of the accession on the markup elasticity is irrelevant to each Chinese exporter's position in each exporting country.

I develop a model of a trademark to discipline my empirical analysis. Existing studies (Nelson, 1970, Nelson, 1974, Milgrom and Roberts, 1986, Wernerfelt, 1988, Johnson and Myatt, 2006 and Marvel and Ye, 2008) have analyzed advertising and other dissipative marketing expenditures based on games of incomplete information in the partial equilibrium setting. In their models, firms use these expenditures to inform potential customers about the existence, characteristics and prices of the products they offer. However, there is a gap between their insightful approaches and my empirical findings. Three points are worth noting here. First, in their models, quality is not treated as a choice variable but rather as exogenously given. Furthermore, they do not even assume that lower quality is cheaper to produce. Thus, their models cannot explain within-firm quality upgrading associated with trademark usage reported in my analysis. Second, the problem addressed in their studies is not the moral hazard one that the firm may have incentives to cheat by cutting quality, but the adverse selection one that the low-quality sellers may imitate the high-quality sellers. Thus, in their models, if the trademark registration fee decreases, the incentive compatibility constraint could be violated, and low-quality sellers could use a trademark to imitate the high-quality sellers. This prediction is at odds with my empirical result that Chinese exporters use a trademark not for their imitation but for their quality upgrading. Third, my empirical analysis shows a reallocation of total market shares from smaller firms not using trademarks to larger firms who have upgraded product quality in the ratifying countries. This finding is hard to predict in the partial equilibrium setting.

To fill this gap, I present a model of a trademark built on built on Bustos (2011) and Hallak and Sivadasan (2013). I introduce a trademark as a signaling device to mitigate information frictions in a general equilibrium framework incorporating firm heterogeneity. In the model, while a less productive firm does not use a trademark because it cannot earn enough revenue to pay for the investment in this technology, a highly productive firm uses a trademark to upgrade quality, sell higher quantities, and earn higher revenue. I then analyze the model under the scenario where the investment cost for a trademark decreases. When the cost decreases, a highly productive firm is more likely to use a trademark. As this firm can earn more revenue with a trademark, this causes the reallocation of market shares, forces a less productive firm to make less revenue, and makes the least productive firm exit the market. I derive the same predictions in an open economy. In an open economy, a highly productive exporter in a foreign country is more likely to use a trademark. As a result of the reallocation of market share, the least-productive exporter is more likely to stop exporting, and a less productive exporter is more likely to decrease its sales.

To quantify how a trademark leads to welfare change, I employ direct and indirect welfare analyses. In a direct welfare analysis, I focus on car accidents. As road traffic injuries are one of the major health and development problems in Africa and a tire quality often plays a major role in causing accidents, I investigate how quality upgrading matters for road accidents. Using the global status reports on road safety and the value of life by the World Health Organization (WHO), I show that both the number and rate of road traffic deaths decrease in the ratifying African countries experiencing severe road traffic injuries and that the economic cost of road traffic accidents saved by this decrease amounts to $0.101 - 0.131\%$ of gross national product (GNP). In an indirect welfare analysis, I do a back-of-the-envelope calculation following Hsieh et al. (2020). The results suggest that the improved quality of tires in the ratifying countries increases welfare by 0.014%, which amounts to the $1,670,277 in total.

My results and interpretations have an important policy implication. If a firm signals its quality with a trademark, the government just needs to subsidize a fee for an application. As the cost decreases, more firms use a trademark and consumers can verify the quality of products more efficiently. As a result, information frictions are mitigated, and an increase in total welfare is induced. This view contrasts with the implication of the alternative hypothesis that the government needs to strengthen law enforcement against counterfeit products to exclude them from the market.

This paper contributes to different strands of literature. First, the paper is built on how quality matters in international trade. While much literature studies the role of quality in international trade theoretically and empirically (Grossman and Helpman, 1991, Verhoogen, 2008, Khandelwal, 2010, Hallak and Schott, 2011, Baldwin and Harrigan, 2011, Kugler and Verhoogen, 2011, Hallak and Sivadasan, 2013, Bastos et al., 2018, and Fieler et al., 2018), evidence is limited on how asymmetric information in international trade affects quality and how it is mitigated with technology adoption. My theoretical framework is based on Bustos (2011) and Hallak and Sivadasan (2013), and I provide empirical evidence that firms can alleviate information frictions with trademarks in international trade, which is consistent with my theoretical predictions.

Second, this paper contributes to the literature on information frictions in developing countries. Much literature examines trading practices and environments in developing countries (Banerjee and Duflo, 2000, Jin and Leslie, 2009, Macchiavello, 2010, Macchiavello and Morjaria, 2015, Bai, 2021 and Startz, 2021). My analysis shows how governments in developing countries support firms' quality upgrading and offers an important policy implication.

Third, this paper contributes to the literature on intellectual property rights, specifically a trademark. While much literature studies intellectual property rights theoretically and empirically (Landes and Posner, 1987, Grossman and Shapiro, 1988a, Grossman and Shapiro, 1988b, Helpman, 1993, Chaudhuri et al., 2006, Qian, 2008, Goldberg, 2010 and Fang et al., 2017), empirical evidence on trademarks is limited. This paper bridges the gaps in existing studies by offering empirical findings of how a trademark works in markets in developing countries. Qian (2008) is most closely related to my study since both provide empirical evidence on intellectual property rights. In an environment where asymmetric information is serious, both discuss the role of intellectual property rights. Qian (2008) investigates how markets function with less government intellectual property rights enforcement. In contrast, I study whether trademarks alleviate market failure and improve welfare.

The rest of this paper is organized in the following way. Section 1.2 describes the institutional context and sudden changes in the institutional framework governing trademarks at the country level. I present my empirical findings in Section 1.3. Section 1.4 explains the theoretical background to explain how a trademark works in a market and to guide my empirical results. Section 1.5 investigates how welfare increases due to the introduction of a trademark both directly and indirectly. Section 3.4 concludes.

1.2 Empirical Settings

1.2.1 Trademark Background

A trademark is a sign that distinguishes the goods and services of one firm from those of other firms. With a trademark, the owner can pursue legal action against trademark infringement. Unlike other intellectual properties, exported goods are not protected in foreign countries if companies have registered their trademarks only in their domestic country. As it is cumbersome for exporters to register their logo and/or brands in each exporting country, there are some regional intellectual property organizations that a firm can apply directly to in order to obtain a trademark in many foreign countries at the same time.

In Africa, there are two regional intellectual property organizations: Organisation Africaine de la Propriété Intellectuelle (OAPI)[1], and the African Regional Industrial Property Organization (ARIPO)[2]. Both[3] of them are in charge of regional trademarks.[4] For exporters, there are practical difficulties in using these regional systems. An application must be filed by any qualified natural or legal person, either in person or through an authorized representative whom the national industrial property office recognizes as having the right to represent the applicant. If the applicant is neither an ordinary resident nor has a principal place of business in any of the OAPI and/or ARIPO member countries, it needs to hire a legal practitioner to apply for a trademark. Due to this system, an exporter bears sizable costs for these applications.

[1] The member countries are Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, and Togo.

[2] The member countries are Botswana, Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mozambique, Namibia, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. The observer countries are Algeria, Angola, Burundi, Egypt, Eritrea, Ethiopia, Libya, Mauritius, Nigeria, Seychelles, South Africa, and Tunisia.

[3] The locations of OAPI and ARIPO member countries are shown in Figure 1.1. OAPI countries are located in West and Central Africa, while ARIPO countries are located in East Africa. Which organization each country belongs to mainly depends on its main language. OAPI mostly includes French-speaking countries, while ARIPO mostly includes English-speaking countries.

[4] There are other regional intellectual property organizations: not only in developed countries, but also in developing ones. Examples include the Arab States Broadcasting Union Website (ASBU), Benelux Office for Intellectual Property (BOIP), the Eurasian Patent Organization (EAPO), the European Patent Organisation (EPO), the International Union for the Protection of New Varieties of Plants (UPOV), the Interstate Council on the Protection of Industrial Property (ICPIP), the Office for Harmonization in the Internal Market (OHIM), and the Patent Office of the Cooperation Council for the Arab States of the Gulf (GCC Patent Office).

The World Intellectual Property Organization (WIPO), which is one of the 15 specialized agencies of the United Nations, was launched in 1967 to encourage creative activity and to promote the protection of intellectual properties throughout the world. For trademarking, the WIPO introduced the Madrid System, which is a convenient and cost-effective solution for registering and managing trademarks worldwide. With this system, a firm can file a single application to apply for protection in up to 120 countries. Once it submits its application and the WIPO formally examines it, it is sent to the regional intellectual property offices and examined substantially again. If it is also approved by the regional intellectual property office, a firm is allowed its registered trademark. The term of trademark registration varies and depends on the goods and services, but it usually lasts for 10 years. It can be renewed indefinitely upon payment of additional fees. Trademark rights are private rights, and protection is enforced through court orders if needed.

A firm can use this system if the countries where it applies for a trademark have ratified the Madrid Protocol. It is not compulsory for each country to be a member of this system, and each local organization makes a decision. In 2015, there was radical change in the Madrid Protocol member countries in Africa, and the percentage of African countries that were Madrid Protocol members doubled (from 29.8% to 64.9%).[5] OAPI played a role in this sudden change of the members in Africa. Although OAPI introduced the regional intellectual property system, the system was not welcomed by foreign exporters due to the reasons mentioned above. To mitigate the hardship faced by foreign exporters and to make the OAPI member countries attractive, OAPI agreed to join the Madrid Protocol and became the 93rd member of the Madrid System on December 5, 2014. This protocol entered into force on March 5, 2015.[6]

The reason why only OAPI members joined the Madrid Protocol in 2015 is due to the different law systems between OAPI and ARIPO countries. ARIPO countries are former British colonies and common law countries. This means they need to modify each country's national laws before they ratify an agreement and become the member countries. This is a complicated and time-consuming step that prevented ARIPO countries from becoming members at that time. In contrast, OAPI members are former French colonies and civil

[5] In the appendix, I examine the history of the Madrid Protocol member countries. Based on the cumulative number of the Madrid Protocol member countries and the number of countries that became members per year, I identify that this sudden change in member countries only happened in Africa, and it was only in 2015.

[6] The years of each country's entry in OAPI and ARIPO are in Table 1.B.1 and 1.B.2 in the appendix. Due to the sudden change, all countries ratified the Madrid Protocol in 2014. On the other hand, the time of entry for ARIPO countries varied. Ghana became the member country in 1996; Kenya, Mozambique, Sierra Leone, and Swaziland did so in 1998; followed by Lesotho (1999), Zambia (2001), Namibia (2004), Botswana (2006), Sao Tome Principe (2008), Liberia (2009), Sudan (2010), Rwanda (2013), and Gambia and Zimbabwe (2015). Malawi, Somalia, Tanzania, and Uganda have not ratified, as of 2018.

law countries. They did not need to modify their laws before the trademark agreement, and easily became member countries. Joining OAPI gives a foreign firm potentially more manageable, faster, and cheaper access to trademark registration of a trademark in West African countries. I investigate this sudden change in the number of member countries in Africa, and evaluate my predictions in the last section.

1.2.2 Tire Industry in Africa

In this subsection, I explain how the tire industry in Africa is suited to my research objective. Due to the improvement of roads and public transportation systems[7] and the rising increase in the sales of new vehicles[8], the demand for tires has been skyrocketing, and Africa is one of the fastest-growing markets for the global tire industry. The rising demand for tires in this emerging market has attracted new tire manufacturers from around the world. Traditionally, European tire manufacturers held a monopoly over the African markets, and many European brands were the top-selling tires in many African countries. However, in recent times, European tire firms have started to lose ground to Chinese and other Asian brands. Chinese tires are gaining popularity in African markets, because consumers in these countries prefer to import low-priced Chinese tires rather than the expensive European and American brands. In recent times, China has emerged as a leading exporter of tires in many African countries.[9]

Although Chinese exporters have played an essential role in the African markets, they have also been a cause of asymmetric information. Since informal traders in informal markets account for much retail trade, trade in counterfeit goods is far more likely to flourish in an informal environment than in a controlled and regulated one. A tire market is one such example, and China is the leading country of provenance for counterfeit tires. Some Chinese exporters combine used tires and sell them as new ones. As a result, many counterfeit products are very hard to separate from the genuine ones, and are in certain instances indistinguishable unless a lab test is conducted.

[7]In urban areas, facing rapid population increase, policymakers have planned to provide transport facilities and opportunities to improve urban mobility and accessibility. Examples include construction of the BRT Red Line in Dakar (Senegal), the Dar es Salaam Rapid Transit Project (Tanzania), transport services on the Amasaman Corridor, the Adenta Corridor and Kasoa Corridor in Accra (Ghana), and completion of the high-capacity light rail network in Lagos (Nigeria). The connectivity between rural and urban areas has improved dramatically. According to Berg et al. (2018), the market access index increased by $3-6\%$ between 1990 and 2005, and $10-20\%$ of the recent growth comes from the improvement of roads.

[8]Registrations and sales of new passenger and commercial vehicles increased by a compound annual growth rate of 3.6% in Africa between 2005 and 2015, and they reached approximately 1.55 million in 2016.

[9]According to the World Integrated Trade Solution, roughly 60% of all exports come from China.

1.2.3 Data Sources

For this study, I use two micro-level data sources: the Chinese Customs Database and the WIPO Global Brand Database. I combine these two datasets to test my predictions.

The Chinese Customs Database provides transaction-level trade flow information on the universe of China's exports and imports over the time period. The data are collected and made available by the Chinese Customs Office. For each transaction, I observe the exporting firm's ID, firm name, trade type, value and quantity of the exports, the HS 8-digit product category, the region or city in China where the product is exported from, the customs office where the transaction is processed, and the final destination of the product. For each firm, the data also provide information on its ownership type and location. This information allows me to construct a unit value price of each exported product by dividing the value of exports by quantity. Since I focus on the Chinese tire exports to Africa, I only use export data for my analysis, and my targeted HS 8-digit product category is 40112000 (Passenger or freight cars with new pneumatic rubber tires).

The WIPO Global Brand Database provides all of the registered international trademark information worldwide. This database is constructed and made available by the WIPO. For each registered international trademark, I observe the name of the registered brand, the name of the applicant company, and the dates of registration and expiry. For each applicant company, I also observe the address and the international classification of goods and services for the registration of marks. For this analysis, I focus on international trademarks registered by Chinese companies in African countries. I match the firm-level observations across these two datasets using identifying variables such as the name and the address of Chinese exporters.

1.3 Empirical Findings

Before explaining the causal impact of a trademark, I show the summary statistics of Chinese exporters' exports. Table 1.1 describes the overall Chinese exporters' behaviors in OAPI and ARIPO countries in 2014, 2015, 2016, and 2017. From this table, I report several findings. Chinese exporters had increased their usage of a trademark over these four years. In 2014, only 11.3% of export transactions had a trademark attached, but this figure had increased to 18.7% in 2017. Chinese exporters did not change the destination countries very much after the accession of OAPI countries into the Madrid Protocol in

2015. Around $36 - 41\%$ of tires were exported to OAPI countries, and around $59 - 64\%$ were exported to ARIPO countries during these four years.

Then, I report the summary statistics for OAPI and ARIPO countries separately. OAPI and ARIPO countries had followed different trends. In OAPI countries, Chinese exporters showed increased usage of a trademark. In 2014, no transaction included a trademark, but trademark use was 1.8% in 2015, 14.6% in 2016, and 19.0% in 2017. In parallel with this change to using a trademark, Chinese exporters decreased their quantities, export values, and prices between 2014 and 2017. They decreased their quantities by $0.004 - 0.069$ log-points, their export values by $0.353 - 0.54$ log-points, and their prices by $0.337 - 0.483$ log-points. In contrast, the usage of a trademark among Chinese exporters was stable in ARIPO countries. It was 19.1% in 2014, 19.3% in 2015, 20.3% in 2016, and 18.5% in 2017. Furthermore, although they decreased their export values and prices between 2014 and 2017, they increased their quantities by $0.016 - 0.059$ log-points; but they decreased their export values by $0.248 - 0.366$ log-points, and their prices by $0.264 - 0.411$ log-points. [10]

Comparing these two OAPI and ARIPO countries' descriptive statistics, I find that a Chinese exporter was more likely to use a trademark, but it exported fewer tires and earned less in OAPI countries after they joined the Madrid Protocol. This suggests that OAPI countries imported more tires that had a trademark, but fewer tires in total.

I also show how competitive this market is, and examine the cost of obtaining a trademark, compared with the export value. First, Figure 1.2 shows the histogram of the log of the annual export value of each Chinese firm in OAPI and ARIPO countries. From this figure, I find that small and large exporters exist in OAPI and ARIPO countries, and that the tire industry is competitive in both types of countries. Second, this figure shows the relative cost of obtaining a trademark, compared to the annual export value. The dotted line is the cost of obtaining a trademark before the international agreement in OAPI countries, while the red line is the cost of a trademark after the agreement in OAPI countries. From this figure, I observe that the cost of obtaining a trademark is a barrier to small exporters. Before the international trademark agreement, the trademark registration fee exceeded the annual export value for 40% of the total Chinese exporters. However, after the agreement, the new fee exceeds the annual value for only 12% of the total Chinese exporters. This large decrease gives Chinese exporters the opportunity to use a trademark in OAPI countries.

[10] Table 1.1 includes the summary statistics of exporters who left the market after the OAPI countries became Madrid Protocol members. To focus on an intensive margin, in the appendix I also report the summary statistics of the companies which continuously exported their tires before and after the accession, in all OAPI and ARIPO countries.

1.3.1 Aggregate Analysis

I exploit the sudden shock caused by the OAPI countries' accession, and examine how Chinese exporters change their behavior at an aggregate level and an individual level. For the aggregate level analysis, I run the following regression:

$$Y_{ct} = \beta_0 + \beta_1 OAPI_c \times After_t + \eta_c + \lambda_t + \varepsilon_{ct}, \tag{1.1}$$

where Y_{ct} is an outcome of interest at country c and time t; it includes the number of exporters, and the log of the sum of export value and quantities. $OAPI_c$ is a dummy variable, which takes 1 if country c belongs to OAPI. $After_t$ is also a dummy variable, which takes 1 if time t is after May 2015, when the Madrid protocol entered into force. η_c is a country fixed effect, and λ_t is a time fixed effect. Since some countries do not export tires from Chinese exporters every month, I perform an aggregate analysis for both the unbalanced and balanced panel datasets.

Table 1.2 reports the analyses for the unbalanced and balanced panels. For the unbalanced panel analysis, the number of Chinese exporters decreases by 2.260 in OAPI countries after they agree with the Madrid Protocol and become members; this is a fall of 17.7%. In columns (2) − (3), the aggregate export value decreases by 26.8%, and the aggregate quantity also decreases by 17.6%. The results are almost the same in the case of the balanced panel dataset. For the balanced panel analysis, after their accession, OAPI countries import tires from 2.548 fewer Chinese firms, and the export value and quantity of Chinese exporters decrease by 30.0% and 17.8%, respectively.

1.3.2 Overall Analysis

Next, I examine an individual exporter's behavior at an extensive margin. For this analysis, I run the following regression:

$$Y_{ict} = \beta_1 OAPI_c \times After_t + X_{ict}\beta + \eta_{it} + \xi_c + \varepsilon_{ict}, \tag{1.2}$$

where $After_t$ takes 1 if time t is after March of 2015 and 0 otherwise. $OAPI_c$ takes 1 if country c belongs to OAPI countries and 0 otherwise. X_{ict} is a control variable which includes export information and macroeconomic variables. η_{it} is an individual time fixed effect, and ξ_c is a country fixed effect. Y_{ict} is an outcome of interest of firm i at country

c and time t, which includes an export dummy variable, a trademark dummy, and each export transaction's quantity, export value, and unit price. For the individual analysis at the extensive margin, I consider all possible combinations of i, c, and t, and create $Export_{ict}$, while for the analysis on the intensive margin, I restrict my observations under the following criterion: a combination of i, c, and t, where firm i exported its tires to country c in 2014 and 2015, in 2014 and 2016, or in 2014 and 2017.

Table 1.3 reports overall consistent results at the extensive margin and on the intensive margin. In this table, $Export_{ict}$ is a dummy variable, which takes 1 if firm i exports its tire to country c at time t, and TM_{ict} is a dummy variable, which takes 1 if firm i uses its trademark in country c at time t. $ln(Value_{ict})$, $ln(Quantity_{ict})$, and $ln(Price_{ict})$ are the logs of export value, quantity, and unit price of firm i in country c at time t. In column (1), a Chinese exporter decreases the probability of exports by 0.156%; this is a 16.3% decrease in exporting probability. In terms of trademark usage, after OAPI countries become Madrid Protocol members, a Chinese exporter increases trademark usage by 9.45%, which is a 38.1% increase. For the export value and quantity, I find negative effects of the accession of OAPI countries. After the accession, a Chinese exporter decreases its export value by 13.0% and its quantity by 15.9%. Finally, since the loss in sales is larger than the loss in quantity, the OAPI countries' entry has a positive effect on price. A Chinese exporter increases its unit price by 2.88%, and the estimate is statistically significant.

These overall Difference-in-Differences results imply the quality-upgrading of the tires that African countries import from a Chinese exporter. Since the marginal cost is part of the unit price, and the unit price is a proxy for quality, the overall increase in the unit price means that each country in the treatment group imports high-quality products. Since high quality is connected to longevity, and quality and quantity are substitutes, each country in the treatment group spends less in total and imports fewer tires. Moreover, the increase in the unit price results from the increased probability of trademark usage. Finally, as a consequence, a decrease in its sales leads to an increase in the probability of a firm exiting from the market.

1.3.3 Heterogeneous Extensive/Intensive Margin

From the overall extensive and intensive analysis, I identify the fact that on average, an African country in the treatment group imports high-quality tires, and a Chinese exporter is more likely to exit the market due to lost sales. However, it remains unclear if it is different across countries due to macroeconomic conditions and their market structures and if it is different between exporters, due to their positions in each exporting country and/or their exporting strategies. To examine the effect of the international trademark agreement in more detail, I split countries into two groups and categorize each firm, then run a heterogeneous Difference-in-Differences analysis with regard to the extensive and the intensive margins.

Table 1.4 reports the heterogeneous effect of an international trademark at the extensive margin. In this table, I categorize each firm in the following way: $Incumbent_{ic2014}$ is a dummy variable which takes 1 if firm i exported its tire to country c in 2014. Moreover, I split the countries into two groups based on the number of Chinese exporters in a country in 2014, their GDP in 2014, the minimum market share of the Chinese exporter in 2014, and the mean of the market share of the Chinese exporter in 2014. From column (1), I find that an international trademark agreement only affects an incumbent exporter. This implies that an incumbent exporter is more likely to exit the market in the treatment group, and that a new exporter enters the market to the same extent as the one in the control group. Columns $(2)-(4)$ discuss the heterogeneous effect due to market structures. If the market is more competitive and its size is larger, a Chinese exporter is more likely to show a decrease in its probability of exports. On the other hand, if all of the incumbent companies have large market shares or the average market share is large, a Chinese exporter is resistant to the effect of an international trademark agreement at the extensive margin.

Table 1.5 reports the heterogeneous effect on the intensive margin. In this table's analysis, I restrict my observations to the criteria used in the previous subsection. In columns $(1)-(4)$, I categorize each firm into four groups as follows: Best 3_{ic} is a dummy variable which takes 1 if firm i was among the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was among the best 10 exporter in country c in 2014, and Best 15_{ic} is a dummy variable which takes 1 if firm i was among the best 15 exporters in country c in 2014. According to Table 1.5, if a firm was among the best 3 or best 10 exporters in country c in 2014, its probability of trademark usage increases by 10.9% or 21.3%. With the increased probability of usage of a trademark, the firm also statistically significantly increases its export value by $24.4-26.5\%$, its quantity by $22.1-24.0\%$, and its price by $2.26-2.51\%$. On the other hand, less productive firms neither increase nor decrease their usage of a trademark or their input price. Furthermore, they statistically significantly decrease their export value by 20.7%, and the quantity by 22.0%. From these results, I find that the effects of the entry of OPAI countries on all dependent variables are heterogeneous among the highly productive and less productive firms. In columns $(5)-(8)$, I also categorize each firm based on each firm's exporting strategy, and define a dummy variable as follows: $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of its total export of firm i was exported into OAPI countries in 2014. The results in columns (5) − (8) show that if a firm exported more than a half of the total exports to OAPI countries in 2014, its usage of a trademark increases by 16.7%. With the increased probability of usage of a trademark, the firm also statistically significantly increases its export value by 27.8%, its quantity by 21.3%, and its price by 6.52%. On the other hand, although a firm whose share was less than 50% in OAPI countries in 2014 increases usage of a trademark by 3.26%, it decreases its export value by 23.7% and the quantity by 24.1%. From these results, I find that the effects of the entry of OPAI countries on all dependent variables are heterogeneous among firms.

These results suggest a reallocation away from less productive exporters. When the cost of obtaining a trademark in a foreign country declines, exporters are more likely to use a trademark. Since asymmetric information between sellers and buyers is mitigated with the use of a trademark, and the demand function is responsive to quality, sellers have an incentive to offer higher quality to buyers. Given that marginal costs increase as the provided quality increases, they set a higher price. Although the higher price is set, buyers are attracted to higher quality, and firms increase their revenue and quantity. At the extensive margin, the least productive firms decide to stop their exports due to reallocation, and the market share moves toward exporters with a trademark, at the extensive margin. On the intensive margin, less productive firms without a trademark sell less and decrease their revenue.

1.3.4 Quality Upgrading

My empirical results for the dependent variables imply that a trademark is helpful for quality upgrading, and that exporters change their behavior in response to quality upgrading. However, product quality is unobserved, and my analyses might reflect other implications. Although related studies (Schott, 2004, Hallak, 2006, and Fan et al., 2018) use the unit price as a proxy for quality of the product, this might not be an appropriate proxy because it also includes each firm's productivity.[11] To strengthen my empirical findings, I estimate quality from Chinese custom records, following Khandelwal et al. (2013). Taking the logarithm of the unit price and quantity, I estimate the quality for each firm-country-month observation as the residual from the following OLS regression with the assumption of a

[11] See Khandelwal (2010) and Amiti and Khandelwal (2013)

particular value for σ,

$$ln(q_{ict}) + \sigma ln(p_{ict}) = \alpha_{ct} + \varepsilon_{ict}, \tag{1.3}$$

where a fixed effect, α_{ct}, captures the country c's aggregate quality-adjusted price index and income, and an error term, ε_{ict}, captures the quality of the product, λ. I assume $\sigma = 2.5$; this is the elasticity across new pneumatic rubber tires in Africa, as reported by Soderbery (2018).[12] Estimated quality is $ln(\hat{\lambda}_{ict}) = \frac{\hat{\varepsilon}_{ict}}{\sigma-1}$.[13] After the estimation of quality, I run the same homogeneous and heterogeneous regressions on the intensive margin as in Sections 1.3.2 and 1.3.3.

The results are reported in Table 1.6. Overall, a Chinese exporter increases quality by 15.4% after the countries join OAPI. The heterogeneous effect depends on a firm's characteristics. If a firm was among the best 3 or best 10 exporters in country c in 2014, it increases its quality by 17.7% or 20.1%, respectively. Moreover, if a firm exports more than a half of the total export to OAPI countries, it increases usage of a trademark by 22.9%. This empirical finding on quality supports my theoretical predictions that a trademark mitigates asymmetric information on quality, and that an exporter with a trademark upgrades the quality and increases the export value, quantity, and unit price.

1.3.5 Parallel Trends and Placebo Test

I exploit the sudden change in the number of ratifying countries, caused by OAPI membership in Africa, in a regression framework. However, my specification in the Difference-in-Differences analyses might capture different macroeconomic trends between OAPI and AIRPO countries. I consider the following specification to check whether my empirical findings in the previous sections suffer from this concern:

$$y_{ict} = \gamma_0 + \sum_j \gamma_j OAPI_c \times d_{jt} + \eta_i + \lambda_t + \xi_c + \varepsilon_{ict}, \tag{1.4}$$

where y_{ict} is an outcome of interest which includes the export dummy, trademark dummy, quantity, export value, unit price, and estimated quality, following Khandelwal et al. (2013). d_{jt} is a dummy variable which takes 1 if j equals to t. Finally, η_i is an individual fixed effect, λ_t is a time fixed effect, and ξ_c is a country fixed effect. If all of γ_j for j before March 2015 are not statistically different from 0, my empirical findings do not suffer from

[12] Related literature uses σ=5 instead of σ=2.5, as derived from Broda et al. (2006). I also use this value of σ for the robustness checking; the results are shown in the appendix.

[13] In addition to this estimation of quality, I also directly proxy quality with $ln(\lambda_j) \propto ln(q_{ict}) + \sigma ln(p_{ict})$, following Manova and Yu (2017) and Bloom et al. (2018). I obtain qualitatively the same results in the appendix.

different macroeconomic trends. Figures 1.3, 1.4, 1.5, 1.6, 1.7, and 1.8 investigate the dynamic patterns in all coefficients, γ_j, on all dependent variables. These figures show the absence of differential trends in all dependent variables. In these figures, the coefficients before OAPI countries join the Madrid Protocol are close to 0, and they show statistically significantly different patterns after the entry.

To further strengthen my argument, I also use the fabric industry as a "placebo" to check that different macroeconomic trends show no spurious impact on Chinese exporters. The fabric industry is an ideal industry for a placebo test, as a trademark is not used by Chinese exporters in this industry, due to the industry's unique characteristics. Fabric is an intermediate good for clothes, and local clothes producers do not need the marks of Chinese producers and/or the symbol "®" on fabric. Therefore, I focus on the aggregate export value, quantity and unit price of fabric exported by Chinese exporters, and use the following specification to run a placebo test.[14]

$$y_{jct} = \beta_1 OAPI_c \times After_t + \eta_{jt} + \xi_c + \varepsilon_{jct}, \tag{1.5}$$

where y_{jct} is an outcome of interest in industry j in country c at time t, which includes the aggregate export value, quantity, and unit price. η_{jt} is an individual time fixed effect, and ξ_c is a country fixed effect.

Table 1.7 presents an estimate of equation 1.5. If Chinese exporters' decisions were driven by unobservable macroeconomic determinants of changes, then the ratification of the international trademark agreement would exhibit spurious effects. However, the coefficients of the intersection in Table 1.7 are never statistically different from zero. Moreover, Figures 1.9, 1.10, and 1.11 investigate dynamic patterns in all coefficients. These figures show the absence of dynamic trends in the aggregate export value, quantity, and unit price. Taken together, these results suggest that my key estimate in Table 1.2−1.6 can be interpreted as a plausibly reliable estimate of the effect of an international trademark agreement.

1.3.6 Law Enforcement

As I explained in Section 1.1, a seller uses a trademark to create its brands and to convey credible signals of a firm's reputation and reliability to a consumer. Since a trademark

[14] The 4-digit product categories for my place analysis include the following: HS 5208, HS 5209, HS 5210, HS 5211, HS 5212, HS 5309, HS 5310, HS 5311, HS 5407, HS 5408, HS 5512, HS 5513, HS 5514, HS 5515, HS 5516, HS 5801, HS 5802, HS 5803 HS 5804 HS 5806, HS 5809, HS 5901, HS 5902, HS 5903, HS 5906, HS 5907, HS 6001, HS 6002, HS 6003, HS 6004, HS 6005, HS 6006.

is registered and protected by the government, an exporter's decision might depend on the government's law enforcement ability. In this subsection, I investigate two questions: (1) whether law enforcement improves after the accession of OAPI countries, and (2) whether this affects Chinese exporters' decision. For an empirical analysis to address these questions, I use two sources of data to obtain proxies: one is the Ibrahim Index of African Governance Data by the Mo Ibrahim Foundation, and the other is Doing Business Data by the World Bank.

The results are reported in Table 1.8. In this table, outcomes of interest include two scores and three costs. The Independence Score and Transparency Score are from the Ibrahim Index of African Governance Data, and the Attorney Cost, Court Cost, and Transparency Score are from the Doing Business Data. The Independence Score captures the independence of the judiciary from the influence of external actors; whether the judiciary has the ability and autonomy to interpret and review existing laws, legislation, and policy; and the integrity of the process of appointing and removing national-level judges. The Transparency Score captures the extent to which the legal process is free from interference, and to which formal judicial reasoning is present. Attorney Cost is the fees that a plaintiff must advance to a local attorney in the standardized case, regardless of a final reimbursement. Court Cost includes all costs that a plaintiff must advance to the court, regardless of the final cost borne by a plaintiff. Enforcement Cost includes all costs that a plaintiff must advance to enforce the judgment through a public sale of a defendant's movable assets, regardless of the final cost borne by the plaintiff. Total Cost includes all of these three costs.

The results show that law enforcement improves, and the cost related to lawsuits decreases, after the international trademark agreement. After the accession of OAPI countries, the Independence Score and Transparency Score increase by 2.662 points and by 3.953 points, respectively. Moreover, the court costs incurred by the plaintiff decrease by 8.57%. These results imply that OAPI countries put effort into improvement of law enforcement and management of the court. Next, I also estimate whether law enforcement matters for a Chinese exporter's decision. The results are reported in Table 1.9. The results show that law enforcement affects a Chinese exporter not at the extensive margin but on the intensive margin. A 1-point increase in the score of the judiciary independence increases the unit price by 0.0749% but decreases the export value and quantity by 0.436% and 0.511%, respectively.

1.3.7 Alternative Hypotheses

My interpretation of the results is that sellers use a trademark to upgrade the quality of their products; they sell and earn more because they can mitigate the information frictions they face by using a trademark. However, there is another hypothesis under which they would use a trademark. This alternative hypothesis is that firms use a trademark not to differentiate their products from others, but to protect their goods from losing sales to counterfeit products. In the appendix, I show theoretical predictions arising from this mechanism. In the model, I assume that there is no asymmetric information between sellers and buyers, but that authentic producers have to compete with counterfeit producers when they both sell the same varieties, if they do not have a trademark. If they can protect their goods from counterfeit ones with a trademark, it means that they face less competition and can increase their market power by excluding counterfeit goods from the market. Then, they feel less pressure and have less incentive to offer high quality with a trademark to consumers. Moreover, when the cost of applying for a trademark decreases, a reallocation occurs from less productive firms to highly productive ones, which induces a reduction in the number of firms in the market, as well as less competition among horizontally differentiated producers. As a result, non-trademark users also downgrade the quality of their product, decrease the unit price, and sell and earn less. Since non-trademark users do not statistically change the unit price when the cost decreases, the prediction of the unit price of non-trademark users based on this mechanism is at odds with my empirical findings. Furthermore, the downgraded quality of the product is not consistent with the results, because my estimated quality increases with a trademark and does not change without a trademark.

Another concern is that a firm uses a trademark to exclude products from the market and to change its markup. If this holds, the increase in the unit price is not derived from the increase in provided quality, but from higher markups resulting from change in the market size (Melitz and Ottaviano, 2008). To check whether a Chinese exporter changes its markup after the accession of OAPI countries into the WIPO, I follow Corsetti et al. (2019) and estimate the destination-specific markup elasticity to the exchange rate. Table 1.10 reports the overall and heterogeneous results. On average, the destination-specific markup elasticity is moderate, of the order of 1.66%. This is consistent with Corsetti et al. (2019)'s findings. However, I locate no empirical evidence of change in the markup elasticity. In column (1), overall, a Chinese exporter does not statistically change the markup elasticity after the accession. Moreover, I do not find the heterogeneous effect.

The results in columns (2)-(3) show that the effect of the accession on the markup elasticity is irrelevant to each Chinese exporter's position in each exporting country and its exporting strategy. I also complement this analysis with the heterogeneous Difference-in-Differences analysis in Table 1.5. According to Melitz and Ottaviano (2008), which incorporates the endogenous markup, every firm in the market determines its unit price due to its market size. Thus, if the endogenous markup is true, I predict that after the agreement, every firm in the market changes its unit price due to the reallocation of the market share. However, in my empirical analysis, only a large firm increases the price by using a trademark; a small firm neither increases its price nor uses a trademark. Thus, I can conclude that this effect does not come from change in the markup.

My empirical findings in the heterogeneous Difference-in-Differences analysis suggest a reallocation away from less productive exporters, due to highly productive exporters' quality upgrading. However, there is another possibility consistent with my empirical findings: highly productive firms might relocate their exports from ARIPO countries to OAPI countries after the ratification of the international trademark agreement in OAPI countries. To check this possibility, I investigate whether the total export to ARIPO countries is different between each exporter's position in OAPI countries. The results are shown in Table 1.11. In this table, there are three outcomes of interest: $Value_{i,ARIPO,t}$ and $Quantity_{i,ARIPO,t}$ are the sum of export value and quantity of firm i to ARIPO countries at time t, respectively, and $Number_{i,ARIPO,t}$ is the number of ARIPO countries to which firm i exports at time t. I also categorize each firm into the following groups: $OAPI\ 15_i$ is a dummy variable which takes 1 if firm i was among the best 15 exporters in at least one country of OAPI countries in 2014, and $ARIPO\ 15_i$ is a dummy variable which takes 1 if firm i was among the best 15 exporters in at least one country of ARIPO countries in 2014. The results in columns $(1)-(3)$ show that large Chinese exporters in OAPI countries do not statistically significantly change their exports to ARIPO countries. I also refute this possibility from the aggregate Difference-in-Differences analysis. If this holds, highly productive exporters relocate their exports from ARIPO countries, which increases the aggregate exports to OAPI countries after the ratification. However, in Table 1.2, the aggregate export value and quantity decrease. These empirical findings are contrary to the reallocation mechanism.

1.4 Theoretical Background

This section develops the trademark choices of heterogeneous firms in closed and two-country open economies, in a general equilibrium framework to guide my empirical analysis. The economy is a single monopolistically competitive industry where firms produce differentiated products. Firms are heterogeneous in terms of productivity, as found in Hallak and Sivadasan (2013); and they face fixed costs to enter into an industry, as in Melitz (2003). They can use a trademark to mitigate information frictions by paying a fixed technology adoption cost, as in Yeaple (2005) and Bustos (2011).

1.4.1 Closed Economy

First, I explain the theoretical model in a closed economy. The economy in a closed economy is a monopolistic competition framework with a constant elasticity of substitution demand. I assume that there is asymmetric information between sellers and buyers, and that a trademark can mitigate information frictions because sellers can build their reputation with their registered marks and/or brands. Buyers can identify how horizontally differentiated each variety is, but they cannot identify how vertically differentiated each variety is if a trademark is not attached. The utility maximization problem, based on these assumptions, is as follows:

$$U = \max_{q_j, q_{j'}} [\int_{j \in \mathcal{J}^{TM}} (q_j \lambda_j)^{\frac{\sigma-1}{\sigma}} dj + \int_{j' \in \mathcal{J}^{NoTM}} (q_{j'} \lambda)^{\frac{\sigma-1}{\sigma}} dj']^{\frac{\sigma}{\sigma-1}}$$
$$s.t. \quad \int_{j \in \mathcal{J}^{TM}} p_j q_j dj + \int_{j' \in \mathcal{J}^{NoTM}} p_{j'} q_{j'} dj' = E, \tag{1.6}$$

where j and j' index product varieties, p_j and q_j are, respectively; the price and quantity of variety j, $\mathcal{J}^{TM}$ is the set of varieties with a trademark, $\mathcal{J}^{NoTM}$ is the set of varieties without a trademark, σ is the elasticity of substitution, and E is the exogenously given level of expenditure. Product quality is interpreted as any attribute that buyers value. If a trademark is attached to variety j, buyers can identify the quality of the variety, λ_j. However, without a trademark, they cannot recognize the difference in quality between varieties, and they believe that without a trademark, the quality of all varieties is the same, λ. From this utility maximization problem, the demand function for each variety with and without a trademark, $j \in \mathcal{J}^{TM}$ and $j' \in \mathcal{J}^{NoTM}$, is as follows.

$$q_j = p_j^{-\sigma} \lambda_j^{\sigma-1} P^{\sigma-1} E, \tag{1.7}$$

$$q_{j'} = p_{j'}^{-\sigma}\lambda^{\sigma-1}P^{\sigma-1}E, \tag{1.8}$$

where $P = [\int_{j\in\mathcal{J}^{TM}} p_j^{1-\sigma}\lambda_j^{\sigma-1}dj + \int_{j'\in\mathcal{J}^{NoTM}} p_{j'}^{1-\sigma}\lambda^{\sigma-1}dj']^{\frac{1}{1-\sigma}}$ is an aggregate quality-adjusted price index. From this demand function, the revenue function for firm j is as follows.

$$r_j = \begin{cases} p_j^{1-\sigma}\lambda_j^{1-\sigma}P^{\sigma-1}E & if \quad j \in \mathcal{J}^{TM}, \\ p_j^{1-\sigma}\lambda^{1-\sigma}P^{\sigma-1}E & otherwise. \end{cases} \tag{1.9}$$

There are two costs required to produce quality λ_j: variable and fixed costs. Each firm has productivity heterogeneity, φ, regarding the variable costs' given quality, and the cost function to produce q_j units with quality λ_j is given as:

$$c(\varphi) = \frac{c}{\varphi}\lambda_j^{\beta}q_j, \qquad 0 \leq \beta < \frac{\sigma-1}{\sigma}, \tag{1.10}$$

where c is a constant parameter. The condition that β is less than $\frac{\sigma-1}{\sigma}$ is sufficient for $0 \leq \beta < 1$ and it ensures concavity of the profit function. Marginal costs are assumed to be independent of scale and increasing in product quality λ_j. On the other hand, the fixed costs include endogenous sunk costs:

$$F = F_0 + \frac{f}{\xi}\lambda_j^{\alpha}, \qquad \alpha > (1-\beta)(\sigma-1), \tag{1.11}$$

where F_0 is the fixed cost for each firm to set up its own variety and $\frac{f}{\xi}\lambda_j^{\alpha}$ is the fixed cost to produce quality, λ_j. The condition that $\alpha > (1-\beta)(\sigma-1)$, which is imposed to ensure the concavity, implies that the fixed costs grow sufficiently fast with quality.

Each firm chooses its own price and quality to maximize its profits, π_j. However, the firm faces one constraint after the entry: it needs to provide at least a certain level of quality, $\underline{\lambda}$, in order to sell its variety in the market. This threshold, $\underline{\lambda}$, can be interpreted as the level of quality required by the government. With this constraint, each firm's profit maximization problem without a trademark is as follows:

$$\pi_j^{NoTM}(\varphi) = \max_{p_j^{NoTM}\in(0,\infty),\lambda_j^{NoTM}\in[\underline{\lambda},\infty)} p_j^{1-\sigma}\lambda^{\sigma-1}P^{\sigma-1}E - \frac{c}{\varphi}\lambda_j^{\beta}p_j^{-\sigma}\lambda^{\sigma-1}P^{\sigma-1}E - F_0 - \frac{f}{\xi}\lambda_j^{\alpha}. \tag{1.12}$$

Solving this problem,

$$\lambda_j^{NoTM}(\varphi) = \underline{\lambda}, \tag{1.13}$$

$$p_j^{NoTM}(\varphi) = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta}, \tag{1.14}$$

$$q_j^{NoTM}(\varphi) = (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma}\underline{\lambda}^{(1-\beta)\sigma-1}P^{\sigma-1}E, \tag{1.15}$$

$$r_j^{NoTM}(\varphi) = (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E, \tag{1.16}$$

$$\pi_j^{NoTM}(\varphi) = \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0. \tag{1.17}$$

In the Bayesian Nash equilibrium, buyers' beliefs are consistent.

$$\lambda = \underline{\lambda}. \tag{1.18}$$

On the other hand, if a trademark is attached, buyers can identify quality separately. The cost of obtaining a trademark is a fixed cost, rendered as F_{TM}. Therefore, the profit maximization problem with a trademark is as follows:

$$\pi_j^{TM}(\varphi) = \max_{p_j^{TM}\in(0,\infty),\lambda_j^{TM}\in[\underline{\lambda},\infty)} p_j^{1-\sigma}\lambda_j^{\sigma-1}P^{\sigma-1}E - \frac{c}{\varphi}\lambda_j^{\beta+\sigma-1}p_j^{-\sigma}P^{\sigma-1}E - F_0 - \frac{f}{\xi}\lambda_j^{\alpha} - F_{TM}. \tag{1.19}$$

Solving this problem, I obtain:

$$\lambda_j^{TM}(\varphi) = \begin{cases} \underline{\lambda}, \\ [\frac{1-\beta}{\alpha}(\frac{\sigma-1}{\sigma})^{\sigma}(\frac{\varphi}{c})^{\sigma-1}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{1}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.20}$$

$$p_j^{TM}(\varphi) = \begin{cases} \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta}, \\ (\frac{\sigma}{\sigma-1})^{\frac{\alpha-\beta-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{c}{\varphi})^{\frac{\alpha-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha}\frac{\xi}{f}P^{\sigma-1}E)^{\frac{\beta}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.21}$$

$$q_j^{TM}(\varphi) = \begin{cases} (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma}\underline{\lambda}^{(1-\beta)\sigma-1}P^{\sigma-1}E, \\ (\frac{\sigma-1}{\sigma})^{\frac{\sigma(\alpha-\beta)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{c})^{\frac{\alpha\sigma-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(P^{\sigma-1}E)^{\frac{(1-\beta)\sigma}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha}\frac{\xi}{f})^{\frac{(1-\beta)\sigma-1}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.22}$$

$$r_j^{TM}(\varphi) = \begin{cases} (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E, \\ (\frac{\sigma-1}{\sigma})^{\frac{(\sigma-1)(\alpha-\beta+1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{c})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\xi}{f})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(P^{\sigma-1}E)^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.23}$$

$$\pi_j^{TM}(\varphi) = \begin{cases} \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0 - F_{TM}, \\ (\frac{\sigma-1}{\sigma})^{\frac{\alpha\sigma}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\alpha-(1-\beta)(\sigma-1)}{(1-\beta)(\sigma-1)})(\frac{\varphi}{c})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\xi}{f})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E)^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}} - F_0 - F_{TM}. \end{cases} \tag{1.24}$$

Each firm decides whether or not to use a trademark by choosing a higher profit from $\pi_j^{NoTM}(\varphi)$ and $\pi_j^{TM}(\varphi)$. Thus, its profit $\pi_j(\varphi)$ is:

$$\pi_j(\varphi) = \max\{\pi_j^{NoTM}(\varphi), \pi_j^{TM}(\varphi)\}. \tag{1.25}$$

I show (i) how a firm changes its quality, price, quantity, and revenue, both with and without a trademark, and (ii) how it is assigned to one of two groups: with a trademark or without a trademark. For the former part, I show the following property.

Proposition 1. *Conditional on φ,*

$$p_j^{TM}(\varphi) \geq p_j^{NoTM}(\varphi). \tag{1.26}$$

$$\lambda_j^{TM}(\varphi) \geq \lambda_j^{NoTM}(\varphi). \tag{1.27}$$

$$q_j^{TM}(\varphi) \geq q_j^{NoTM}(\varphi). \tag{1.28}$$

$$r_j^{TM}(p_j^{TM}, \lambda_j^{TM}) \geq r_j^{NoTM}(p_j^{NoTM}, \lambda_j^{NoTM}). \tag{1.29}$$

Proof. See the appendix. □

With a trademark, the asymmetric information between sellers and buyers is mitigated. Since the demand function is responsive to quality, a firm has an incentive to offer higher quality to buyers. Since marginal costs increase as the provided quality increases, it sets a higher price. However, despite the higher price, buyers buy higher quantities because they are attracted to higher quality. As a result, revenue increases.

In the next proposition, I show the sorting process for which firms use a trademark.

Proposition 2.

$$\pi_j^{TM}(p_j^{TM}(\varphi), \lambda_j^{TM}(\varphi)) \geq \pi_j^{NoTM}(p_j^{NoTM}(\varphi), \lambda_j^{NoTM}(\varphi)) \quad for \quad all \quad \varphi \geq \varphi^{TM}, \tag{1.30}$$

where φ^{TM} satisfies $\pi_j^{TM}(p_j^{TM}(\varphi^{TM}), \lambda_j^{TM}(\varphi^{TM})) = \pi_j^{NoTM}(p_j^{NoTM}(\varphi^{TM}), \lambda_j^{NoTM}(\varphi^{TM}))$.

Proof. See the appendix. □

Trademark choice is represented in Figure 1.12, in which the two possible profits are described as functions of firm productivity, $\varphi^{\sigma-1}$. The technology adoption cutoff is denoted by φ^{TM}. Since the demand function does not respond to the provided quality without a trademark, the slope of a firm's profit function when not using a trademark is not steep. On the other hand, although the slope of the profit function is steeper when it offers higher quality with a trademark, it must then bear the cost of obtaining a trademark. If it has limited productivity, it cannot sell sufficient quantities to cover the fixed cost. Therefore, only a highly productive firm uses a trademark to differentiate its variety from others and to earn a higher profit.

To derive the closed economy equilibrium, I state the conditions for the exit and trademark usage as functions of the exit cutoff, φ^*, and the trademark cutoff, φ^{TM}. I assume $\varphi^{TM} > \varphi^*$, which is consistent with the empirical findings I report in Section 1.3.[15] At the exit cutoff, φ^*, the firm's profit is zero, and the following condition holds.

$$\pi_j^{NoTM}(\varphi^*) = 0. \tag{1.31}$$

At the trademark cutoff, φ^{TM}, the firm's profit is the same with and without a trademark, and it satisfies the following condition:

$$\pi_j^{TM}(\varphi^{TM}) = \pi_j^{NoTM}(\varphi^{TM}). \tag{1.32}$$

As in Melitz (2003), the average expected profit level, $\overline{\pi}$, and the exit cutoff, φ^* are determined by the free entry condition and zero cutoff profit condition.

$$\overline{\pi} = \frac{1}{1 - G(\varphi^*)}[\int_{\varphi^*}^{\varphi^{TM}} \pi^{NoTM}(\varphi)dG(\varphi) + \int_{\varphi^{TM}}^{\infty} \pi^{TM}(\varphi)dG(\varphi)]. \tag{1.33}$$

$$\overline{\pi} = \frac{\delta f_e}{1 - G(\varphi^*)}. \tag{1.34}$$

where f_e is the required cost for entry and $G(\varphi)$ is a cumulative distribution of productivity φ.

I analyze the impact of the cost of obtaining a trademark on the economy, which I check in my empirical analysis. With the assumption that $G(\varphi)$ follows a Pareto productivity distribution with $G(\varphi) = 1 - \varphi_{min}^k \varphi^{-k}$, I show how a reduction in the cost, F_{TM}, affects the entry of firms at an extensive margin and their behaviors at an intensive margin in a general equilibrium framework.

Proposition 3. *When F_{TM} decreases,*

1. *The fraction of surviving of firms that use a trademark, $(\frac{\varphi^{TM}}{\varphi^*})^{-k}$, increases, that is, $\frac{\partial \frac{\varphi^{TM}}{\varphi^*}}{\partial - F_{TM}} < 0$.*
2. *The average expected profit increases, that is, $\frac{\partial \overline{\pi}}{\partial - F_{TM}} > 0$.*
3. *The exit cutoff increases, that is, $\frac{\partial \varphi^*}{\partial - F_{TM}} > 0$.*

[15] The same assumption is also made in Bustos (2011). I can support this assumption with various conditions. Furthermore, this is consistent with my empirical findings.

4. *The aggregate price index decreases, that is,* $\frac{\partial P}{\partial - F_{TM}} < 0$.

5. *Quantity, revenue and profit without a trademark decreases, that is,* $\frac{\partial q_j^{NoTM}}{\partial - F_{TM}} < 0$, $\frac{\partial r_j^{NoTM}}{\partial - F_{TM}} < 0$, *and* $\frac{\partial \pi_j^{NoTM}}{\partial - F_{TM}} < 0$.

6. *Welfare increases, that is,* $\frac{\partial W}{\partial - F_{TM}} > 0$.

Proof. See the appendix. □

I show the effect of a reduction in F_{TM} in Figure 1.13 and 1.14. When the cost of obtaining a trademark declines, the line of the profit function with a trademark in Figure 1.13 goes upward. As a result, a firm is more likely to use a trademark, and this increases its average expected profit. Then, the zero cutoff profit condition moves rightward, and the exit cutoff, φ^*, increases. When the least productive firm decides to exit the market, the aggregate quality-adjusted price index decreases, and the firms sell fewer quantities and decrease their revenues without a trademark.

1.4.2 Open Economy

Since the international trademark agreement only decreases the trademark registration fee for exporters, I also use the same setting in the symmetric two-country open economy model and examine how exporters change their exporting behaviors in response to the agreement. The symmetry assumption ensures that all aggregate variables are the same for both countries. I consider the home country's side. Then, for the demand side, I assume the same utility function. Thus, the demand function for variety j with or without a trademark is as follows.

$$q_j = p_j^{-\sigma} \lambda_j^{\sigma-1} P^{\sigma-1} E, \tag{1.35}$$

$$q_{j'} = p_{j'}^{-\sigma} \lambda^{\sigma-1} P^{\sigma-1} E, \tag{1.36}$$

where $P = [\int_{j \in \mathcal{J}^{TM}} p_j^{1-\sigma} \lambda_j^{\sigma-1} dj + \int_{j' \in \mathcal{J}^{NoTM}} p_{j'}^{1-\sigma} \lambda^{\sigma-1} dj']^{\frac{1}{1-\sigma}}$ is the aggregate quality-adjusted price index and E is the exogenously given level of expenditures in the two countries.

I assume that a firm that wishes to export must make an initial fixed investment and pay per-unit trade costs. The initial fixed investment cost is F_{ex}, and the per-unit trade costs are modeled in the standard iceberg formulation, whereby $\tau > 1$ units of a good must be shipped in order for one unit to arrive at a destination. From here on, a domestic market is denoted by d, and a foreign market is denoted by ex. With the production function I use in the closed economy, the profits in domestic and foreign markets are as follows:

$$\pi_{j,d}^{NoTM}(\varphi) = \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0, \tag{1.37}$$

$$\pi_{j,d}^{TM}(\varphi) = \begin{cases} \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0 - F_{d,TM}, \\ (\frac{\sigma-1}{\sigma})^{\frac{\alpha\sigma}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\alpha-(1-\beta)(\sigma-1)}{(1-\beta)(\sigma-1)})(\frac{\varphi}{c})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\xi}{f})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E)^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}} - F_0 - F_{d,TM}, \end{cases} \tag{1.38}$$

$$\pi_{j,ex}^{NoTM}(\varphi) = \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{\tau c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_{ex}, \tag{1.39}$$

$$\pi_{j,ex}^{TM}(\varphi) = \begin{cases} \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{\tau c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_{ex} - F_{ex,TM}, \\ (\frac{\sigma-1}{\sigma})^{\frac{\alpha\sigma}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\alpha-(1-\beta)(\sigma-1)}{(1-\beta)(\sigma-1)})(\frac{\varphi}{\tau c})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\xi}{f})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E)^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}} - F_{ex} - F_{ex,TM}, \end{cases} \tag{1.40}$$

where $F_{d,TM}$ and $F_{ex,TM}$ are the cost of a trademark for home products and exporters, respectively.

To solve the open-economy equilibrium, I explain the conditions for the exit and trademark usage in domestic and foreign markets as functions of the exit cutoff, φ_d^*; the export cutoff, φ_{ex}^*; and the trademark cutoffs in home and foreign countries, φ_d^{TM} and φ_{ex}^{TM}, respectively.[16] I assume $\varphi_{ex}^* > \varphi_d^*$, $\varphi_d^{TM} > \varphi_d^*$ and $\varphi_{ex}^{TM} > \varphi_{ex}^*$, which is consistent with my empirical findings.[17] At the exit cutoff, the profit in a domestic market is zero:

$$\pi_{j,d}^{NoTM}(\varphi_d^*) = 0. \tag{1.41}$$

At the export cutoff, the profit in a foreign market is zero:

$$\pi_{j,ex}^{NoTM}(\varphi_{ex}^*) = 0. \tag{1.42}$$

At the trademark cutoff in domestic and foreign markets, the profits with or without a trademark are the same. Therefore, the following two conditions are satisfied:

$$\pi_{j,d}^{TM}(\varphi_d^{TM}) = \pi_{j,d}^{NoTM}(\varphi_d^{TM}). \tag{1.43}$$

$$\pi_{j,ex}^{TM}(\varphi_{ex}^{TM}) = \pi_{j,ex}^{NoTM}(\varphi_{ex}^{TM}). \tag{1.44}$$

[16] I do not describe the conditions for the exit cutoff and the export cutoff of a firm in a foreign country, due to the assumption of symmetry.

[17] The same assumption is also made in Bustos (2011), and I can support this assumption with further conditions. Furthermore, this is consistent with my empirical findings.

As in Melitz (2003), the average expected profit level, $\overline{\pi}$, and the exit cutoff, φ_d^* are determined by the free entry condition and zero cutoff profit condition.

$$\overline{\pi} = \frac{1}{1-G(\varphi^*)}[\int_{\varphi_d^*}^{\varphi_d^{TM}} \pi_d^{NoTM}(\varphi)dG(\varphi)+\int_{\varphi_d^{TM}}^{\infty} \pi_d^{TM}(\varphi)dG(\varphi)+\int_{\varphi_{ex}^*}^{\varphi_{ex}^{TM}} \pi_{ex}^{NoTM}(\varphi)dG(\varphi)+\int_{\varphi_{ex}^{TM}}^{\infty} \pi_{ex}^{TM}(\varphi) \tag{1.45}$$

$$\overline{\pi} = \frac{\delta f_e}{1-G(\varphi_d^*)}, \tag{1.46}$$

where f_e is the required cost for entry and $G(\varphi)$ is a cumulative distribution of productivity φ. I also analyze the impact of the cost of obtaining a trademark in a foreign country on the economy in the symmetric two-country open economy. With the assumption that $G(\varphi)$ follows a Pareto productivity distribution with $G(\varphi) = 1 - \varphi_{min}^k \varphi^{-k}$, I show how a reduction in the cost, $F_{ex,TM}$, affects the entry of exporters at an extensive margin and their behaviors at an intensive margin in a general equilibrium framework.

Proposition 4. *When $F_{ex,TM}$ decreases,*

1. *The fraction of surviving of firms that use a trademark in a foreign country, $(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k}$, increases, that is, $\frac{\partial \frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}}{\partial - F_{ex,TM}} < 0$.*
2. *The average expected profit increases, that is, $\frac{\partial \overline{\pi}}{\partial - F_{ex,TM}} > 0$.*
3. *The exit cutoff increases, that is, $\frac{\partial \varphi_d^*}{\partial - F_{ex,TM}} > 0$.*
4. *The export cutoff increases, that is, $\frac{\partial \varphi_{ex}^*}{\partial - F_{ex,TM}} > 0$.*
5. *The aggregate price index decreases, that is, $\frac{\partial P}{\partial - F_{ex,TM}} < 0$.*
6. *Quantity, revenue and profit without a trademark decreases in a domestic market, that is, $\frac{\partial q_{j,d}^{NoTM}}{\partial - F_{ex,TM}} < 0$, $\frac{\partial r_{j,d}^{NoTM}}{\partial - F_{ex,TM}} < 0$, and $\frac{\partial \pi_{j,d}^{NoTM}}{\partial - F_{ex,TM}} < 0$.*
7. *Quantity, revenue, and profit without a trademark decrease in a foreign market, that is, $\frac{\partial q_{j,ex}^{NoTM}}{\partial - F_{ex,TM}} < 0$, $\frac{\partial r_{j,ex}^{NoTM}}{\partial -_{ex,TM}} < 0$, and $\frac{\partial \pi_{j,ex}^{NoTM}}{\partial - F_{ex,TM}} < 0$.*
8. *Welfare increases, that is, $\frac{\partial W}{\partial - F_{ex,TM}} > 0$.*

Proof. See the appendix. □

When the cost of obtaining a trademark for exports declines, an exporter is more likely to use a trademark, and this increases its average expected profit. Then, the exit cutoff, φ_d^*, and the export cutoff, φ_{ex}^*, increase, and the least productive firm decides to leave the market in a domestic country and to stop its export to a foreign country, due to the reallocation mechanism. If the least productive firm stops its exporting, the aggregate quality-adjusted price index decreases, and the exporter sells lower quantities and decreases its revenue without a trademark. I explore these predictions in my empirical analysis.

1.5 Welfare Analysis

From the previous section, I find that when the cost of obtaining a trademark for exports declines, (i) an exporter is more likely to use a trademark, (ii) the least productive firm decides to stop its export to a foreign country due to the reallocation mechanism, (iii) a small firm not using a trademark decreases its quantity and revenue, and (iv) a large firm using a trademark increases its unit price, quantity, quality, and revenue. However, at the current stage, it is not clear whether or not a trademark is a welfare-enhancing technology. In this section, I measure two variables to answer this question: (i) the number of car accidents, and (ii) the gains from trade, following Hsieh et al. (2020).

1.5.1 Road Accident Analysis

Road traffic injuries are one of the most significant health and development problems throughout the world, but especially in Africa. According to the global status reports on road safety 2013 and 2018 by the WHO (World Health Organization, 2013 and World Health Organization, 2018), Africa's road fatality rate is 26.6 deaths per 100,000 people, which is nearly three times the rate in Europe, which has the lowest rate globally. Tires are one of vehicles' safety components, and are also considered a vital factor in the reduction of road accidents. Since my empirical analyses reveal that the quality of tires improves in OAPI countries, I predict that the road traffic death rate decreases in these countries.

To check my prediction, I use these two WHO reports mentioned above and employ the overall and heterogeneous Difference-in-Differences analyses. Table 1.12 shows the results. After the ratification of the international trademark agreement, OAPI countries decrease the road traffic death rate and the log of that rate by 2.682 and 0.0818, but the differences are not statistically significant. Although the overall effect is not statistically different from zero, the effect is different depending on whether or not a country experienced a high death rate in 2013. When a country belongs to the OAPI and the road traffic death rate in 2013 is above the median, that country decreases the road traffic death rate and the log of that rate statistical significantly by 2.87 and 0.108 in total. Furthermore, when it is in the 3rd quartile or the 4th quartile, the road traffic death rate in OAPI countries statistically significantly decreases by 2.533 and 3.575 in the value and 0.101 and 0.131 in the log unit in total.

A crucial issue is whether these decreases are derived from improved quality of tires. I discuss this point from the viewpoint of mechanical engineering. According to Jansen et al. (2014), each % of reduced tire use and underinflated tire use decreases the number of fatalities by 3.772% and 0.0015−0.05% in the EU. Since the road mortality rate in Africa is three times as high as the rate in Europe due to unsafe road infrastructure, these numbers suggest the lower bounds for the ones in the OAPI countries. With my empirical evidence in Table 1.6 that quality improves by 15% on average, I conclude that the numbers in Table 1.12 are credible and improved quality of tires contributes to a decrease in the road traffic accidents in the OAPI countries.

According to the world report on road traffic injury prevention by the WHO (World Health Organization, 2004), in economic terms, the cost of road crash injuries is estimated to be roughly 1% of the gross national product (GNP) in low-income countries, 1.5% in middle-income countries, and 2% in high-income countries. Thus, from Table 1.12, I find that the economic cost of road traffic accidents saved by this decrease amounts to 0.101% and 0.131% of the GNP in the ratifying African countries belonging to the 3rd and 4th quartile.

1.5.2 The Gains from Trade

In this subsection, I assume country j takes the Cobb-Douglas aggregate of real consumption of multiple sectors utility:[18]

$$ln(U_j) = \sum_{s \in S} \eta_{sj} ln(C_s) \quad s.t. \quad \sum_{s \in S} \eta_{sj} = 1, \tag{1.47}$$

where s denotes a sector, S is the set of sectors, $C_s = [\sum_{i \in N} \int_{\omega \in \Omega_{is}^{TM}} (q_{is}(\omega)\lambda_{is}(\omega))^{\frac{\sigma_s - 1}{\sigma_s}} d\omega + \int_{\omega'_{is} \in \Omega_{is}^{NoTM}} (q_{is}(\omega')\lambda)^{\frac{\sigma_s - 1}{\sigma_s}} d\omega']^{\frac{\sigma_s}{\sigma_s - 1}}$ is an aggregate consumption index for sector s, i is a serving country, σ_s is an elasticity of substitution in sector s and η_{sj} is the share of expenditure on sector s in country j.

From the utility maximization problem in sector s, the aggregate welfare, W, is described

[18] This specification is used, e.g. in Arkolakis et al. (2012), Hottman et al. (2016) and Redding and Weinstein (2019).

in the following way:

$$ln(W_j) = \sum_{s \in S} \eta_{sj} ln(\frac{\eta_{sj} w_j L_j}{P_{sj}}), \tag{1.48}$$

where $P_{sj} = [\sum_{i \in N} \int_{\omega \in \Omega_{is}^{TM}} p_{ij}(\omega)^{1-\sigma_s} \lambda_{ij}(\omega)^{\sigma_s - 1} d\omega + \int_{\omega' \in \Omega_{is}^{NoTM}} p_{is}(\omega')^{1-\sigma_s} \lambda^{\sigma_s - 1} d\omega']^{\frac{1}{1-\sigma_s}}$ is an aggregate quality-adjusted price index in sector s. Therefore, the welfare change in country j caused by the entry of OAPI countries into the Madrid Union can be measured by:

$$ln(\frac{W_j'}{W_j}) = \sum_{s \in S} \eta_{sj} [ln(\frac{w_j' L_j'}{w_j L_j}) - ln(\frac{P_{sj}'}{P_{sj}})], \tag{1.49}$$

where $'$ denotes after the entry. When I use the same specification for the supply side as the one used in Section 1.4, the value of bilateral trade flows in sector s can be written as:

$$X_{ijs} = \int_{\varphi \in \Phi_{ijs}} M_{ijs} (\frac{\sigma_s}{\sigma_s - 1} \frac{w_i \tau_{ijs}}{\varphi})^{1-\sigma_s} \lambda_{ijs}^{(1-\beta)(\sigma_s - 1)} P_j^{\sigma_s - 1} \eta_{sj} w_j L_j dG_i(\varphi | \varphi \in \Phi_{ijs}), \tag{1.50}$$

where M_{ij} is the number of firms from country i serving county j in sector s, Φ_{ij} is the set of productivities corresponding to all country i firms serving country j in sector s, and $dG_i(\varphi | \varphi \in \Phi_{ijs})$ is the cumulative distribution. These bilateral trade flows can be rewritten as $X_{ijs} = M_{ijs}(\frac{\sigma_s}{\sigma_s - 1} w_i \tau_{ijs})^{1-\sigma_s} \widetilde{\lambda\varphi}_{ijs}^{\sigma_s - 1} P_j^{\sigma_s - 1} \eta_{sj} w_j L_j$, where $\widetilde{\lambda\varphi}_{ijs} = [\int_{\varphi \in \Phi_{ijs}} \lambda_{ijs}^{(1-\beta)(\sigma_s - 1)} \varphi^{\sigma_s - 1} dG_i(\varphi | \varphi \in \Phi_{ijs})]^{\frac{1}{\sigma_s - 1}}$ is the measure of quality-adjusted productivity. From this specification,

$$ln\frac{P_{js}'}{P_{js}} = -\frac{1}{\sigma_s - 1} ln\frac{M_{ijs}'}{M_{ijs}} + ln\frac{w_i' L_i'}{w_i L_i} + ln\frac{\tau_{ijs}'}{\tau_{ijs}} - \frac{1}{\sigma_s - 1} ln\frac{\widetilde{\lambda\varphi}_{ijs}'}{\widetilde{\lambda\varphi}_{ijs}} + \frac{1}{\sigma_s - 1} ln\frac{s_{ijs}'}{s_{ijs}}, \tag{1.51}$$

where $s_{ijs} = \frac{X_{ijs}}{\eta_{sj} w_j L_j}$. Summing up all source countries using the Sato-Vartia weights $\tilde{s}_{ijs} = (\frac{s_{ijs}' - s_{ijs}}{ln s_{ijs}' - ln s_{ijs}}) / (\sum_{m=1}^{N} \frac{s_{mjs}' - s_{mjs}}{ln s_{mjs}' - ln s_{mjs}})$,

$$ln\frac{P_{js}'}{P_{js}} = \sum_{i=1}^{N} \tilde{s}_{ijs} [-\frac{1}{\sigma_s - 1} ln\frac{M_{ijs}'}{M_{ijs}} + ln\frac{w_i' L_i'}{w_i L_i} + ln\frac{\tau_{ijs}'}{\tau_{ijs}} - \frac{1}{\sigma_s - 1} ln\frac{\widetilde{\lambda\varphi}_{ijs}'}{\widetilde{\lambda\varphi}_{ijs}}]. \tag{1.52}$$

To make explicit that $\widetilde{\lambda\varphi}_{ijs}$ can change because of changes in the quality-adjusted average of continuing firms or because of changes in the composition of firms, I separately define the quality-adjusted average productivity of continuing firms $\widetilde{\lambda\varphi}_{ijs}^{c}$ and expand $ln\frac{\widetilde{\lambda\varphi}_{ijs}'}{\widetilde{\lambda\varphi}_{ijs}} = ln\frac{\widetilde{\lambda\varphi}_{ijs}^{c\prime}}{\widetilde{\lambda\varphi}_{ijs}^{c}} + (ln\frac{\widetilde{\lambda\varphi}_{ijs}'}{\widetilde{\lambda\varphi}_{ijs}} - ln\frac{\widetilde{\lambda\varphi}_{ijs}^{c\prime}}{\widetilde{\lambda\varphi}_{ijs}^{c}})$. Substituting the price index decomposition and this productivity decomposition yields the welfare decomposition:

$$
\begin{aligned}
ln(\frac{W'_j}{W_j}) = & \underbrace{\sum_{s\in S}\eta_{sj}\sum_{i=1}^{N}\tilde{s}_{ijs}(\frac{1}{\sigma_s-1}ln\frac{M'_{ijs}}{M_{ijs}}+ln\frac{\tilde{\lambda\varphi}'_{ijs}}{\tilde{\lambda\varphi}_{ijs}}-ln\frac{\widetilde{\lambda\varphi}^{c\prime}_{ijs}}{\widetilde{\lambda\varphi}^{c}_{ijs}})}_{\text{gain at the extensive margin}} \\
& + \underbrace{\sum_{s\in S}\eta_{sj}\sum_{i=1}^{N}\tilde{s}_{ijs}(ln\frac{\tau'_{ijs}}{\tau_{ijs}}-ln\frac{\widetilde{\lambda\varphi}^{c\prime}_{ijs}}{\widetilde{\lambda\varphi}^{c}_{ijs}}-ln\frac{w'_iL'_i}{w_iL_i})}_{\text{gain on the intensive margin}} \qquad (1.53) \\
& + \underbrace{ln\frac{w'_jL'_j}{w_jL_j}}_{\text{income gain}}.
\end{aligned}
$$

The gains from trade are divided into two parts. I call the first part "gain at the extensive margin" and the second part "gain on the intensive margin." The gain at the extensive margin describes the gain that only arises if there are changes in the set of firms serving county j, while the gain on the intensive margin describes the gain that also arises if there are no changes in the set of firms serving country j.

I estimate the gain from trade at the extensive margin by expressing it in terms of simple sufficient statistics, which allow $X_{ijs} = M_{ijs}(\frac{\sigma_s}{\sigma_s-1}w_i\tau_{ijs})^{1-\sigma_s}\widetilde{\lambda\varphi}^{\sigma_s-1}_{ijs}P_j^{\sigma_s-1}\eta_{sj}w_jL_j$. In particular, I consider the total sales from country i to country j associated with only continuing firms, $X^c_{ijs} = M^c_{ijs}(\frac{\sigma_s}{\sigma_s-1}w_i\tau_{ijs})^{1-\sigma_s}(\widetilde{\lambda\varphi}^{c}_{ijs})^{\sigma_s-1}P_j^{\sigma_s-1}\eta_{sj}w_jL_j$. With these specifications, I obtain my basic measurement equation for the gain from trade at the extensive margin:

$$
-\frac{1}{\sigma_s-1}ln(\frac{X^{c\prime}_{ijs}/X'_{ijs}}{X^c_{ijs}/X_{ijs}}) = ln\frac{M'_{ijs}}{M_{ijs}}+(ln\frac{\widetilde{\lambda\varphi}'_{ijs}}{\widetilde{\lambda\varphi}_{ijs}}-ln\frac{\widetilde{\lambda\varphi}^{c\prime}_{ijs}}{\widetilde{\lambda\varphi}^{c}_{ijs}}). \qquad (1.54)
$$

I estimate the overall welfare gain from the empirical analysis on the individual intensive margin:

$$
ln(r^{NoTM}_{ijs,ex}) = (\sigma_s-1)ln(\frac{\sigma_s-1}{\sigma_s}w_i\tau_{ijs})+(\sigma_s-1)ln(\varphi_{is})+(\sigma_s-\beta\sigma_s-1)ln\underline{\lambda}+(\sigma_s-1)lnP_{sj}+ln\eta_{sj}w_jL_j. \qquad (1.55)
$$

From the intensive margin analysis with a firm-time fixed effect and the log of GDP as controls, I estimate the change in $(\sigma_s-1)lnP_{sj}$. With the value of $\tilde{s}_{ijs}$, I also estimate what percentage of the welfare gain comes from Chinese exporters. For this welfare analysis, I need the values of σ_s, η_{sj} and $\tilde{s}_{ijs}$. As in Section 1.3, I assume $\sigma_s = 2.5$, as reported by Soderbery (2018). To find out η_{js} and $\tilde{s}_{ijs}$, I use the UN COMTRADE (United Nations Statistics Division, 2021) database and the World Bank database, and derive the expenditure share on the tire sector.

Table 1.13 describes an overall welfare analysis based on my used σ_s, η_{sj} and $\tilde{s}_{ijs}$. The effect on welfare change produced by my investigated industry and caused by an introduction of an international trademark is positive: the welfare increases by 0.014%. Chinese exporters contribute to this welfare gain to the large extent, accounting for 64% of the total welfare increase (0.0089/0.0140). When I examine the two gains separately, the loss at the extensive margin is 0.0028%, and the gain at the intensive margin is 0.0117%. Although the least productive firm exits the market at the extensive margin and the overall productivity increases, the number of available varieties in each country decreases; this induces welfare loss as a result. On the other hand, since some of the continuing firms upgrade the quality of their products, welfare gain is positive. In my analyses, the gain on the intensive margin outweighs the loss at the extensive margin, and overall welfare increases owing to Chinese exporters.

1.6 Conclusion

Quality upgrading of goods and services has been a significant concern in developing countries due to information frictions. The question of how to help sellers to upgrade quality through public policy has been debated among policymakers in recent years, and a trademark is considered to be a critical targeting policy for policymakers. However, there are limited empirical findings regarding the role of trademarks in a market, especially international markets in developing countries. I empirically examine the impact of a trademark on sellers in international trade in the African tire industry, a context which is particularly suited to my study.

To guide my empirical analyses, I derive my theoretical model, in which only highly productive firms use a trademark to differentiate their products from others. In this theoretical setting, I show that when the cost of applying for a trademark decreases, a firm which starts using a trademark increases its sales and prices as a result of quality upgrading, but one that does not use a trademark loses sales due to reallocation of its market share. I find empirical evidence that is consistent with this theoretical model.

I also obtain empirical findings on net welfare gain in Africa, which arises from the tire industry in direct and indirect ways. In the road accident analysis, I show that the road traffic death rate decreases in the ratifying African countries that had experienced a high rate of road traffic injuries prior to ratification. In an indirect analysis, I perform a back-of-the-envelope calculation from the reduced form estimates, following Hsieh et al. (2020).

This calculation implies that the African tire industry contributes to a 0.19% welfare increase. This welfare gain is mainly caused by Chinese exporters' quality upgrading, and it outweighs welfare loss in terms of the number of varieties at the extensive margin.

This evidence, regarding both the effect of a trademark and the underlying mechanism, suggests a policy implication that may be particularly essential for trade in and between developing countries. An intervention that decreases the cost of a trademark application may be an effective way of achieving welfare improvement, particularly in a market where no other methods, such as long-term relationships, are feasible. Future work on identifying how a trademark interacts with other methods to mitigate information frictions could be valuable.

Tables

Table 1.1: Descriptive Statistics

All Countries										
Year	2014−2017		2014		2015		2016		2017	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ln(Quantity)	9.617	1.580	9.609	1.518	9.594	1.579	9.617	1.582	9.645	1.630
ln(Value)	10.491	1.519	10.757	1.502	10.447	1.482	10.323	1.503	10.456	1.551
ln(Price)	0.874	0.399	1.148	0.460	0.853	0.326	0.707	0.324	0.811	0.337
OAPI	0.374	0.484	0.407	0.491	0.363	0.481	0.361	0.480	0.368	0.482
ARIPO	0.626	0.484	0.593	0.491	0.637	0.481	0.639	0.480	0.632	0.482
TM	0.155	0.362	0.113	0.317	0.130	0.336	0.182	0.386	0.187	0.390
OAPI Countries										
Year	2014−2017		2014		2015		2016		2017	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ln(Quantity)	9.584	1.486	9.615	1.407	9.546	1.518	9.558	1.491	9.611	1.529
ln(Value)	10.506	1.447	10.826	1.433	10.420	1.429	10.286	1.415	10.473	1.453
ln(Price)	0.922	0.419	1.211	0.513	0.874	0.326	0.728	0.324	0.862	0.305
TM	0.091	0.288	0.000	0.000	0.018	0.133	0.146	0.353	0.190	0.393
ARIPO Countries										
Year	2014−2017		2014		2015		2016		2017	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ln(Quantity)	9.637	1.633	9.605	1.590	9.621	1.613	9.650	1.630	9.664	1.687
ln(Value)	10.482	1.561	10.710	1.545	10.462	1.512	10.344	1.550	10.446	1.606
ln(Price)	0.845	0.384	1.105	0.414	0.841	0.325	0.694	0.323	0.781	0.351
TM	0.193	0.395	0.191	0.393	0.193	0.395	0.203	0.402	0.185	0.388

Note: Value is measured by the US$. Price is the unit price and it is derived by Value/Quantity. TM takes 1 if a Chinese company uses its trademark in its destination country at its export date. The OAPI member countries are Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, and Togo. The ARIPO member countries are Botswana, Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mozambique, Namibia, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

Table 1.2: Aggregate Difference in Differences Analysis

Unbalanced Panel	(1)	(2)	(3)
VARIABLES	$Number_{ct}$	$ln(Value_{ct})$	$ln(Quantity_{ct})$
$OAPI_c \times After_t$	-2.260***	-0.268***	-0.176**
	(0.384)	(0.0836)	(0.0865)
Mean of Dependent Variable	12.717	13.085	12.119
Month FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
R-squared	0.909	0.848	0.845

Balanced Panel	(1)	(2)	(3)
VARIABLES	$Number_{ct}$	$ln(Value_{ct})$	$ln(Quantity_{ct})$
$OAPI_c \times After_t$	-2.548***	-0.300***	-0.178**
	(0.459)	(0.0756)	(0.0767)
Mean of Dependent Variable	15.090	13.557	12.683
Month FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
R-squared	0.892	0.823	0.827

Note: Robust standard errors are in parentheses. $Number_{ct}$ is the number of export companies in country c at time t. $Value_{ct}$ and $Quantity_{ct}$ are the sum of those of each export transaction in country c at time t, respectively. $Value_{ct}$ is measured by the US$. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after the 1st of March in 2015.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.3: Overall Analysis

	(1)	(2)	(3)	(4)	(5)
VARIABLES	$Export_{ict}$	TM_{ict}	$ln(Value_{ict})$	$ln(Quantity_{ict})$	$ln(Price_{ict})$
$OAPI_c \times After_t$	-0.00156**	0.0945***	-0.130**	-0.159***	0.0288***
	(0.000624)	(0.0230)	(0.0480)	(0.0497)	(0.00913)
Mean of Dependent Variable	0.00956	0.154	10.487	9.617	0.869
Firm FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Export Information	No	Yes	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes
Firm × Time FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.175	0.511	0.405	0.422	0.875

Note: Country-clustered standard errors are in parentheses. In columns (2) – (5), the observation is restricted to a combination of i, c and t where firm i exports its tire in 2014 and 2015, 2014 and 2016, or 2014 and 2017. $Export_{ict}$ takes 1 if firm i exports in country c at time t. $Value_{ict}$ is measured by the US$. $Price_{ict}$ is the unit price; it is derived by $Value_{ict}/Quantity_{ict}$. TM_{ict} takes 1 if firm i uses its trademark in country c at time t. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after March 1, 2015. Export Information includes the Chinese port from which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports, and the log of total imports.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.4: Heterogeneous Extensive Margin

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$Export_{ict}$		
$OAPI_c \times After_t$	9.16e-06	-0.000388	-0.000476	-0.00261***	-0.00219***
	(0.000416)	(0.000415)	(0.000391)	(0.000825)	(0.000763)
$OAPI_c \times After_t \times Incumbent_{ic2014}$	-0.0181***				
	(0.00666)				
$OAPI_c \times After_t \times \mathbb{1}\{\#ofExporters_{c2014} \geq Median\}$		-0.00266**			
		(0.00108)			
$OAPI_c \times After_t \times \mathbb{1}\{GDP_{c2014} \geq Median\}$			-0.00191*		
			(0.00106)		
$OAPI_c \times After_t \times \mathbb{1}\{MinMarketShare_{c2014} \geq Median\}$				0.00237**	
				(0.000904)	
$OAPI_c \times After_t \times \mathbb{1}\{MeanMarketShare_{c2014} \geq Median\}$					0.00167*
					(0.000939)
Mean of Dependent Variable			0.00956		
Firm FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes
Firm × Time FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.221	0.194	0.194	0.194	0.194

Note: Country-clustered standard errors are in parentheses. $Export_{ict}$ takes 1 if firm i exports in country c at time t. $Incumbent_{ic2014}$ is a dummy variable which takes 1 if firm i exports in country c in 2014. $\mathbb{1}\{\#ofExporters_{c2014} \geq Median\}$ is a dummy variable which takes 1 if the number of Chinese exporters in country c in 2014 is above the median of all countries' ones. $\mathbb{1}\{GDP_{c2014} \geq Median\}$ is a dummy variable which takes 1 if country c's GDP in 2014 exceeds the median across all countries. $\mathbb{1}\{MinMarketShare_{c2014} \geq Median\}$ is a dummy variable which takes 1 if the minimum market share a Chinese exporter had in 2014 exceeds the median across all countries. $\mathbb{1}\{MeanMarketShare_{c2014} \geq Median\}$ is a dummy variable which takes 1 if the mean of the market share a Chinese exporter had in 2014 exceeds the median across all countries. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports and the log of total imports.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.5: Heterogeneous Intensive Margin

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	TM_{ict}	$ln(Value_{ict})$	$ln(Quantity_{ict})$	$ln(Price_{ict})$	TM_{ict}	$ln(Value_{ict})$	$ln(Quantity_{ict})$	$ln(Price_{ict})$
$OAPI_c \times After_t$	0.00240	-0.207**	-0.220**	0.0132	0.0326**	-0.237***	-0.241***	0.00398
	(0.0449)	(0.0875)	(0.0858)	(0.0120)	(0.0159)	(0.0618)	(0.0655)	(0.00965)
$OAPI_c \times After_t \times$ Best 15_{ic}	0.0635	-0.234	-0.251	0.0167				
	(0.0821)	(0.188)	(0.194)	(0.0166)				
$OAPI_c \times After_t \times$ Best 10_{ic}	0.109*	0.265**	0.240*	0.0251*				
	(0.0632)	(0.125)	(0.126)	(0.0125)				
$OAPI_c \times After_t \times$ Best 3_{ic}	0.213***	0.244*	0.221*	0.0226*				
	(0.0665)	(0.131)	(0.128)	(0.0124)				
$OAPI_c \times After_t \times \mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$					0.167***	0.278***	0.213**	0.0652***
					(0.0364)	(0.0895)	(0.0885)	(0.0118)
Mean of Dependent Variable	0.154	10.487	9.617	0.869	0.154	10.487	9.617	0.869
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Export Information	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.525	0.460	0.474	0.874	0.507	0.415	0.429	0.874

Note: Country-clustered standard errors are in parentheses. The observation is restricted to a combination of i, c and t where firm i exports its tire in 2014 and 2015, 2014 and 2016, or 2014 and 2017. $Value_{ict}$ is measured by the US\$. $Price_{ict}$ is the unit price; it is derived is derived by $Value_{ict}/Quantity_{ict}$. TM_{ict} takes 1 if firm i uses its trademark in country c at time t. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after March 1, 2015. Best 3_{ic} is a dummy variable which takes 1 if firm i was among the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was among the best 10 exporters in country c in 2014, and Best 15_{ic} is a dummy variable which takes 1 if firm i was among the best 15 exporters in country c in 2014. $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of the total export of firm i was exported into OAPI countries in 2014. Export Information includes the Chinese port from which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports, and the log of total imports.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.6: Quality Updating

VARIABLE	(1)	(2)	(3)
	ln(Estimated Quality)		
$OAPI_c \times After_t$	0.154***	0.0807**	0.0678
	(0.0354)	(0.0388)	(0.0422)
$OAPI_c \times After_t \times$ Best 15_{ic}		-0.0790	
		(0.123)	
$OAPI_c \times After_t \times$ Best 10_{ic}		0.177**	
		(0.0711)	
$OAPI_c \times After_t \times$ Best 3_{ic}		0.201**	
		(0.0792)	
$OAPI_c \times After_t \times \mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$			0.229***
			(0.0617)
Mean of Dependent Variable		0	
Firm FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Export Information	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes
Firm × Time FE	Yes	Yes	Yes
R-squared	0.383	0.436	0.395

Note: Country-clustered standard errors are in parentheses. The observation is restricted to a combination of i, c and t where firm i exports its tire in 2014 and 2015, 2014 and 2016, or 2014 and 2017. Quality is estimated by following Khandelwal et al. (2013). $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after March 1, 2015. Best 3_{ic} is a dummy variable which takes 1 if firm i was among the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was among the best 10 exporters in country c in 2014, and Best 15_{ic} is a dummy variable which takes 1 if firm i was among the best 15 exporters in country c in 2014. $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of the total export of firm i was exported into OAPI countries in 2014. Export Information includes the Chinese port from which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports and the log of total imports.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.7: Placebo Test

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln(Value_{jct})$		$\ln(Quantity_{jct})$		$\ln(Price_{jct})$	
$OAPI_c \times After_t$	0.128	0.122	0.169	0.142	-0.0366	-0.0252
	(0.176)	(0.182)	(0.163)	(0.171)	(0.0389)	(0.0376)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
HS 4 Digit Code FE	Yes	Yes	Yes	Yes	Yes	Yes
HS 4 Digit Code FE × Year FE	No	Yes	No	Yes	No	Yes
R-squared	0.638	0.661	0.643	0.666	0.398	0.510

Note: Country-clustered standard errors are in parentheses. $Value_{jct}$ and $Quantity_{jct}$ are the aggregate export value and quantity of Chinese exports in an industry j to country c at time t, respectively. $Value_{jct}$ is measured by the US\$. $Price_{ict}$ is the unit price and it is derived by $Value_{jct}/Quantity_{jct}$. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after 2015.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.8: Law Enforcement

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Independence Score	Transparency Score	ln(Attorney Cost)	ln(Court Cost)	ln(Enforcement Cost)	ln(Total Cost)
$OAPI_c \times After_t$	2.662**	3.953**	0.0849	-0.0857***	-0.0469	0.0310
	(1.096)	(1.890)	(0.0617)	(0.0242)	(0.0351)	(0.0404)
R-squared	0.958	0.919	0.899	0.988	0.989	0.945

Data Sources: Ibrahim Index of African Governance Data by the Mo Ibrahim Foundation and Doing Business Data by the World Bank.

Note: Robust standard errors are in parentheses. Independence Score, and Transparency Score are from Ibrahim Index of African Governance Data, and Attorney Cost, Court Cost, and Transparency Score are from Doing Business Data. Independence Score captures the independence of the judiciary from the influence of external actors; whether the judiciary has the ability and autonomy to interpret and review existing laws, legislation and policy; and the integrity of the process of appointing and removing national-level judges. Transparency Score captures the extent to which the legal process is free from interference, and the extent to which formal judicial reasoning exists. Attorney Cost is the fees that plaintiff must advance to a local attorney in the standardized case, regardless of final reimbursement. Court Cost includes all costs that plaintiff must advance to the court, regardless of the final cost borne by plaintiff. Enforcement Cost includes all costs that plaintiff must advance to enforce the judgment through a public sale of defendant's movable assets, regardless of the final cost borne by plaintiff. Total Cost includes all of these three costs. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after 2015.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.9: Heterogeneous Effect of Law Enforcement

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	$Export_{ict}$	$Export_{ict}$ (Incumbent Only)	TM_{ict}	$ln(Value_{ict})$	$ln(Quantity_{ict})$	$ln(Price_{ict})$
$OAPI_c \times After_t$	-0.00183	-0.0479**	0.0522*	0.0255	0.0167	0.00887
	(0.00165)	(0.0235)	(0.0267)	(0.0731)	(0.0737)	(0.0144)
$OAPI_c \times After_t \times IndependenceScore_c$	2.03e-05	0.000916	0.00114	-0.00436**	-0.00511***	0.000749*
	(3.90e-05)	(0.000546)	(0.000873)	(0.00166)	(0.00184)	(0.000410)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Export Information	No	No	Yes	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm × Time FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.194	0.281	0.507	0.395	0.412	0.873

Data Sources: Ibrahim Index of African Governance Data by the Mo Ibrahim Foundation and Doing Business Data by the World Bank.

Country-Clustered standard errors in parentheses In columns (2) − (5), the observation is restricted to a combination of i, c, and t where firm i exports its tires in 2014 and 2015, 2014 and 2016, or 2014 and 2017. $Export_{ict}$ takes 1 if firm i exports in country c at time t. $Value_{ict}$ is measured by the US$. Price is the unit price and it is derived by $Value_{ict}/Quantity_{ict}$. TM_{ict} takes 1 if firm i uses its trademark in country c at time t. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after March 1, 2015. Independence Score captures the independence of the judiciary from the influence of external actors; whether the judiciary has the ability and autonomy to interpret and review existing laws, legislation and policy; and the integrity of the process of appointing and removing national-level judges. Export Information includes the Chinese port from which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports, and the log of total imports.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.10: Destination Specific Markup Elasticity

	(1)	(2)	(3)
	Destination Specific Markup Elasticity		
$Exchange\ rate_{ct}$	0.0166*	0.0521***	0.0180*
	(0.00855)	(0.0186)	(0.00970)
$OAPI_c \times After_t \times Exchange\ rate_{ct}$	0.0262	0.0460	0.0235
	(0.0341)	(0.0355)	(0.0567)
$OAPI_c \times After_t \times$ Best $15_{ic2014} \times Exchange\ rate_{ct}$		-0.117	
		(0.0933)	
$OAPI_c \times After_t \times$ Best $10_{ic2014} \times Exchange\ rate_{ct}$		-0.0289	
		(0.0514)	
$OAPI_c \times After_t \times$ Best $3_{ic2014} \times Exchange\ rate_{ct}$		0.0678	
		(0.0701)	
$OAPI_c \times After_t \times \mathbb{1}\{\text{OAPI Share}_{i2014} \geq 50\%\} \times Exchange\ rate_{ct}$			0.0104
			(0.0723)
R-squared	0.004	0.006	0.005

Note: Country-clustered standard errors are in parentheses. The observation is restricted by following Corsetti et al. (2019). $Exchange\ rate_{ct}$ is defined as renminbis per unit of destination currency; an increase means an appreciation of the destination currency. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after March 1, 2015. Best 3_{ic} is a dummy variable which takes 1 if firm i was among the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was among the best 10 exporters in country c in 2014, and Best 15_{ic} is a dummy variable which takes 1 if firm i was among the best 15 exporters in country c in 2014. $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of the total export of firm i was exported into OAPI countries in 2014. Export Information includes the Chinese port from which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports, and the log of total imports.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.11: Reallocation

	(1)	(2)	(3)
VARIABLES	$ln(Value_{i,ARIPO,t})$	$ln(Quantity_{i,ARIPO,t})$	$ln(Number_{i,ARIPO,t})$
$After_t \times OAPI\ 15_i$	0.0403	0.0238	-0.0436
	(0.254)	(0.266)	(0.0794)
$After_t \times OAPI\ 15_i \times ARIPO\ 15_i$	-0.223	-0.0868	0.0753
	(0.285)	(0.297)	(0.0986)
Month FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
R-squared	0.821	0.833	0.759

Note: Robust standard errors are in parentheses. $Value_{i,ARIPO,t}$ and $Quantity_{i,ARIPO,t}$ are the sum of export value and quantity of firm i to ARIPO countries at time t, respectively. $Number_{i,ARIPO,t}$ is the number of ARIPO countries to which firm i exports at time t. $Value_{i,ARIPO,t}$ is measured by the US$. $After_t$ takes 1 if time t is after the 1st of March in 2015. $OAPI\ 15_i$ is a dummy variable which takes 1 if firm i was among the best 15 exporters in at least one country of OAPI countries in 2014. $ARIPO\ 15_i$ is a dummy variable which takes 1 if firm i was among the best 15 exporters in at least one country of ARIPO countries in 2014.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.12: Road Accident Analysis

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES		Death Rate			ln(Death Rate)	
$OAPI_c \times After_t$	-2.682	-2.447	-2.520	-0.0818	-0.0555	-0.0248
	(2.229)	(2.447)	(3.242)	(0.0978)	(0.111)	(0.149)
$OAPI_c \times After_t \times$ *Above Median*		-0.422			-0.0527	
		(2.774)			(0.122)	
$OAPI_c \times After_t \times$ *The 2nd Quantile*			1.153			-0.0290
			(3.799)			(0.168)
$OAPI_c \times After_t \times$ *The 3rd Quantile*			-0.0133			-0.0761
			(3.535)			(0.158)
$OAPI_c \times After_t \times$ *The 4th Quantile*			-1.055			-0.106
			(3.557)			(0.158)
The Total Effect (Above Median)		-2.870			-0.108	
$p-value$		0.0364			0.0387	
The Total Effect (The 2nd Quantile)			-1.367			-0.0538
$p-value$			0.497			0.499
The Total Effect (The 3rd Quantile)			-2.533			-0.101
$p-value$			0.0847			0.0672
The Total Effect (The 4th Quantile)			-3.575			-0.131
$p-value$			0.0224			0.0220
Mean of Dependent Variable		24.937			3.195	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.652	0.865	0.918	0.644	0.859	0.918

Data Sources: The Global Status Report on Road Safety 2013 and 2018 by WHO (World Health Organization, 2013 and World Health Organization, 2018)
Note: Robust standard errors are in parentheses. Number of Deaths is the number of road traffic deaths. Death Rate is the road traffic death rate per 100,000 population. $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after March 1, 2015.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.13: Welfare Analysis: The Gains from Trade

Welfare Increase (%)	OAPI Countries
0.0140	All Exporters in the tire Industry
0.0089	Chinese Exporters in the tire Industry
0.0051	Others in the tire Industry

Welfare Increase (%)	OAPI Countries
0.0089	Chinese Exporters in the tire Industry
−0.0028	"Gain at the Extensive Margin"
0.0117	"Gain on the Intensive Margin"

Welfare Increase (%)	OAPI Countries
−0.0028	"Gain at the Extensive Margin"
−0.0084	"Variety Change"
0.0056	"Changes in the Composition of Firms"

Note: I assume $\sigma_s = 2.5$, and this is the elasticity across new rubber pneumatic tires in Africa, as reported by Soderbery (2018). To derive η_{js} and $\tilde{s}_{ijs}$, I use the UN COMTRADE database and the World Bank database.

Figures

Figure 1.1: OAPI and ARIPO Member Countries in Africa

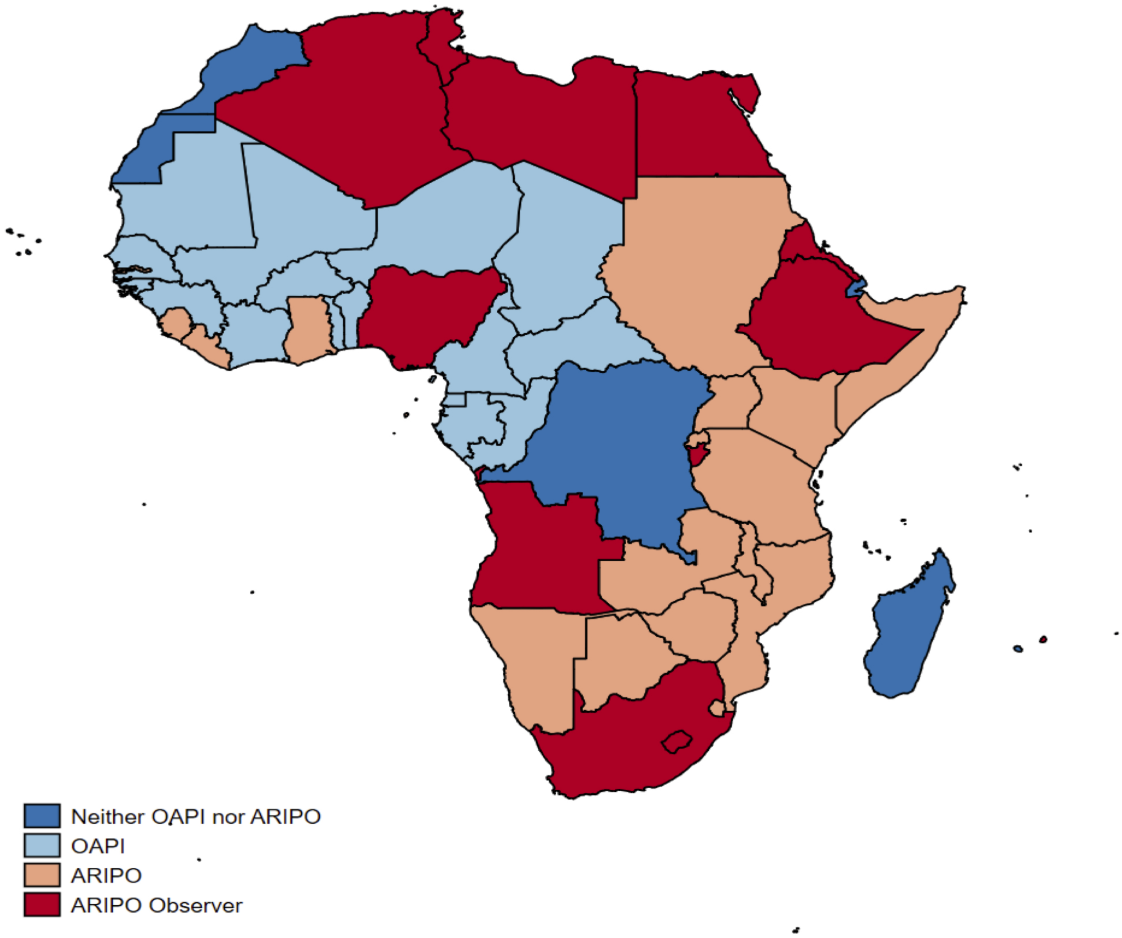

Figure 1.1 shows the location of OAPI and ARIPO member countries in Africa. The OAPI member countries are Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, and Togo. The ARIPO member countries are Botswana, Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mozambique, Namibia, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. The observer countries are Algeria, Angola, Burundi, Egypt, Eritrea, Ethiopia, Libya, Mauritius, Nigeria, Seychelles, South Africa and Tunisia. Which organization each country belongs to mainly depends on its used language. In OAPI, they are former French colonies and mostly French-speaking countries while they are former British colonies and mostly English-speaking countries in ARIPO.

Figure 1.2: Size Distribution of Chinese Exports to Africa and Relative Cost of a Trademark

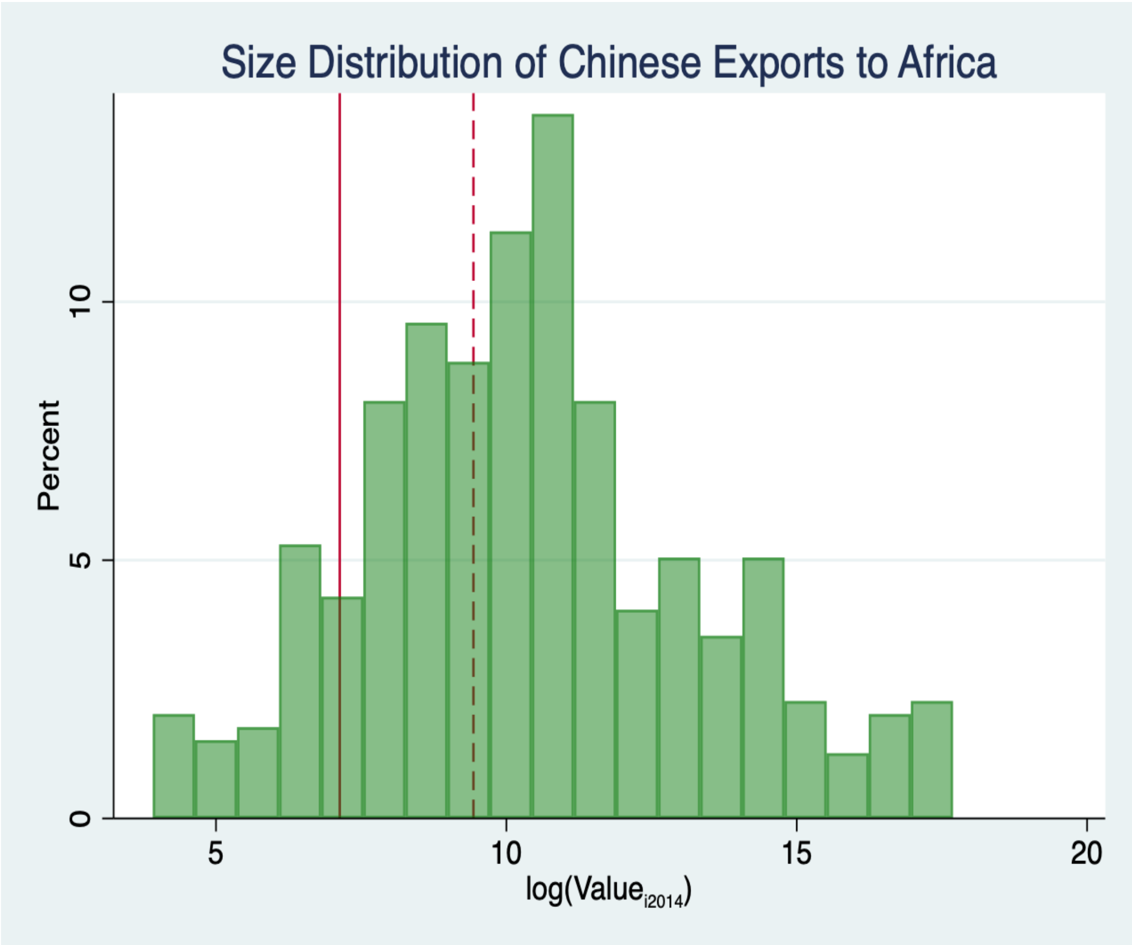

Figure 1.2 shows the size distribution of Chinese exporters in Africa and the relative cost of obtaining a trademark. The dotted line is the cost of obtaining trademark before the international agreement in OAPI countries while the red line is the cost after the international agreement in OAPI countries.

Figure 1.3: Parallel Trend Assumption: Export Dummy

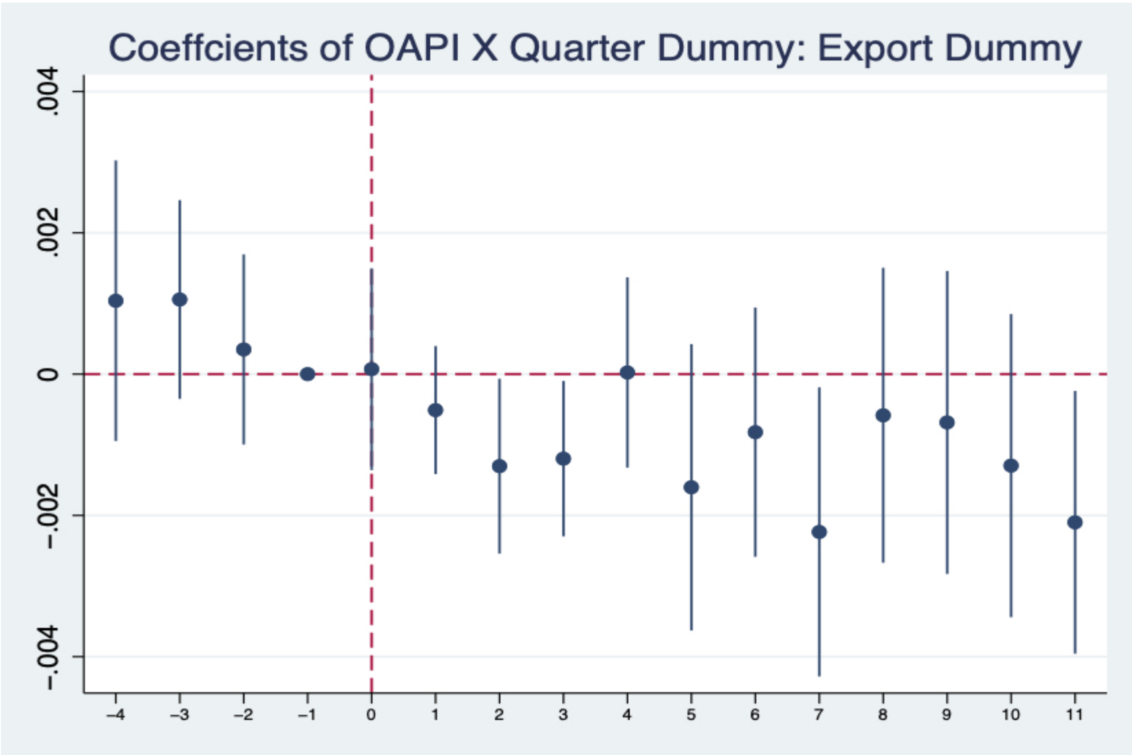

Figure 1.3 investigates pre-trends for an export dummy variable following the baseline Difference in Differences specification in column 1 of Table 1.3. To mitigate typical concerns arising in DID designs, this figure investigates dynamic patterns around the time when OAPI joined with the international trademark agreement. The figure shows the absence of differential trends in an export dummy variable in the quarters preceding the agreement. This figure also shows a long-term decrease in an export dummy variable after the agreement.

Figure 1.4: Parallel Trend Assumption: Trademark Dummy

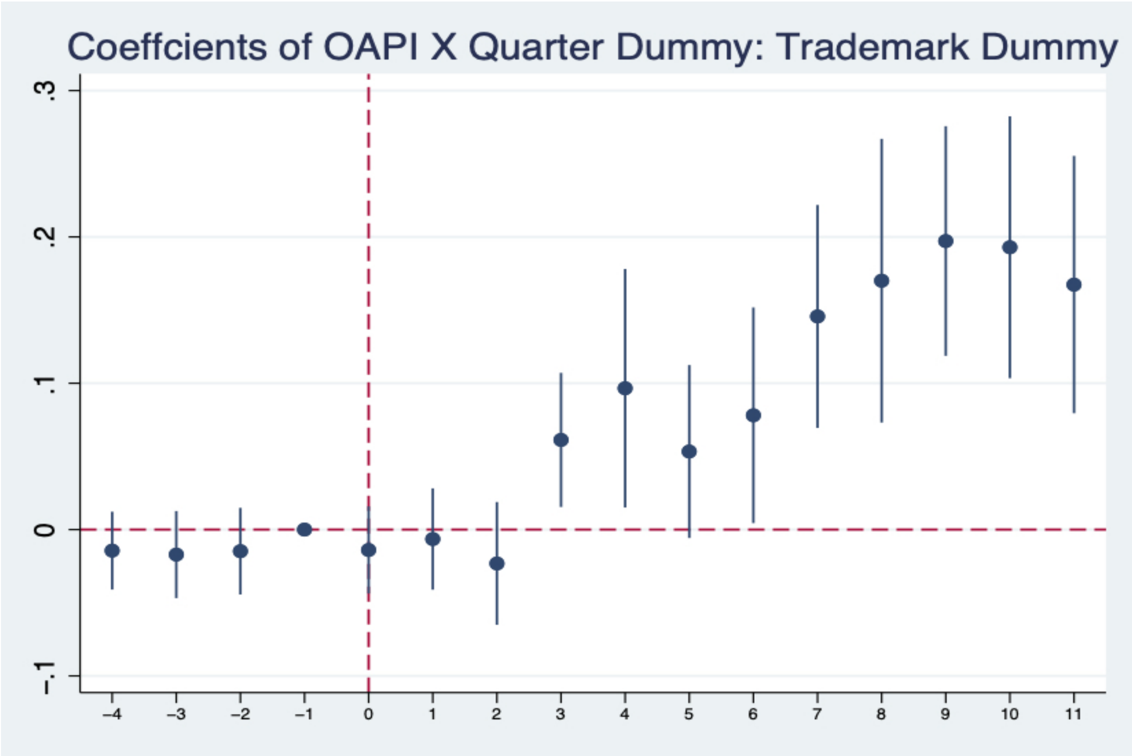

Figure 1.4 investigates pre-trends for a trademark dummy variable following the baseline Difference in Differences specification in column 2 of Table 1.3. To mitigate typical concerns arising in DID designs, this figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in a trademark dummy variable in the quarters preceding the agreement. This figure also shows a long-term increase in a trademark dummy variable after the agreement.

Figure 1.5: Parallel Trend Assumption: ln(Value)

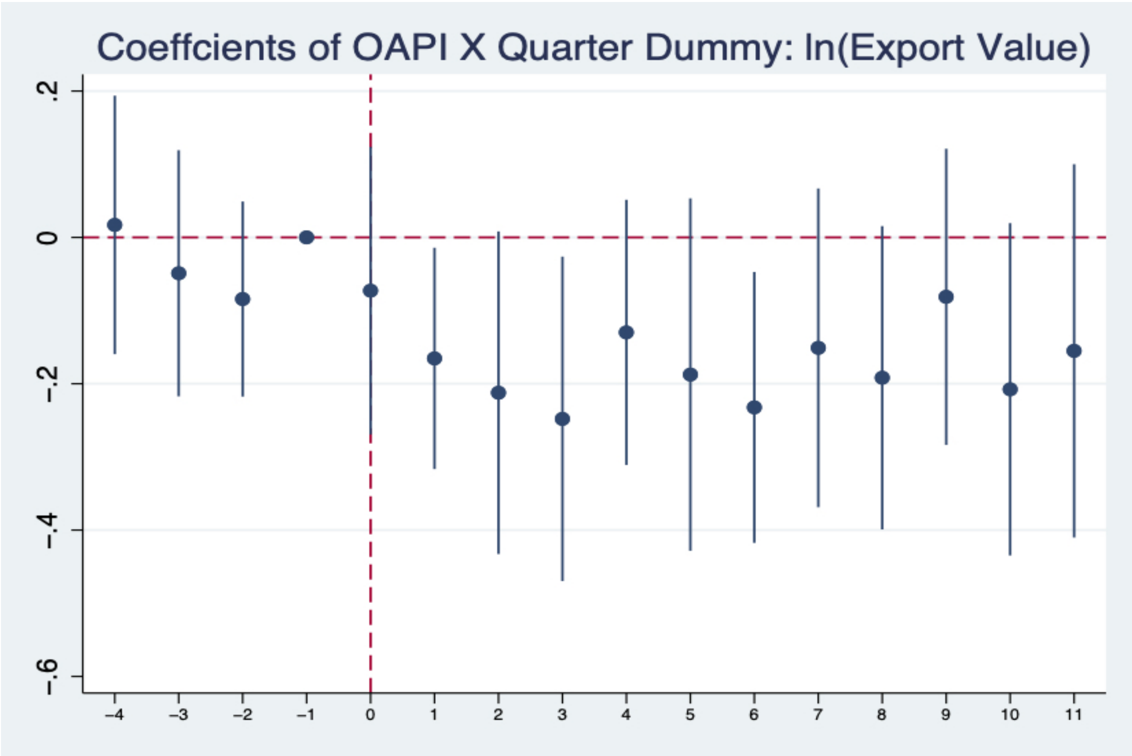

Figure 1.5 investigates pre-trends for export value following the baseline Difference in Differences specification in column 3 of Table 1.3. To mitigate typical concerns arising in DID designs, this figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in export value in the quarters preceding the agreement. This figure also shows a long-term decrease in export value after the agreement.

Figure 1.6: Parallel Trend Assumption: ln(Quantity)

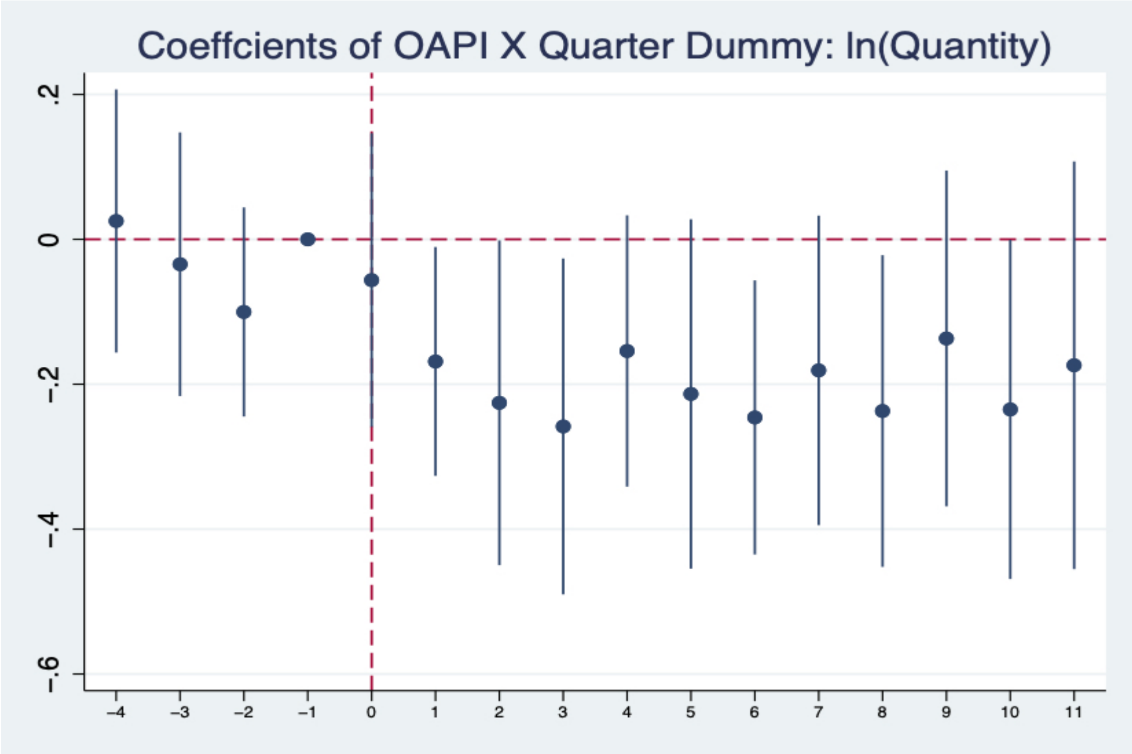

Figure 1.6 investigates pre-trends for quantity following the baseline Difference in Differences specification in column 4 of Table 1.3. To mitigate typical concerns arising in DID designs, this figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in quantity in the quarters preceding the agreement. This figure also shows a long-term decrease in quantity after the agreement.

Figure 1.7: Parallel Trend Assumption: ln(Price)

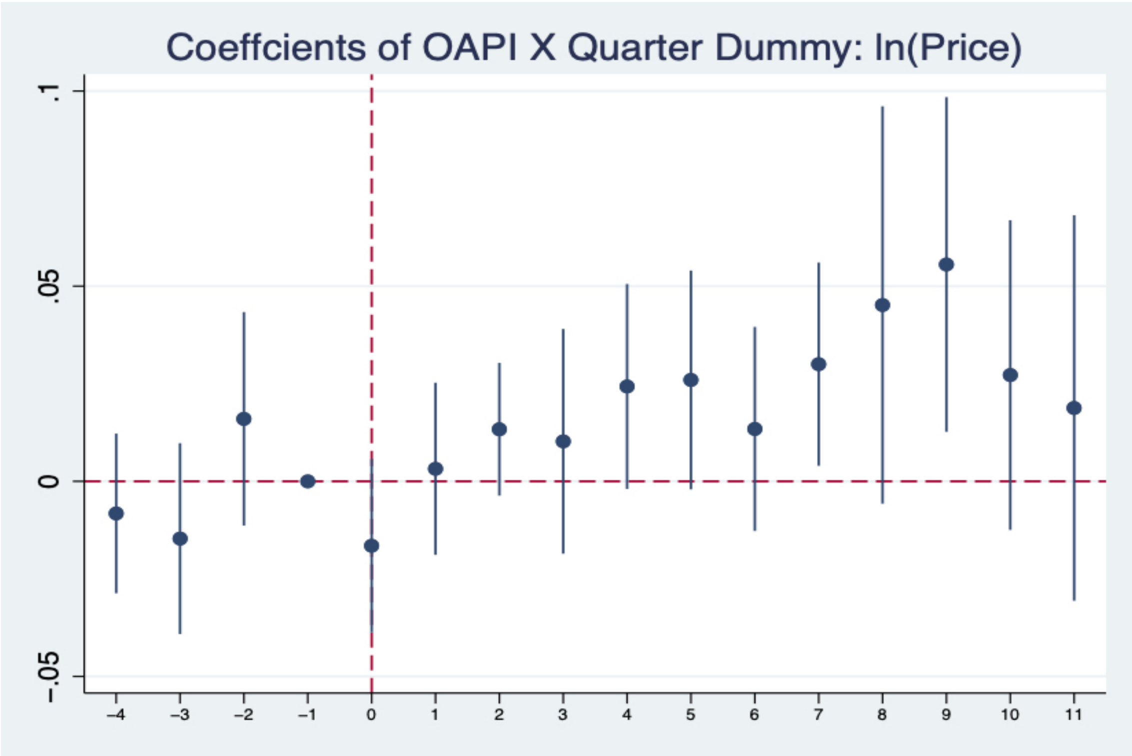

Figure 1.7 investigates pre-trends for the unit price following the baseline Difference in Differences specification in column 5 of Table 1.3. To mitigate typical concerns arising in DID designs, this figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in the unit price in the quarters preceding the agreement. This figure also shows a long-term increase in the unit price after the agreement.

Figure 1.8: Parallel Trend Assumption: ln(Estimated Quality)

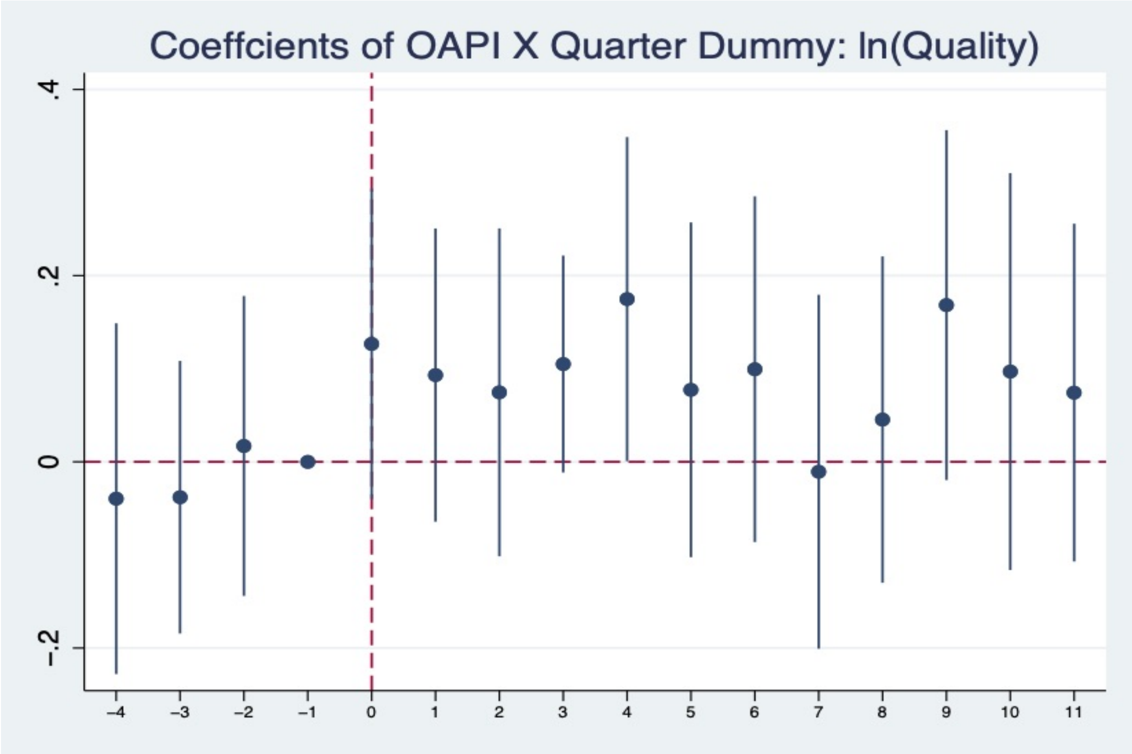

Figure 1.8 investigates pre-trends for the estimated quality following the baseline Difference in Differences specification in column 1 of Table 1.6. To mitigate typical concerns arising in DID designs, this figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in provided quality in the quarters preceding the agreement. This figure also shows a long-term increase in provided quality after the agreement.

Figure 1.9: Placebo Test: ln(Value)

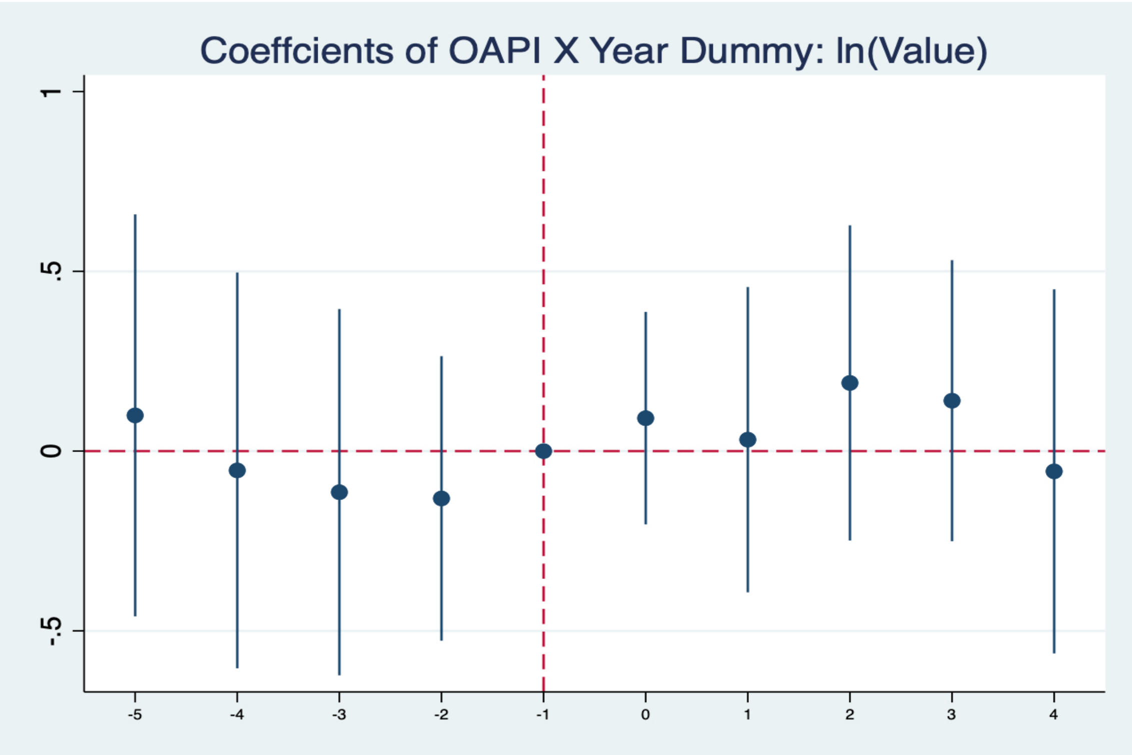

Figure 1.9 investigates pre-trends and post-trends for export value following the baseline Difference in Differences specification in column 2 of Table 1.7. This figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in a trademark dummy variable in the years before and after the agreement.

Figure 1.10: Placebo Test: ln(Quantity)

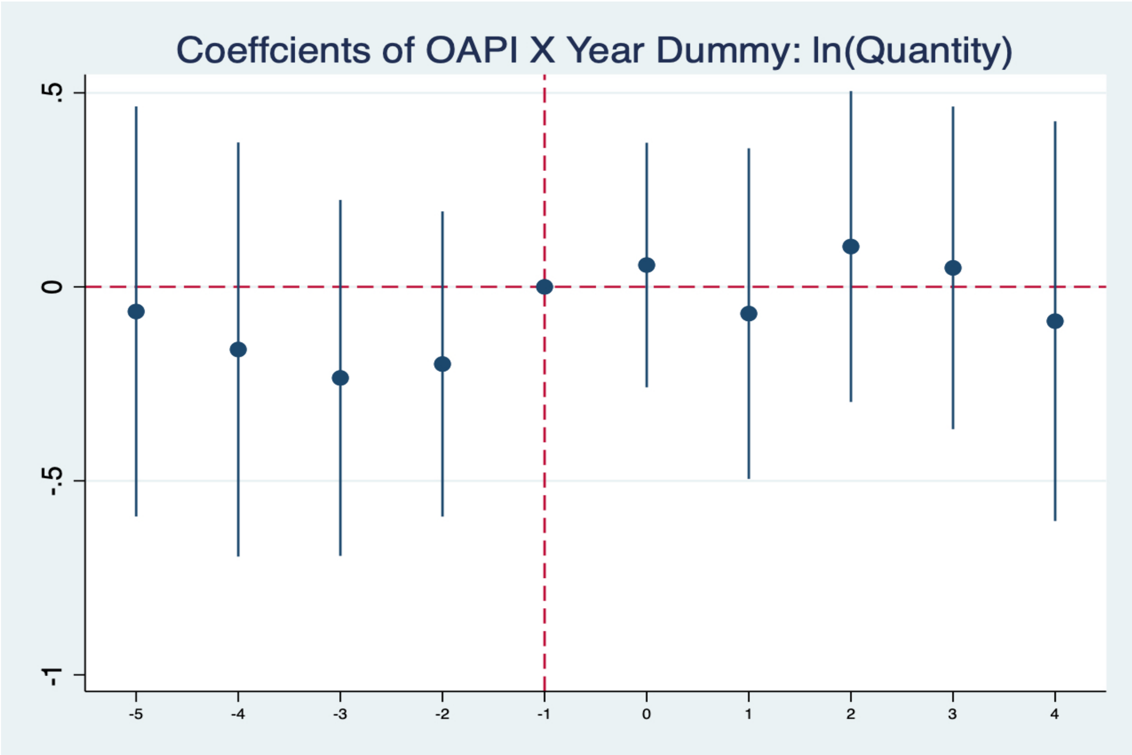

Figure 1.10 investigates pre-trends and post-trends for quantity following the baseline Difference in Differences specification in column 4 of Table 1.7. This figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in a trademark dummy variable in the years before and after the agreement.

Figure 1.11: Placebo Test: ln(Price)

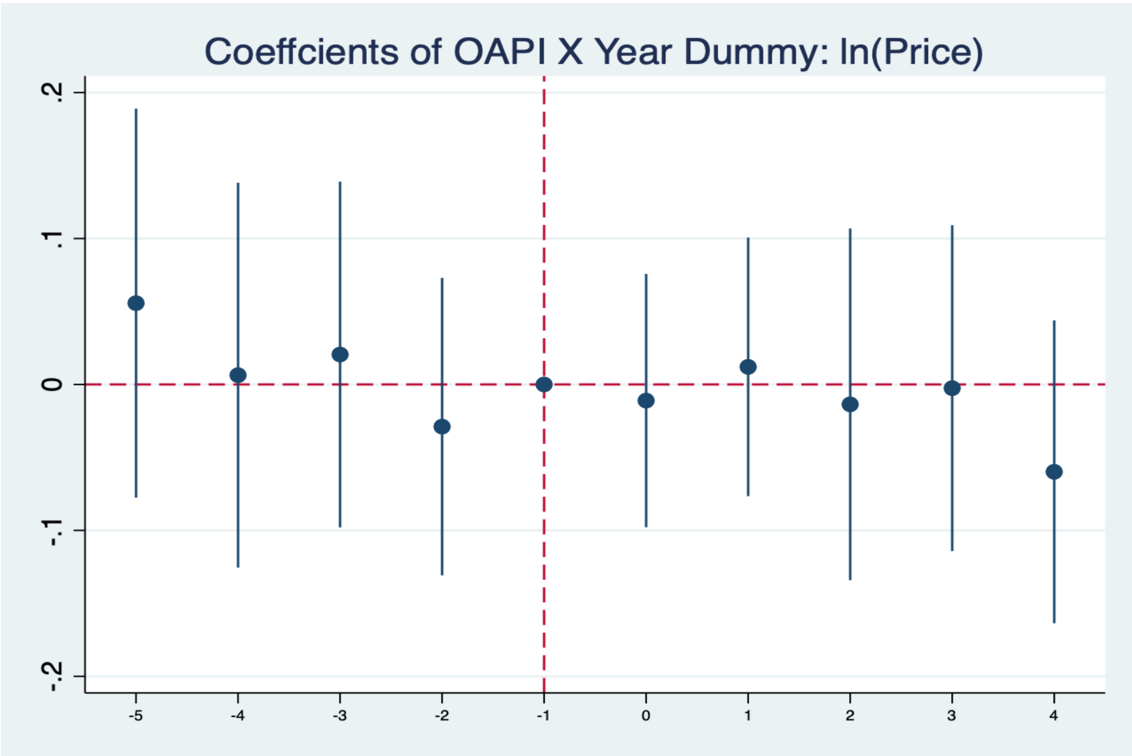

Figure 1.11 investigates pre-trends and post-trends for the unit price following the baseline Difference in Differences specification in column 6 of Table 1.7. This figure investigates dynamic patterns around the time when OAPI joined the international trademark agreement. The figure shows the absence of differential trends in a trademark dummy variable in the years before and after the agreement.

Figure 1.12: Technology Adoption

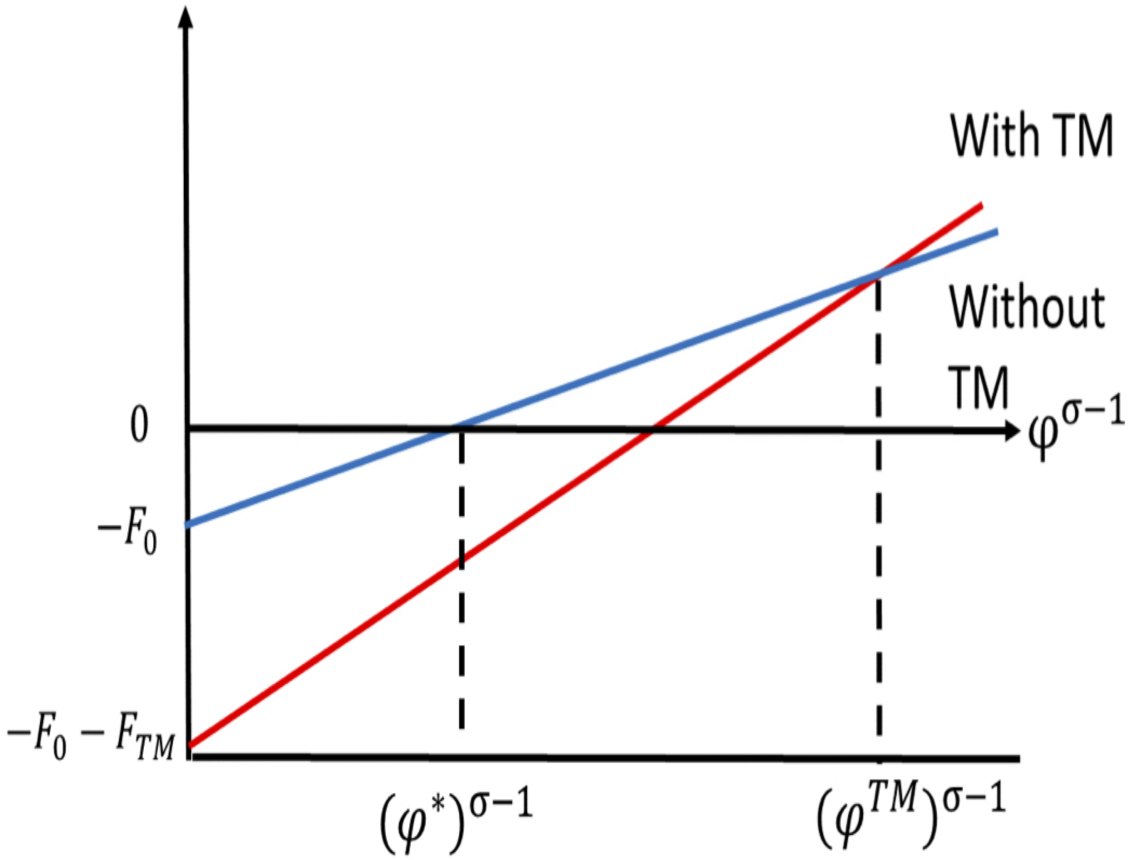

Figure 1.12 represents technology choice of each firm. The x asis describes how productive each firm is, and the y axis is its profit. Each firm has two possible profit functions: the blue line is the profit function without a trademark, and the red one is the profit function with a trademark, in which the two possible profits are described as functions of firm productivity, $\varphi^{\sigma-1}$. Since the demand function does not respond to provided quality without a trademark, the slope of a firm's profit function when not using a trademark is not steep. On the other hand, while it offers higher quality with a trademark and the slope of the profit function is steeper, it needs to bear the cost of obtaining a trademark, F_{TM}, in addition to its own fixed cost, F_0. The trademark adoption cutoff is denoted by φ^{TM}, and the exit cutoff is denoted by φ^*.

Figure 1.13: Effect of F_{TM} on Technology Adoption

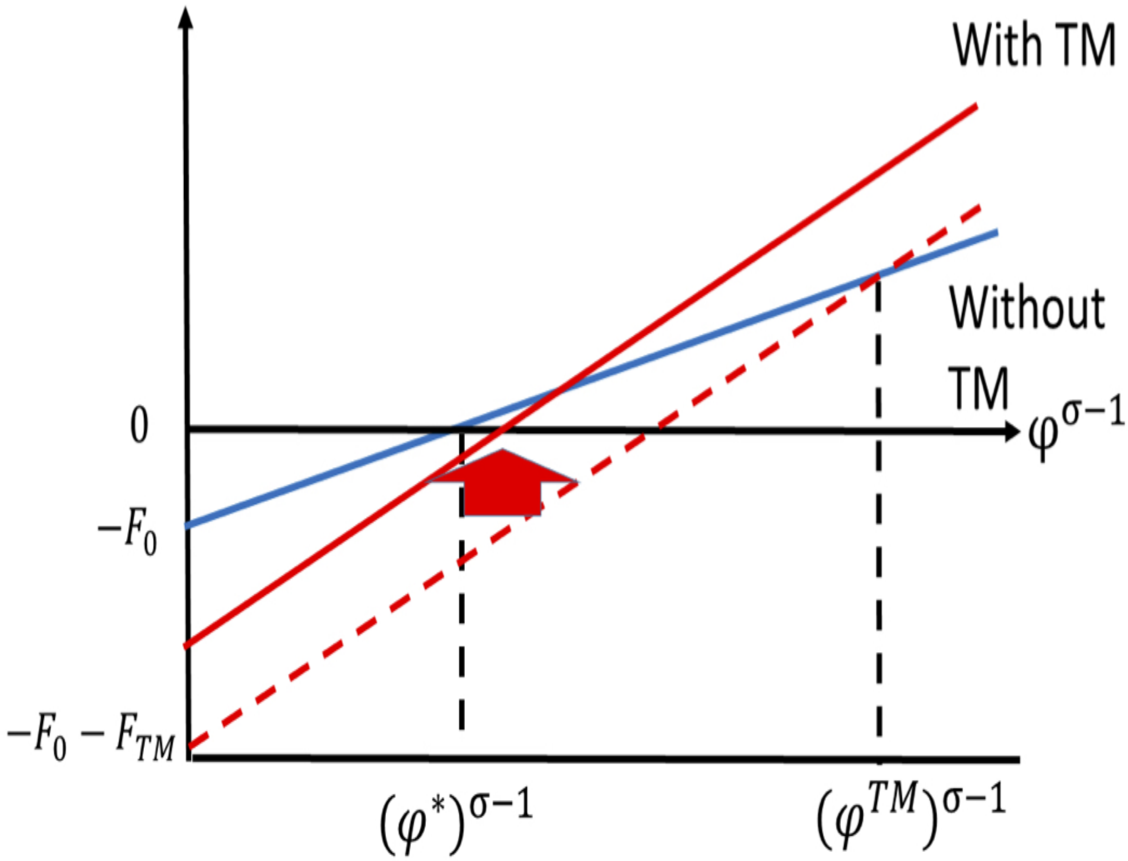

Figure 1.13 describes the effect of decrease in the trademark cost on trademark choice. When the cost of obtaining a trademark decreases, the line of the profit function with a trademark goes upward. As a result, the technology cutoff, $(\varphi^{TM})^{\sigma-1}$ shifts rightward, and a firm is more likely to use a trademark.

Figure 1.14: Effect of F_{TM} on the Equilibrium

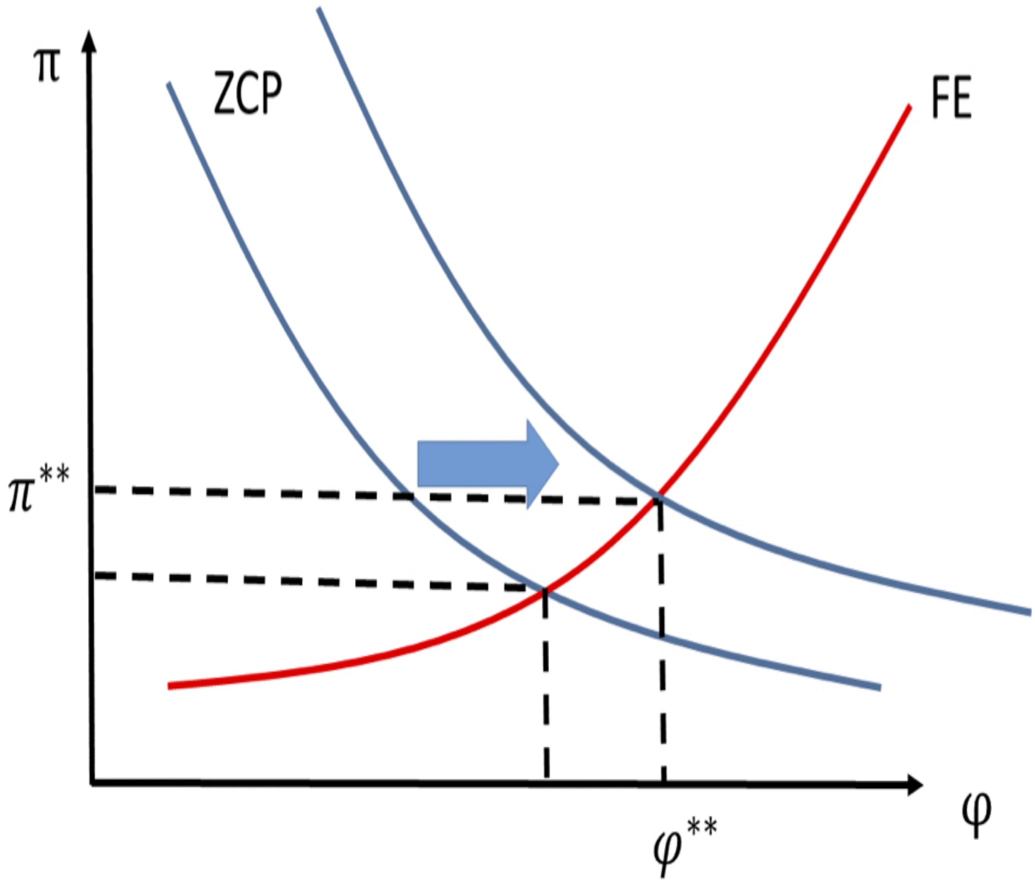

Figure 1.14 describes the effect of decrease in the trademark cost on the exit cutoff, φ^*. The exit cutoff, φ^*, and the average expected profit level, $\overline{\pi}$, are determined by the two conditions at the equilibrium: the free entry (FE) condition and the zero cutoff profit (ZCP) condition. In figure 1.14, the blue curve denotes the ZCP condition and the red curve denotes the FE condition. When the cost of obtaining a trademark decreases, a firm is more likely to use a trademark, and the average expected profit in the ZCP increases. Since the ZCP curve shifts toward the right, the exit cutoff, φ^*, increases, and the least productive firm decides to exit the market at the new equilibrium.

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Appendix

1.A Theoretical Appendix

1.A.1 Proof of Propositoin 1

There are two cases for a trademark user: (1) the quality constraint is binding and (2) the quality constraint is non-binding. I consider these two cases separately.

- Case 1: The Quality Constraint is Binding

In this case, $\lambda^{NoTM}(\varphi) = \lambda^{TM}(\varphi) = \underline{\lambda}$. Then, a trademark user and a non-trademark user solve the same profit maximization problem. Therefore, $\lambda^{NoTM}(\varphi) = \lambda^{TM}(\varphi) = \underline{\lambda}$, $p_j^{TM}(\varphi) = p_j^{NoTM}(\varphi)$, $q_j^{TM}(\varphi) = q_j^{NoTM}(\varphi)$, and $r_j^{TM}(\varphi) = r_j^{NoTM}(\varphi)$.

- Case 2: The Quality Constraint is Not Binding

When the quality constraint is not binding, a trademark user produces quality which is above the threshold, $\underline{\lambda}$. Since all of non-trademark users choose this threshold for their quality, $\lambda^{TM}(\varphi) > \lambda_j^{NoTM}(\varphi)$. Since the price comes from the constant markup, $\frac{\sigma}{\sigma-1}$, and the marginal cost, $\frac{c}{\varphi}\lambda_j^{\beta}$, I show that $p_j^{TM}(\varphi) = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\lambda_j^{TM}(\varphi)^{\beta} > p_j^{NoTM}(\varphi) = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\lambda_j^{NoTM}(\varphi)^{\beta}$. In addition, $q_j^{TM}(\varphi) = (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma}\lambda_j^{TM}(\varphi)^{(1-\beta)\sigma-1}P^{\sigma-1}E > q_j^{NoTM}(\varphi) = (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma}\underline{\lambda}^{(1-\beta)\sigma-1}P^{\sigma-1}E$. Finally with $p_j^{TM}(\varphi) > p_j^{NoTM}(\varphi)$ and $q_j^{TM}(\varphi) > q_j^{NoTM}(\varphi)$, $r_j^{TM}(p_j^{TM}, \lambda_j^{TM}) = p_j^{TM}(\varphi)q_j^{TM}(\varphi) > p_j^{NoTM}(\varphi)q_j^{NoTM}(\varphi) = r_j^{NoTM}(p_j^{NoTM}, \lambda_j^{NoTM})$.

1.A.2 Proof of Propositoin 2

There are two cases for a trademark user: (1) the quality constraint is binding and (2) the quality constraint is non-binding. I consider these two cases separately.

- Case 1: The Quality Constraint is Binding

Since the quality constraint is binding if a firm uses a trademark,

$\pi_j^{TM}(\varphi) = \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0 - F_{TM}$ and $\pi_j^{NoTM}(\varphi) = \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0$,

$$\pi_j^{TM} - \pi_j^{NoTM} = -F_{TM} < 0. \tag{1.56}$$

Therefore, no firm uses a trademark if it faces the quality constraint with a trademark.

- Case 2: The Quality Constraint is Not Binding

Since the quality constraint is not binding if a firm uses a trademark,

$\pi_j^{TM}(\varphi) = (\frac{\sigma-1}{\sigma})^{\frac{\alpha\sigma}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\alpha-(1-\beta)(\sigma-1)}{(1-\beta)(\sigma-1)})(\frac{\varphi}{c})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\xi}{f})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E)^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}} - F_0 - F_{TM}$ and $\pi_j^{NoTM}(\varphi) = \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0$. From the first order conditions of a firm with and without a trademark,

$$\pi_j^{TM} - \pi_j^{NoTM} = \frac{1}{(1-\beta)(\sigma-1)}\frac{f}{\xi}[\{\alpha-(1-\beta)(\sigma-1)\}(\lambda_j^{TM})^{\alpha} - \alpha(\lambda_j^{TM})^{\alpha-(1-\beta)(\sigma-1)}\underline{\lambda}^{(1-\beta)(\sigma-1)}] + \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_{TM}. \tag{1.57}$$

To prove this proposition, I need to show that $\pi_j^{TM} - \pi_j^{NoTM}$ is an increasing function with respect to φ. To decide the sign, I focus on $f(\lambda) = [\alpha-(1-\beta)(\sigma-1)]\lambda^{\alpha} - \alpha\lambda^{\alpha-(1-\beta)(\sigma-1)}\underline{\lambda}^{(1-\beta)(\sigma-1)}$. I derive $\frac{\partial f(\lambda)}{\partial\varphi}$ as follows:

$$\frac{\partial f(\lambda)}{\partial\varphi} = \alpha[\alpha-(1-\beta)(\sigma-1)]\lambda^{\alpha-(1-\beta)(\sigma-1)-1}[\lambda^{(1-\beta)(\sigma-1)} - \underline{\lambda}^{(1-\beta)(\sigma-1)}]\frac{\partial\lambda}{\partial\varphi}. \tag{1.58}$$

Since the quality constraint is not binding, $\lambda > \underline{\lambda}$ and $\frac{\partial\lambda}{\partial\varphi} > 0$. Therefore, $\frac{\partial f(\lambda)}{\partial\varphi} > 0$ and $\pi_j^{TM} - \pi_j^{NoTM}$ is an increasing function with respect to φ.

1.A.3 Proof of Proposition 3

As in Melitz (2003), I assume that the equilibrium is stationary and the aggregate variables remain constant over time. With the aggregate stability condition, the free entry condition and the labor market clearing condition,

$$E = L, \tag{1.59}$$

where L is the aggregate labor force.

From the exit cutoff condition,

$$\pi_j^{NoTM}(\varphi^*) = 0 \iff \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi^*}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}L - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0 = 0. \tag{1.60}$$

Substituting this into the trademark cutoff, I can get the following condition:

$$\pi_j^{TM}(\varphi^{TM}) = \pi_j^{NoTM}(\varphi^{TM}) \iff$$
$$[1-\tfrac{(\sigma-1)(1-\beta)}{\alpha}][\tfrac{(\sigma-1)(1-\beta)}{\alpha}\tfrac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}}[\tfrac{\varphi^{TM}}{\varphi^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(\sigma-1)(1-\beta)}}F_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} - F_2 = [(\tfrac{\varphi^{TM}}{\varphi^*})^{\sigma-1}-1]F_1, \tag{1.61}$$

where $F_1 = \frac{f}{\xi}\underline{\lambda}^{\alpha} + F_0$ and $F_2 = F_0 + F_{TM}$. From this condition, I use the implicit function theorem and find out $\frac{\partial \frac{\varphi^{TM}}{\varphi^*}}{\partial F_{TM}}$ as follows.

$$\begin{aligned} \frac{\partial \frac{\varphi^{TM}}{\varphi^*}}{\partial F_{TM}} &= \frac{1}{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}A(\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-1} - (\sigma-1)F_1(\frac{\varphi^{TM}}{\varphi^*})^{\sigma-2}} \\ &= \frac{1}{(\sigma-1)(\frac{\varphi^{TM}}{\varphi^*})^{-1}[\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}(F_2-F_1) + \frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}F_1(\frac{\varphi^{TM}}{\varphi^*})^{\sigma-1}]}, \end{aligned} \tag{1.62}$$

where $A = [1-\frac{(\sigma-1)(1-\beta)}{\alpha}][\frac{(\sigma-1)(1-\beta)}{\alpha}\frac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}}F_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}}$. To decide the sign, I focus on $f(x) = \frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}(F_2-F_1) + \frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}F_1 x^{\sigma-1}$. Since $f(x)$ is an increasing function with respect to x and $\frac{\varphi^{TM}}{\varphi^*} > x_0$ such that $F_1 x_0^{\sigma-1} = \frac{\alpha}{(1-\beta)(\sigma-1)}\frac{f}{\xi}\underline{\lambda}^{\alpha}$,

$$\begin{aligned} f(\frac{\varphi^{TM}}{\varphi^*}) &= \frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}(F_2-F_1) + \frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}F_1(\frac{\varphi^{TM}}{\varphi^*})^{\sigma-1} \\ &> \frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}(F_2-F_1) + \frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}F_1 x_0^{\sigma-1} \\ &= \frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}(F_2-F_1) + \frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}\frac{f}{\xi}\underline{\lambda}^{\alpha} \\ &= \frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}F_{TM} \\ &> 0. \end{aligned} \tag{1.63}$$

Next, I show that $\frac{\partial \overline{\pi}}{\partial F_{TM}} < 0$. With the exit and trademark cutoff conditions and the assumption of φ following a Pareto distribution, $\overline{\pi}$ can be described under the zero cutoff profit condition in the following way:[19]

$$\begin{aligned}\overline{\pi} =& \frac{kF_1}{k-\sigma+1}[1-(\frac{\varphi^{TM}}{\varphi^*})^{-k+\sigma-1}] - F_1[1-(\frac{\varphi^{TM}}{\varphi^*})^{-k}] \\ & + \frac{k}{k-\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[1-\frac{(\sigma-1)(1-\beta)}{\alpha}][\frac{(\sigma-1)(1-\beta)}{\alpha}\frac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}} F_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}}[\frac{\varphi^{TM}}{\varphi^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-k} - F_2(\frac{\varphi^{TM}}{\varphi^*})^{-k}.\end{aligned} \tag{1.64}$$

Then, I derive $\frac{\partial\overline{\pi}}{\partial\frac{\varphi^{TM}}{\varphi^*}}$ in the following way.

$$\begin{aligned}\frac{\partial\overline{\pi}}{\partial\frac{\varphi^{TM}}{\varphi^*}} &= k(\frac{\varphi^{TM}}{\varphi^*})^{k-1}[F_1(\frac{\varphi^{TM}}{\varphi^*})^{\sigma-1} - F_1 - A(\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} + F_2] \\ &= 0.\end{aligned} \tag{1.65}$$

From this,

$$\begin{aligned}\frac{\partial\overline{\pi}}{\partial F_{TM}} &= -(\frac{\varphi^{TM}}{\varphi^*})^{-k} + \underbrace{\frac{\partial\overline{\pi}}{\partial\frac{\varphi^{TM}}{\varphi^*}}}_{=0}\frac{\partial\frac{\varphi^{TM}}{\varphi^*}}{\partial F_{TM}} \\ &= -(\frac{\varphi^{TM}}{\varphi^*})^{-k} \\ &< 0.\end{aligned} \tag{1.66}$$

With the assumption of φ following a Pareto distribution, I can describe φ^* as a function of $\overline{\pi}$, δ, f_e and k under the free entry conditoin.

$$\varphi^* = (\frac{\overline{\pi}}{\delta f_e})^{\frac{1}{k}}. \tag{1.67}$$

From (1.66),

$$\begin{aligned}\frac{\partial\varphi^*}{\partial F_{TM}} &= \frac{1}{k\delta f_e}\frac{\partial\overline{\pi}}{\partial F_{TM}}(\frac{\overline{\pi}}{\delta f_e})^{\frac{1}{k}-1} \\ &< 0.\end{aligned} \tag{1.68}$$

From the exit cutoff condition, $\frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi^*}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}L - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0 = 0$. Since $\frac{\partial\varphi^*}{\partial F_{TM}} < 0$, $\frac{\partial P}{\partial F_{TM}} > 0$. Since q_j^{NoTM}, q_j^{NoTM} and π_j^{NoTM} are increasing functions with respect to P, $\frac{\partial q_j^{NoTM}}{\partial F_{TM}} > 0$, $\frac{\partial r_j^{NoTM}}{\partial F_{TM}} > 0$, and $\frac{\partial \pi_j^{NoTM}}{\partial F_{TM}} > 0$. Finally, since welfare is defined as $W = \frac{L}{P}$ in the closed economy and $\frac{\partial P}{\partial F_{TM}} > 0$, $\frac{\partial W}{\partial F_{TM}} < 0$.

[19] For the average expected profit to be positive, the condition $k - \frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)} > 0$ is required.

1.A.4 Proof of Proposition 4

In the symmetric two-country open economy, I also assume that the equilibrium is stationary. With the aggregate stability condition, the free entry condition and the labor market clearing condition,

$$E = L. \tag{1.69}$$

From the exit and export cutoff conditions,

$$\pi_{j,d}^{NoTM}(\varphi_d^*) = 0 \iff \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi_d^*}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}L - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0 = 0. \tag{1.70}$$

$$\pi_{j,ex}^{NoTM}(\varphi_{ex}^*) = 0 \iff \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi_{ex}^*}{\tau c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}L - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_{ex} = 0. \tag{1.71}$$

Substituting these into the trademark cutoff in domestic and foreign markets, I can get the following conditions:

$$\pi_{j,d}^{TM}(\varphi_d^{TM}) = \pi_{j,d}^{NoTM}(\varphi_d^{TM}) \iff$$

$$[1-\tfrac{(\sigma-1)(1-\beta)}{\alpha}][\tfrac{(\sigma-1)(1-\beta)}{\alpha}\tfrac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}}[\tfrac{\varphi_d^{TM}}{\varphi_d^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(\sigma-1)(1-\beta)}}F_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} - F_2 = [(\tfrac{\varphi_d^{TM}}{\varphi_d^*})^{\sigma-1}-1]F_1, \tag{1.72}$$

$$\pi_{j,ex}^{TM}(\varphi_{ex}^{TM}) = \pi_{j,ex}^{NoTM}(\varphi_{ex}^{TM}) \iff$$

$$[1-\tfrac{(\sigma-1)(1-\beta)}{\alpha}][\tfrac{(\sigma-1)(1-\beta)}{\alpha}\tfrac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}}[\tfrac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(\sigma-1)(1-\beta)}}\overline{F}_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} - \overline{F}_2 = [(\tfrac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{\sigma-1}-1]\overline{F}_1, \tag{1.73}$$

where $F_1 = \frac{f}{\xi}\underline{\lambda}^{\alpha} + F_0$, $F_2 = F_0 + F_{d,TM}$, $\overline{F}_1 = \frac{f}{\xi}\underline{\lambda}^{\alpha} + F_{ex}$, and $\overline{F}_2 = F_{ex} + F_{ex,TM}$. I use the implicit function thorem and derive $\frac{\partial \frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}}{\partial F_{ex,TM}}$ as follows.

$$\begin{aligned}
\frac{\partial \frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}}{\partial F_{ex,TM}} &= \frac{1}{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}A(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)-1}} - (\sigma-1)\overline{F}_1(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{\sigma-2}} \\
&= \frac{1}{(\sigma-1)(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-1}[\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}(\overline{F}_2-\overline{F}_1) + \frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}\overline{F}_1(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{\sigma-1}]} \\
&= \frac{1}{(\sigma-1)(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-1}[\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}F_{ex,TM} + \frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}\overline{F}_1(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{\sigma-1}]} \\
&> 0,
\end{aligned} \tag{1.74}$$

where $A = [1-\frac{(\sigma-1)(1-\beta)}{\alpha}][\frac{(\sigma-1)(1-\beta)}{\alpha}\frac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}}\overline{F}_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}}$.

Next, I show $\frac{\partial \overline{\pi}}{\partial F_{ex,TM}} < 0$. With the exit, export and trademark cutoff conditions, and the assumption of φ following a Pareto distribution, I explain $\overline{\pi}$ under the zero cutoff profit condition in the following way.[20]

$$\begin{aligned}\overline{\pi} &= \frac{kF_1}{k-\sigma+1}[(\frac{\varphi_d^{TM}}{\varphi_d^*})^{-k+\sigma-1}-1] - F_1[1-(\frac{\varphi_d^{TM}}{\varphi_d^*})^{-k}] - F_2(\frac{\varphi_d^{TM}}{\varphi_d^*})^{-k} \\ &+ \frac{k}{k-\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[1-\frac{(\sigma-1)(1-\beta)}{\alpha}][\frac{(\sigma-1)(1-\beta)}{\alpha}\frac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}} F_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} [\frac{\varphi_d^{TM}}{\varphi_d^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-k} \\ &+ (\frac{\varphi_{ex}^*}{\varphi_d^*})^{-k}\{\frac{k\overline{F}_1}{k-\sigma+1}[1-(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k+\sigma-1}] - \overline{F}_1[1-(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k}] - \overline{F}_2(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k}\} \\ &+ \frac{k}{k-\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[1-\frac{(\sigma-1)(1-\beta)}{\alpha}][\frac{(\sigma-1)(1-\beta)}{\alpha}\frac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}} \overline{F}_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} [\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-k} (\frac{\varphi_{ex}^*}{\varphi_d^*})^{-k}.\end{aligned} \tag{1.75}$$

From (1.70) and (1.71), I describe the relationship between φ_d^* and φ_{ex}^*:

$$\frac{\varphi_{ex}^*}{\varphi_d^*} = \tau(\frac{\overline{F}_1}{F_1})^{\frac{1}{\sigma-1}}. \tag{1.76}$$

Substituting this into (1.75), the expected profit $\overline{\pi}$ is as follows.

$$\begin{aligned}\overline{\pi} &= \frac{kF_1}{k-\sigma+1}[(\frac{\varphi_d^{TM}}{\varphi_d^*})^{-k+\sigma-1}-1] - F_1[1-(\frac{\varphi_d^{TM}}{\varphi_d^*})^{-k}] - F_2(\frac{\varphi_d^{TM}}{\varphi_d^*})^{-k} \\ &+ \frac{k}{k-\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[1-\frac{(\sigma-1)(1-\beta)}{\alpha}][\frac{(\sigma-1)(1-\beta)}{\alpha}\frac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}} F_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} [\frac{\varphi_d^{TM}}{\varphi_d^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-k} \\ &+ [\tau(\frac{\overline{F}_1}{F_1})^{\frac{1}{\sigma-1}}]^{-k}\{\frac{k\overline{F}_1}{k-\sigma+1}[1-(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k+\sigma-1}] - \overline{F}_1[1-(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k}] - \overline{F}_2(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k}\} \\ &+ \frac{k}{k-\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[1-\frac{(\sigma-1)(1-\beta)}{\alpha}][\frac{(\sigma-1)(1-\beta)}{\alpha}\frac{\xi}{f}\underline{\lambda}^{-\alpha}]^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}} \overline{F}_1^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} [\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}]^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-k} [\tau(\frac{\overline{F}_1}{F_1})^{\frac{1}{\sigma-1}}]^{-k}.\end{aligned} \tag{1.77}$$

From this $\overline{\pi}$, I derive $\frac{\partial\overline{\pi}}{\partial\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}}$ in the following way:

$$\begin{aligned}\frac{\partial\overline{\pi}}{\partial\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}} &= k(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{k-1}[\tau(\frac{\overline{F}_1}{F_1})^{\frac{1}{\sigma-1}}]^{-k}[\overline{F}_1(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{\sigma-1} - \overline{F}_1 - A(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} + \overline{F}_2] \\ &= 0.\end{aligned} \tag{1.78}$$

[20]For the average expected profit to be positive, the condition $k - \frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)} > 0$ is required.

From this equation, $\frac{\partial \overline{\pi}}{\partial F_{ex,TM}}$ is as follows.

$$\begin{aligned}
\frac{\partial \overline{\pi}}{\partial F_{ex,TM}} &= -[\tau(\frac{\overline{F}_1}{F_1})^{\frac{1}{\sigma-1}}]^{-k}(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k} + \underbrace{\frac{\partial \overline{\pi}}{\partial \frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}}}_{=0} \frac{\partial \frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*}}{\partial F_{TM}} \\
&= -[\tau(\frac{\overline{F}_1}{F_1})^{\frac{1}{\sigma-1}}]^{-k}(\frac{\varphi_{ex}^{TM}}{\varphi_{ex}^*})^{-k} \\
&< 0.
\end{aligned} \tag{1.79}$$

With the Pareto distribution assumption, I can describe φ_d^* as a function of $\overline{\pi}$, δ, f_e and k under the free entry condition.

$$\varphi_d^* = (\frac{\overline{\pi}}{\delta f_e})^{\frac{1}{k}}. \tag{1.80}$$

With the result from (1.79),

$$\begin{aligned}
\frac{\partial \varphi_d^*}{\partial F_{ex,TM}} &= \frac{1}{k\delta f_e}\frac{\partial \overline{\pi}}{\partial F_{ex,TM}}(\frac{\overline{\pi}}{\delta f_e})^{\frac{1}{k}-1} \\
&< 0.
\end{aligned} \tag{1.81}$$

From the relationship between φ_d^* and φ_{ex}^*,

$$\begin{aligned}
\frac{\partial \varphi_{ex}^*}{\partial F_{ex,TM}} &= [\tau(\frac{\overline{F}_1}{F_1})^{\frac{1}{\sigma-1}}]^{-k}\frac{\partial \varphi_d^*}{\partial F_{ex,TM}} \\
&< 0.
\end{aligned} \tag{1.82}$$

From the exit cutoff and export conditions, $\frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi^*}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}L-\frac{f}{\xi}\underline{\lambda}^{\alpha}-F_0=0$ and $\frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi_{ex}^*}{\tau c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}L-\frac{f}{\xi}\underline{\lambda}^{\alpha}-F_{ex}=0$. Since $\frac{\partial \varphi_d^*}{\partial F_{ex,TM}}<0$ and $\frac{\partial \varphi_{ex}^*}{\partial F_{ex,TM}}<0$, $\frac{\partial P}{\partial F_{ex,TM}}>0$. Since $q_{j,d}^{NoTM}$, $q_{j,d}^{NoTM}$, $\pi_{j,d}^{NoTM}$, $q_{j,ex}^{NoTM}$, $q_{j,ex}^{NoTM}$ and $\pi_{j,ex}^{NoTM}$ are increasing functions with respect to P, $\frac{\partial q_{j,d}^{NoTM}}{\partial F_{ex,TM}}>0$, $\frac{\partial r_{j,d}^{NoTM}}{\partial F_{ex,TM}}>0$, $\frac{\partial \pi_{j,d}^{NoTM}}{\partial F_{ex,TM}}>0$, $\frac{\partial q_{j,ex}^{NoTM}}{\partial F_{ex,TM}}>0$, $\frac{\partial r_{j,ex}^{NoTM}}{\partial F_{ex,TM}}>0$, and $\frac{\partial \pi_{j,ex}^{NoTM}}{\partial F_{ex,TM}}>0$. Finally, since welfare is defined as $W=\frac{L}{P}$ in both two countries, $\frac{\partial W}{\partial F_{ex,TM}}<0$.

1.B Empirical Appendix

1.B.1 History of the Madrid Protocol member countries

The countries which have ratified the Madrid Protocol are members of the Madrid Union. Since the 1990s, many countries have been the members of the Madrid Union. Figure 1.B.1 and 1.B.2 show the cumulative number of members of the Madrid Union and the number of countries which became members per year. Until 2005, there was a gradual increase of the members of the Madrid Union, and more than 5 countries ratified the agreement almost every year. This trend slowed down between 2005 and 2014, and fewer than only 5 countries participated in the members during this period. However, in 2015, there was a radical change in the trend, and more than 10 countries suddenly entered into the system. I show 5 (Africa, Oceania, North/South America, Asia and Europe) different regional trends of the cumulative number of members of the Madrid Union in Figure 1.B.3. In Oceania and North/South America, the system has not been popular among the countries and only 10% of them participates in the system. On the other hand, participation in the Madrid Union is common in Asia and Europe. There has been a gradual increase of the members since 1995 and it has reached 60% in Asia and 80% in Europe. Compared with these two regional trends, African countries have followed a unique trend. Although there was a growing trend as in Asia and Europe between 1995 and 2014, a sudden spike hit Africa in 2015. In 2015, the percentage of African countries being Madrid Union members doubled (from 29.8% to 64.9%).

1.B.2 Summary Statistics at an Intensive Margin

Table 1.B.3 reports the summary statistics at an intensive margin. I restrict my observations under the following criterion: a combination of i, c and t where firm i exports its tire in country c in 2014 and 2015, in 2014 and 2016 or 2014 and 2017. Although the summary statistics follows a similar trend, the values are larger compared with Table 1.1. This means that Chinese exporters selling large amounts of quantity and achieving larger sales are likely to survive in the market and export their tires before and after the accession of the international trademark agreement. Furthermore, on the intensive margin, more transactions are attached with a trademark. Although 15.5% of a transaction is attached with a trademark from 2014 to 2017, it is 18.2% in Table 1.B.3. In OAPI countries, the trend of usage of a trademark is the same but the value is larger. On the intensive margin, it is 0% in 2014, 1.8% in 2015, 16.2% in 2016 and 27.8% in 2017. Further-

more, the number of the transactions among Chinese exporters on the intensive margin decrease over the years. It is 1660 in 2014, 1398 in 2015, 1280 in 2016, and 1171 in 2017. This shows that a continuing Chinese exporter in OAPI countries is more likely to use a trademark and that company is likely to force another incumbent exporter to exit the market. In ARIPO countries, the trend is almost the same even on the intensive margin in the quantity, export value and price. The log of the quantity in ARIPO countries is 9.798 in 2014, 9.886 in 2015, 9.983 in 2016 and 10.124 in 2017, the log of the export value 10.895 in 2014, 10.702 in 2015, 10.661 in 2016 and 10.889 in 2017, and the log of the unit price is 1.097 in 2014, 0.815 in 2015, 0.677 in 2016 and 0.764 in 2017. The number of the transactions among Chinese exporters on the intensive margin decreases over the years in ARIPO countries as well, but the number is small. It is 2507 in 2014, 2422 in 2015, 2180 in 2016 and 1902 in 2017. The percentage decrease (24.1%) is smaller compared with the one in OAPI countries (29.4%). This implies that an increase in usage of trademark is more linked to a decrease in the number of transactions in each country.

1.B.3 Empirical Findings: Quality Upgrading with a Different σ and Using an Proxy for Quality

In this subsection, I check whether or not Chinese exporters upgrade their quality with a trademark with two robustness checking.

First, I assume $\sigma = 5$ instead of $\sigma = 2.5$ as a value of constant elasticity of substitution in the utility function and estimate quality by following Khandelwal et al. (2013). This value $\sigma = 5$ is the estimated value from Broda et al. (2006) and related literature use this value. Table 1.B.4 reports my analysis based on $\sigma = 5$. Overall, Chinese exporters increase their quality statistically significantly even with a different estimate of quality. On average, Chinese exporters statistically significantly increase quality 11.1%. In addition, the effect is different among exporters due to their positions in each targeting country and exporting strategies . If a firm was one of the best 3 or best 10 exporters in country c in 2014, it further increases its quality statistically significantly by 10.3% or 11.0%. The result in columns (3) shows that if a firm exports more than a half of the total export to OAPI countries, it increases its quality by 12.3%.

Second, I use a proxy of quality instead of the estimation strategy. Following Manova and Yu (2017) and Bloom et al. (2018), I directly proxy quality with $ln(\lambda_j) \propto ln(q_{ict}) + \sigma ln(p_{ict})$. Even with this proxy, I obtain the results consistent with the quality upgrading story. Table 1.B.5 shows that on average a Chinese exporter neither increase nor decrease its quality statistically significantly. However, the effect is different among exporters again. If a firm was one of the best 3 or best 10 exporters in country c in 2014, it increases its quality statistically significantly by 36.5% or 33.4%. The result in columns (3) shows that if a firm exports more than a half of the total export to OAPI countries, it increases its quality by 53.9% while others decrease their quality by 22.1%.

Table 1.B.1: Year of Entry in OAPI countries

Name of OAPI Countries	Year of the entry into the Madrid Protocol
Benin	2015
Burkina Faso	2015
Cameroon	2015
Central African Republic	2015
Chad	2015
Congo	2015
Cote d'Ivoire	2015
Equatorial Guinea	2015
Gabon	2015
Guinea	2015
Guinea-Bissau	2015
Mali	2015
Mauritania	2015
Niger	2015
Senegal	2015
Togo	2015
Comoros	2015

Note: OAPI is the abbreviation of the Organisation Africaine de la Propriété Intellectuelle. The Madrid Protocol is the protocol relating to the Madrid Agreement concerning the International Registration of Marks. It is concluded in 1989 and amended in 2006 and in 2007.

Table 1.B.2: Year of Entry in ARIPO countries

Name of ARIPO Countries	Year of the entry into the Madrid Protocol
Botswana	2006
Gambia	2015
Ghana	1996
Kenya	1998
Lesotho	1999
Liberia	2009
Malawi	Not Yet
Mozambique	1998
Namibia	2004
Rwanda	2013
Sao Tome Principe	2008
Sierra Leone	1998
Somalia	Not Yet
Sudan	2010
Swaziland	1998
Tanzania	Not Yet
Uganda	Not Yet
Zambia	2001
Zimbabwe	2015

Note: ARIPO is the abbreviation of the African Regional Intellectual Property Organization. The Madrid Protocol is the protocol relating to the Madrid Agreement concerning the International Registration of Marks. It is concluded in 1989 and amended in 2006 and in 2007. As of 2018, Malawi, Somalia, Tanzania and Uganda have not ratified the Madrid Protocol.

Table 1.B.3: Descriptive Statistics: Case 1

All Countries										
Year	2014−2017		2014		2015		2016		2017	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ln(Quantity)	9.891	1.422	9.790	1.384	9.849	1.421	9.921	1.430	10.047	1.451
ln(Value)	10.771	1.384	10.939	1.378	10.677	1.364	10.615	1.375	10.835	1.401
ln(Price)	0.880	0.352	1.150	0.434	0.828	0.234	0.694	0.249	0.788	0.206
OAPI	0.379	0.485	0.398	0.490	0.366	0.482	0.370	0.483	0.381	0.486
ARIPO	0.621	0.485	0.602	0.490	0.634	0.482	0.630	0.483	0.619	0.486
TM	0.182	0.386	0.127	0.333	0.145	0.352	0.216	0.412	0.263	0.440

OAPI Countries										
Year	2014−2017		2014		2015		2016		2017	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ln(Quantity)	9.819	1.342	9.777	1.283	9.784	1.363	9.815	1.352	9.923	1.382
ln(Value)	10.748	1.329	11.006	1.305	10.635	1.315	10.537	1.302	10.749	1.350
ln(Price)	0.929	0.391	1.228	0.486	0.851	0.251	0.722	0.262	0.825	0.210
TM	0.101	0.302	0.000	0.000	0.018	0.133	0.162	0.368	0.278	0.448

ARIPO Countries										
Year	2014−2017		2014		2015		2016		2017	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ln(Quantity)	9.935	1.467	9.798	1.446	9.886	1.453	9.983	1.470	10.124	1.488
ln(Value)	10.785	1.417	10.895	1.423	10.702	1.391	10.661	1.414	10.889	1.429
ln(Price)	0.850	0.322	1.097	0.388	0.815	0.222	0.677	0.239	0.764	0.200
TM	0.231	0.422	0.212	0.409	0.218	0.413	0.249	0.432	0.253	0.435

Note: Value is measured by the US$. Price is the unit price and it is derived by Value/Quantity. TM takes 1 if a Chinese company uses its trademark in its destination country at its export date. The OAPI member countries are Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, and Togo. The ARIPO member countries are Botswana, Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mozambique, Namibia, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

Table 1.B.4: Quality Upgrading: $\sigma = 5$

VARIABLE	(1)	(2)	(3)
	ln(Estimated Quality)		
$OAPI_c \times After_t$	0.111***	0.0612***	0.0666***
	(0.0219)	(0.0194)	(0.0237)
$OAPI_c \times After_t \times$ Best 15_{ic}		0.00324	
		(0.0475)	
$OAPI_c \times After_t \times$ Best 10_{ic}		0.103***	
		(0.0298)	
$OAPI_c \times After_t \times$ Best 3_{ic}		0.110***	
		(0.0359)	
$OAPI_c \times After_t \times \mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$			0.123***
			(0.0280)
Mean of Dependent Variable		0	
Firm FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Export Information	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes
Firm $\times$ Time FE	Yes	Yes	Yes
R-squared	0.534	0.574	0.552

Note: Country-clustered standard errors are in parentheses. The observation is restricted to a combination of i, c and t where firm i exports its tire in 2014 and 2015 or 2016. Quality is calculated by following Khandelwal et al. (2013). $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after the 1st of March in 2015. Best 3_{ic} is a dummy variable which takes 1 if firm i was one of the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was one of the best 10 exporters in country c in 2014 and Best 15_{ic} is a dummy variable which takes 1 if firm i was one of the best 15 exporters in country c in 2014. $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of the total export of firm i was exported into OAPI countries in 2014. Export Information includes the Chinese port at which a Chinese company exports and the countries at which a Chinese company transits. Export Information includes the Chinese port at which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports and the log of total imports.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.B.5: Quality Upgrading

	(1)	(2)	(3)
VARIABLE	ln(Estimated Quality)		
$OAPI_c \times After_t$	-0.0212	-0.155	-0.221***
	(0.0591)	(0.109)	(0.0618)
$OAPI_c \times After_t \times$ Best 15_{ic}		-0.167	
		(0.174)	
$OAPI_c \times After_t \times$ Best 10_{ic}		0.365**	
		(0.135)	
$OAPI_c \times After_t \times$ Best 3_{ic}		0.334**	
		(0.153)	
$OAPI_c \times After_t \times \mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$			0.539***
			(0.107)
Mean of Dependent Variable		0	
Firm FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Export Information	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes
Firm × Time FE	Yes	Yes	Yes
R-squared	0.658	0.689	0.673

Note: Country-clustered standard errors are in parentheses. The observation is restricted to a combination of i, c and t where firm i exports its tire in 2014 and 2015 or 2016. Quality is calculated by following Manova and Yu (2017) and Bloom et al. (2018). $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after the 1st of March in 2015. Best 3_{ic} is a dummy variable which takes 1 if firm i was one of the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was one of the best 10 exporter in country c in 2014 and Best 15_{ic} is a dummy variable which takes 1 if firm i was one of the best 15 exporters in country c in 2014. $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of the total export of firm i was exported into OAPI countries in 2014. Export Information includes the Chinese port at which a Chinese company exports and the countries at which a Chinese company transits. Export Information includes the Chinese port at which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports and the log of total imports.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Figure 1.B.1: History of Entry into the Madrid Protocol

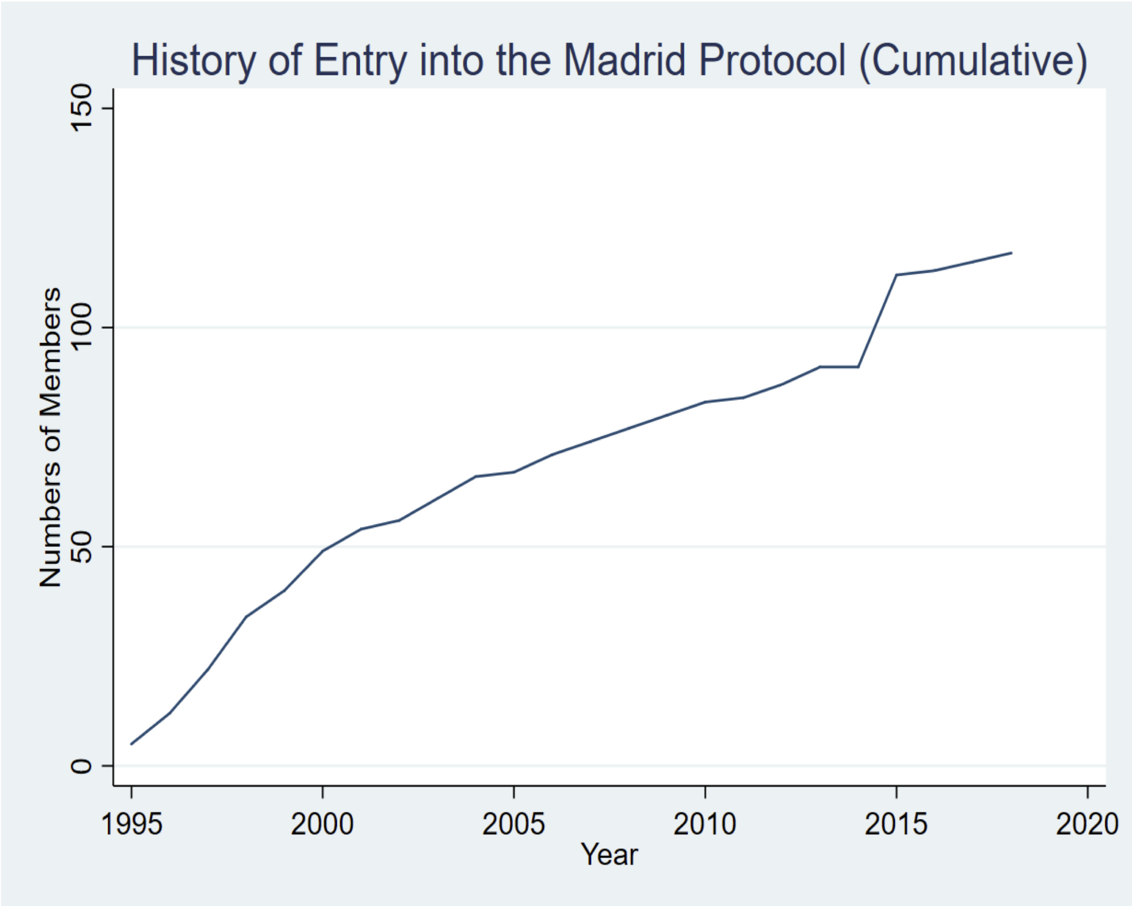

Figure 1.B.1 plots the cumulative number of the parties to the Madrid Protocol by year between 1995 to 2018.
Source: The World Intellectual Property Organization (WIPO).

Figure 1.B.2: Entry into the Madrid Protocol per Year

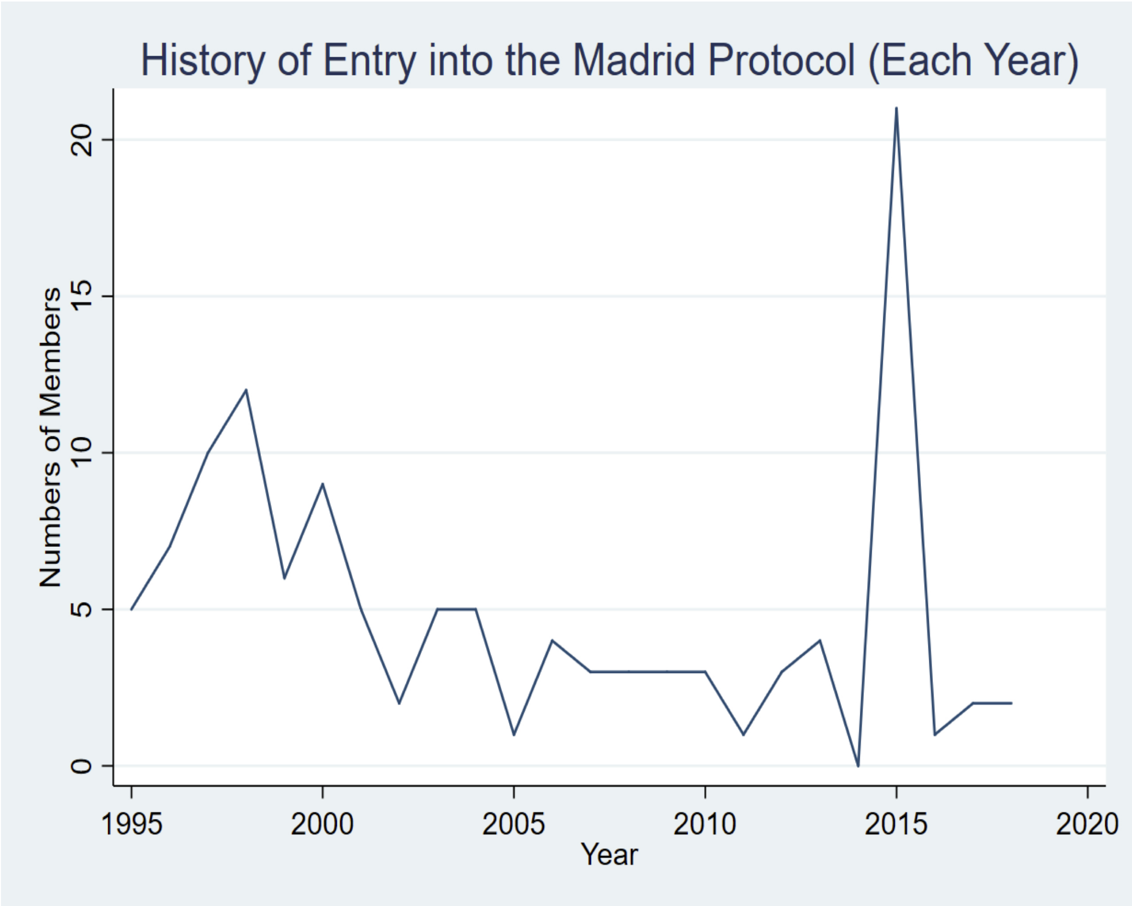

Figure 1.B.2 plots the number of the countries ratifying the Madrid Protocol per year between 1995 to 2018.
Source: The World Intellectual Property Organization (WIPO).

Figure 1.B.3: Regional Trends of Entry into the Madrid Protocol

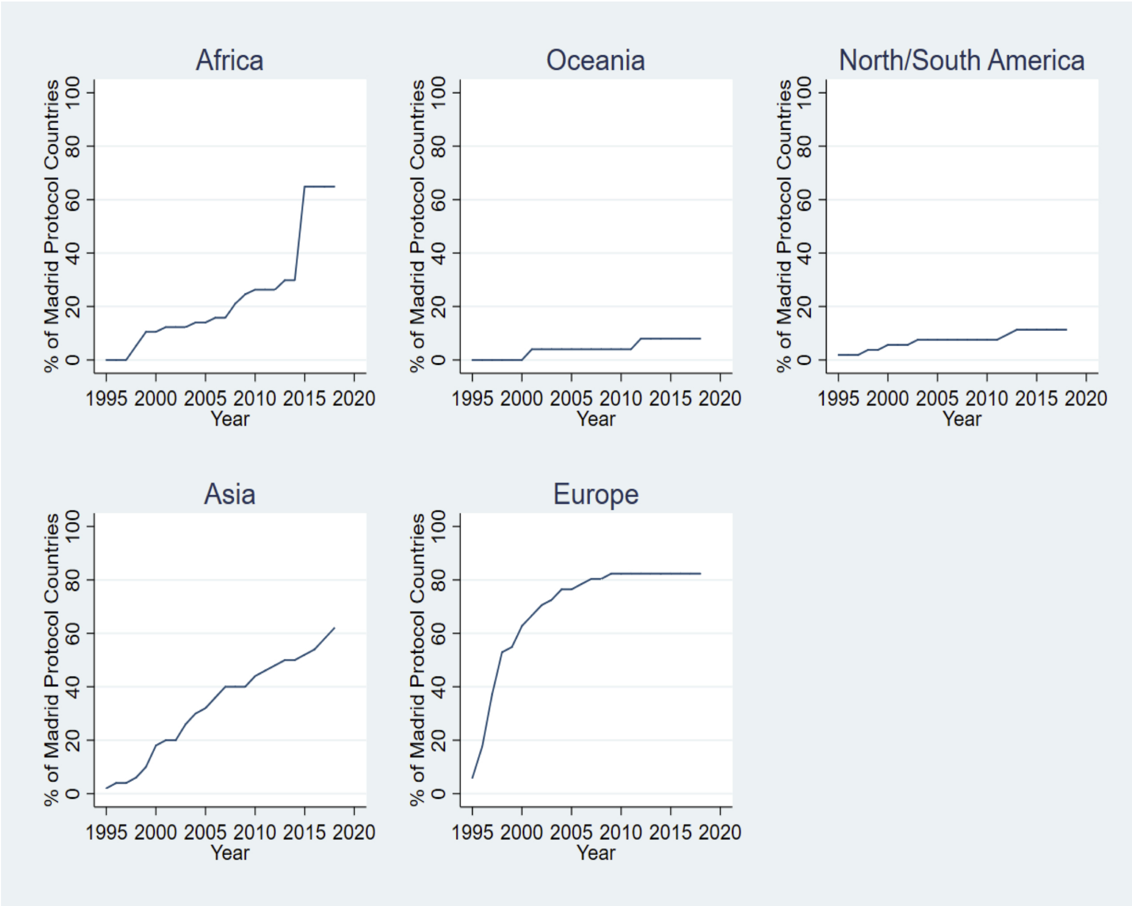

Figure 1.B.3 plots the 5 regional cumulative number of the parties to the Madrid Protocol by year between 1995 to 2018. The 5 regions are Africa, Oceania, North/South America, Asia and Europe.
Source: The World Intellectual Property Organization (WIPO).

1.C An Alternative Hypothesis Testing

1.C.1 An Alternative Hypothesis

I predict that sellers use a trademark to upgrade the quality of their products, sell more quantities and earn more revenues because they can mitigate information frictions they face with a trademark. However, there is another hypothesis under which they use a trademark. An alternative hypothesis could be that firms use a trademark not to differentiate their products from other genuine products but to protect their goods from counterfeit products.

In this subsection, I explain how a trademark works in a market where a counterfeit producer enters. In this hypothesis, I assume that there is no asymmetric information between sellers and buyers, but that an authentic producer has to compete with a counterfeit producer to sell its own variety for the same variety without a trademark. A counterfeit producer is less productive, but it does not have to pay the cost of creating a brand, F_0, because it just imitates the brand of an authentic producer. I only consider the closed economy in this subsection but the predictions I obtain in the closed economy are applicable to the open-economy model.

First, I cover the demand side and a consumer's utility maximization problem is as follows:

$$U = \max_{q_j, q_{j'}} [\int_{j \in \mathcal{J}^{TM}} (q_j \lambda_j)^{\frac{\sigma-1}{\sigma}} dj + \int_{j' \in \mathcal{J}^{NoTM}} (q_{j'} \lambda_{j'})^{\frac{\sigma-1}{\sigma}} dj']^{\frac{\sigma}{\sigma-1}}$$
$$s.t. \quad \int_{j \in \mathcal{J}^{TM}} p_j q_j dj + \int_{j' \in \mathcal{J}^{NoTM}} p_{j'} q_{j'} dj' = E, \tag{1.83}$$

where $\mathcal{J}^{TM}$ is the total number of products with a trademark while $\mathcal{J}^{NoTM}$ is the total number of products without a trademark. Demand for each product with and without a trademark is as follows:

$$q_j = p_j^{-\sigma} \lambda_j^{\sigma-1} P^{\sigma-1} E. \tag{1.84}$$

$$q_{j'} = p_{j'}^{-\sigma} \lambda_{j'}^{\sigma-1} P^{\sigma-1} E. \tag{1.85}$$

Then, I cover the profit maximization problem for a firm which has its own trademark. The cost for obtaining a trademark is a fixed cost, F_{TM}, and it can exclude counterfeit producers from the market with this trademark. With a trademark, the profit maximization problem is as follows:

$$\pi_j^{TM} = \max_{p_j^{TM}\in(0,\infty),\lambda_j^{TM}\in[\underline{\lambda},\infty)} p_j^{1-\sigma}\lambda_j^{\sigma-1}P^{\sigma-1}E - \frac{c}{\varphi}\lambda_j^{\beta+\sigma-1}p_j^{-\sigma}P^{\sigma-1}E - F_0 - \frac{f}{\xi}\lambda_j^{\alpha} - F_{TM}. \tag{1.86}$$

Solving this problem,

$$\lambda_j^{TM}(\varphi) = \begin{cases} \underline{\lambda}, \\ [\frac{1-\beta}{\alpha}(\frac{\sigma-1}{\sigma})^{\sigma}(\frac{\varphi}{c})^{\sigma-1}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{1}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.87}$$

$$p_j^{TM}(\varphi) = \begin{cases} \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta}, \\ (\frac{\sigma}{\sigma-1})^{\frac{\alpha-\beta-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{c}{\varphi})^{\frac{\alpha-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{\beta}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.88}$$

$$q_j^{TM}(\varphi) = \begin{cases} (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma}\underline{\lambda}^{(1-\beta)\sigma-1}P^{\sigma-1}E, \\ (\frac{\sigma-1}{\sigma})^{\frac{\sigma(\alpha-\beta)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{c})^{\frac{\alpha\sigma-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(P^{\sigma-1}E)^{\frac{(1-\beta)\sigma}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}]^{\frac{(1-\beta)\sigma-1}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.89}$$

$$r_j^{TM}(\varphi) = \begin{cases} (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E, \\ (\frac{\sigma-1}{\sigma})^{\frac{(\sigma-1)(\alpha-\beta+1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{c})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[\frac{\xi}{f}]^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[P^{\sigma-1}E]^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}}. \end{cases} \tag{1.90}$$

$$\pi_j^{TM}(\varphi) = \begin{cases} \frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} - F_0 - F_{TM}, \\ (\frac{\sigma-1}{\sigma})^{\frac{\alpha\sigma}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\alpha-(1-\beta)(\sigma-1)}{(1-\beta)(\sigma-1)})(\frac{\varphi}{c})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\xi}{f})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E)^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}} - F_0 - F_{TM}. \end{cases} \tag{1.91}$$

Next, I cover the case where a firm does not have a trademark. The timing of events is as follows. An authentic producer sets the price p_j^{NoTM} and quality λ_j^{NoTM} for variety j. Then, a counterfeit producer sets the price p_j^c and quality λ_j^c for the same variety. Finally, a consumer decides which product to buy and the profits are realized. This problem is solved backwards. The demand side is a consumer maximization problem with a Dixit-Stiglitz utility function defined in terms of quality-adjusted units of consumption and quality-adjusted prices. Thus, the best response of a consumer is as follows:

$$q_j = \begin{cases} (p_j^{NoTM})^{-\sigma}(\lambda_j^{NoTM})^{\sigma-1}P^{\sigma-1}E \quad if \quad \frac{p_j^c}{\lambda_j^c} \geq \frac{p_j^{NoTM}}{\lambda_j^{NoTM}} \\ (p_j^c)^{-\sigma}(\lambda_j^c)^{\sigma-1}P^{\sigma-1}E \quad otherwise \end{cases} \tag{1.92}$$

Then, I move to the counterfeit producer's profit maximization problem. In order to attract customers, a counterfeit producer faces the constraint, $\frac{p_j^c}{\lambda_j^c} \leq \frac{p_j^{NoTM}}{\lambda_j^{NoTM}}$. Therefore, the profit maximization problem is as follows:

$$\pi_j^c = \max_{p_j\in(0,\infty),\lambda_j\in[0,\infty)} (1-p)p_j^{1-\sigma}\lambda_j^{\sigma-1}P^{\sigma-1}E - \frac{\gamma c}{\varphi}\lambda_j^{\beta+\sigma-1}p_j^{-\sigma}P^{\sigma-1}E - \frac{f}{\xi}\lambda_j^{\alpha} \quad s.t. \quad \frac{p_j}{\lambda_j} \leq \frac{p_j^{NoTM}}{\lambda_j^{NoTM}}, \tag{1.93}$$

where γ captures how less productive it is compared with an authentic producer and p is the probability of being confiscated by the government. In the counterfeit producer's profit maximization problem, it does not need to satisfy the quality requirement, $\underline{\lambda}$, which is set by the government because the product is just the counterfeit and it is not examined by the government. Solving this problem, I can get p^c and λ^c, respectively.

$$\lambda_j^c(\varphi,\gamma) = [\frac{1-\beta}{\alpha}\frac{\gamma c}{\varphi}(\frac{p_j^{NoTM}}{\lambda_j^{NoTM}})^{-\sigma}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{1}{\alpha-\beta+1}}. \tag{1.94}$$

$$p_j^c(\varphi,\gamma) = \frac{p_j^{NoTM}}{\lambda_j^{NoTM}}[\frac{1-\beta}{\alpha}\frac{\gamma c}{\varphi}(\frac{p_j^{NoTM}}{\lambda_j^{NoTM}})^{-\sigma}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{1}{\alpha-\beta+1}}. \tag{1.95}$$

$$q_j^c(\varphi,\gamma) = [\frac{p_j^{NoTM}}{\lambda_j^{NoTM}}]^{\frac{-\sigma(\alpha-\beta)}{\alpha-\beta+1}}[\frac{1-\beta}{\alpha}\frac{\gamma c}{\varphi}\frac{\xi}{f}]^{\frac{-1}{\alpha-\beta+1}}[P^{\sigma-1}E]^{\frac{\alpha-\beta}{\alpha-\beta+1}}. \tag{1.96}$$

$$r_j^c(\varphi,\gamma) = (1-p)(\frac{p_j^{NoTM}}{\lambda_j^{NoTM}})^{1-\sigma}P^{\sigma-1}E. \tag{1.97}$$

$$\pi_j^c(\varphi,\gamma) = [(1-p)\frac{p_j^{NoTM}}{\lambda_j^{NoTM}} - \frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{p_j^{NoTM}}{\lambda_j^{NoTM}})^{\frac{\sigma(1-\beta)}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}](\frac{p_j^{NoTM}}{\lambda_j^{NoTM}})^{-\sigma}P^{\sigma-1}E. \tag{1.98}$$

A counterfeit producer sets these p_j^c and λ_j^c only if $\pi_j^c \geq 0$. Thus, an authentic producer can exclude him from the market by setting the price and quality satisfying the condition, $(1-p)\frac{p_j^{NoTM}}{\lambda_j^{NoTM}} \leq \frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{p_j^{NoTM}}{\lambda_j^{NoTM}})^{\frac{\sigma(1-\beta)}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}} \iff \frac{p_j^{NoTM}}{\lambda_j^{NoTM}} \leq [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}$. In this condition, I need to know whether the binding constraint is related to a firm heterogeneity, φ. The following proposition discusses this point.

Proposition 5. *Whether the constraint,* $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}} \leq [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}$, *is binding for an authentic producer's profit maximization problem is irrelevant to a firm heterogeneity,* φ, *under the condition* $\frac{\sigma}{\sigma-1} > [\frac{\alpha}{(\sigma-1)(1-\beta)}]^{\frac{1-\beta}{\alpha-\beta+1}}\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$. *That is, if* $\frac{\sigma}{\sigma-1} > [\frac{\alpha}{(\sigma-1)(1-\beta)}]^{\frac{1-\beta}{\alpha-\beta+1}}\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$ *is satisfied, all firms without a trademark take this constraint into consideration for their profit maximization problems.*

Proof. Without a counterfeit producer, an authentic producer without a trademark sets the same price and quality as the ones set by the one with a trademark. Thus, if $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}} =$

$\frac{\sigma}{\sigma-1}\frac{c}{\varphi}\lambda_j(\varphi)^{\beta-1}$ is less than or equal to $[\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}$, the constraint is not binding and an authentic producer does not take this constraint into consideration for the profit maximization problem. I consider two cases separately: one case where the quality constraint is binding and the other where the constraint is non-binding.

- Case 1: The Quality Constraint is Binding

In this case, an authentic producer offers $\lambda_j(\varphi) = \underline{\lambda}$ with $p_j(\varphi) = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta-1}$ if it does not compete with a counterfeit producer. Thus, the quality-adjusted price is $\frac{p_j(\varphi)}{\lambda_j(\varphi)} = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta-1}$. I need to know whether this is less than or equal to $[\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}$. To show this, I define the cut-off, $\varphi_{\#}$, which is the highest productivity of a firm to offer quality $\underline{\lambda}$:

$$\underline{\lambda} = [\frac{1-\beta}{\alpha}(\frac{\sigma-1}{\sigma})^{\sigma}(\frac{\varphi_{\#}}{c})^{\sigma-1}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{1}{\alpha-(1-\beta)(\sigma-1)}} \iff \varphi_{\#} = c[\frac{1-\beta}{\alpha}(\frac{\sigma-1}{\sigma})^{\sigma}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{-1}{\sigma-1}}\underline{\lambda}^{\frac{\alpha-(1-\beta)(\sigma-1)}{\sigma-1}}. \tag{1.99}$$

Then, the quality-adjusted price is rearranged in the following way:

$$\begin{aligned}\frac{p_j(\varphi)}{\lambda_j(\varphi)} &= \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta-1} \\ &= \frac{\sigma}{\sigma-1}\frac{c}{\varphi}[\frac{1-\beta}{\alpha}(\frac{\sigma-1}{\sigma})^{\sigma}(\frac{\varphi_{\#}}{c})^{\sigma-1}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{\beta-1}{\alpha-(1-\beta)(\sigma-1)}}.\end{aligned} \tag{1.100}$$

From this, the inequality I focus on is:

$$\begin{aligned}&\frac{p_j(\varphi)}{\lambda_j(\varphi)} > [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}} \\ \iff &(\frac{\sigma}{\sigma-1})^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{\varphi_{\#}})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} > [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}.\end{aligned} \tag{1.101}$$

If an authentic producer is in the market, $\pi \geq 0$ is satisfied. With the constraint, the lowest productive firm in the market has a productivity $\varphi_{\#\#}$ satisfying

$$\frac{1}{\sigma}(\frac{\sigma-1}{\sigma}\frac{\varphi_{\#\#}}{c})^{\sigma-1}\underline{\lambda}^{(1-\beta)(\sigma-1)}P^{\sigma-1}E - \frac{f}{\xi}\underline{\lambda}^{\alpha} = 0 \iff \varphi_{\#\#} = c[\frac{1}{\sigma}(\frac{\sigma-1}{\sigma})^{\sigma-1}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{-1}{\sigma-1}}\underline{\lambda}^{\frac{\alpha-(1-\beta)(\sigma-1)}{\sigma-1}}. \tag{1.102}$$

From these, the relationship between $\varphi_{\#}$ and $\varphi_{\#\#}$ is described as follows.

$$\varphi_{\#\#} = \varphi_{\#}[\frac{(1-\beta)(\sigma-1)}{\alpha}]^{\frac{1}{\sigma-1}}. \tag{1.103}$$

Therefore, I get the following inequality.

$$
\begin{aligned}
(\frac{\sigma}{\sigma-1})^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{\varphi_{\#}})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} &> (\frac{\sigma}{\sigma-1})^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi_{\#\#}}{\varphi_{\#}})^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} \\
&= (\frac{\sigma}{\sigma-1})^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}[\frac{(1-\beta)(\sigma-1)}{\alpha}]^{\frac{1-\beta}{\alpha-(1-\beta)(\sigma-1)}}.
\end{aligned}
\tag{1.104}
$$

Therefore, if $\frac{\sigma}{\sigma-1} > [\frac{\alpha}{(\sigma-1)(1-\beta)}]^{\frac{1-\beta}{\alpha-\beta+1}}\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$ holds, the firm with this quality constraint takes the constraint into consideration for its profit maximization problem.

- Case 2: The Quality Constraint is Not Binding

  In this case, an authentic producer offers $\lambda_j(\varphi) > \underline{\lambda}$ if it does not face a counterfeit producer and $p_j(\varphi) = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\lambda_j(\varphi)^{\beta}$. Thus, the quality-adjusted price is as follows.

$$
\begin{aligned}
\frac{p_j(\varphi)}{\lambda_j(\varphi)} &= \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\lambda_j(\varphi)^{\beta-1} \\
&= \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\{(\frac{\sigma-1}{\sigma})^{\frac{\sigma(\alpha-\beta)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{c})^{\frac{\alpha\sigma-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(P^{\sigma-1}E)^{\frac{(1-\beta)\sigma}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}]^{\frac{(1-\beta)\sigma-1}{\alpha-(1-\beta)(\sigma-1)}}\}^{\beta-1} \\
&= [\frac{\sigma}{\sigma-1}(\frac{c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}}.
\end{aligned}
\tag{1.105}
$$

  From this, the condition under which a firm takes competition with a counterfeit producer into consideration is

$$
\begin{aligned}
&\frac{p_j(\varphi)}{\lambda_j(\varphi)} > [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}(\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})^{\frac{\beta-1}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}} \\
\Longleftrightarrow\ &[\frac{\sigma}{\sigma-1}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}} > [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(1-\beta)(\sigma-1)}} \\
\Longleftrightarrow\ &\frac{\sigma}{\sigma-1} > \frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}.
\end{aligned}
\tag{1.106}
$$

  Therefore, if $\frac{\sigma}{\sigma-1} > [\frac{\alpha}{(\sigma-1)(1-\beta)}]^{\frac{1-\beta}{\alpha-\beta+1}}\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$ holds, the firm without the quality constraint takes the constraint into consideration for its profit maximization problem.

From these two cases, if $\frac{\sigma}{\sigma-1} > [\frac{\alpha}{(\sigma-1)(1-\beta)}]^{\frac{1-\beta}{\alpha-\beta+1}}\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$ holds, all firms face the constraint in the profit maximization problem, and the constraint is irrelevant to firm heterogeneity, φ. □

From now on, I assume that this condition, $\frac{\sigma}{\sigma-1} > [\frac{\alpha}{(\sigma-1)(1-\beta)}]^{\frac{1-\beta}{\alpha-\beta+1}} \frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} \gamma^{\frac{\alpha}{\alpha-\beta+1}}$ is satisfied and that all firms without a trademark take this constraint into consideration for their profit maximization problem. Then, without a trademark, an authentic producer's profit maximization problem is as follows.

$$\pi_j^{NoTM} = \max_{p_j \in (0,\infty), \lambda_j \in [\underline{\lambda}, \infty)} p_j^{1-\sigma} \lambda_j^{\sigma-1} P^{\sigma-1} E - \frac{c}{\varphi} \lambda_j^{\beta+\sigma-1} p_j^{-\sigma} P^{\sigma-1} E - F_0 - \frac{f}{\xi} \lambda_j^{\alpha}$$
$$s.t. \quad \frac{p_j}{\lambda_j} \leq [\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} (\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(\sigma-1)(1-\beta)}} [\frac{1-\beta}{\alpha} P^{\sigma-1} E \frac{\xi}{f}]^{\frac{\beta-1}{\alpha-(\sigma-1)(1-\beta)}}. \tag{1.107}$$

Solving this problem,

$$\lambda_j^{NoTM}(\varphi) = \begin{cases} \underline{\lambda}, \\ [(\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} \gamma^{\frac{\alpha}{\alpha-\beta+1}})^{-\sigma} (\frac{\varphi}{c})^{\sigma-1} (\frac{1-\beta}{\alpha} P^{\sigma-1} E \frac{\xi}{f})]^{\frac{1}{\alpha-(\sigma-1)(1-\beta)}}. \end{cases} \tag{1.108}$$

$$p_j^{NoTM}(\varphi) = \begin{cases} [\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} (\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{\alpha-\beta+1}{\alpha-(\sigma-1)(1-\beta)}} [\frac{1-\beta}{\alpha} P^{\sigma-1} E \frac{\xi}{f}]^{\frac{\beta-1}{\alpha-(\sigma-1)(1-\beta)}} \underline{\lambda}, \\ [(\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} \gamma^{\frac{\alpha}{\alpha-\beta+1}})^{\alpha-\sigma+1-\beta} (\frac{c}{\varphi})^{\alpha-\sigma+1} (\frac{1-\beta}{\alpha} P^{\sigma-1} E \frac{\xi}{f})^{\beta}]^{\frac{1}{\alpha-(\sigma-1)(1-\beta)}}. \end{cases} \tag{1.109}$$

$$q_j^{NoTM}(\varphi) = \begin{cases} [\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} (\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma(\alpha-\beta+1)}{\alpha-(\sigma-1)(1-\beta)}} [\frac{1-\beta}{\alpha} \frac{\xi}{f}]^{\frac{\sigma(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}} (P^{\sigma-1} E)^{\frac{\alpha+1-\beta}{\alpha-(\sigma-1)(1-\beta)}} \underline{\lambda}^{-1}, \\ [\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} \gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma(\alpha-\beta)}{\alpha-(\sigma-1)(1-\beta)}} [\frac{\varphi}{c}]^{\frac{\alpha\sigma-(\sigma-1)}{\alpha-(\sigma-1)(1-\beta)}} [\frac{1-\beta}{\alpha} \frac{\xi}{f}]^{\frac{(1-\beta)\sigma-1}{\alpha-(\sigma-1)(1-\beta)}} (P^{\sigma-1} E)^{\frac{(1-\beta)\sigma}{\alpha-(\sigma-1)(1-\beta)}}. \end{cases} \tag{1.110}$$

$$r_j^{NoTM}(\varphi) = [\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} (\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{(1-\sigma)(\alpha-\beta+1)}{\alpha-(\sigma-1)(1-\beta)}} [\frac{1-\beta}{\alpha} P^{\sigma-1} E \frac{\xi}{f}]^{\frac{(1-\sigma)(\beta-1)}{\alpha-(\sigma-1)(1-\beta)}}. \tag{1.111}$$

$$\pi_j^{NoTM}(\varphi) = \begin{cases} r_j^{NoTM}(\varphi) - \frac{c}{\varphi} [\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} (\frac{\gamma c}{\varphi})^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma(\alpha-\beta+1)}{\alpha-(\sigma-1)(1-\beta)}} [\frac{1-\beta}{\alpha} P^{\sigma-1} E \frac{\xi}{f}]^{\frac{\sigma(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}} \underline{\lambda}^{\beta-1} P^{\sigma-1} E - \frac{f}{\xi} \underline{\lambda}^{\alpha} - F_0, \\ [\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} \gamma^{\frac{\alpha}{\alpha-\beta+1}} - 1][\frac{1}{1-p} \frac{\alpha-\beta+1}{\alpha} \gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma\alpha}{\alpha-(1-\beta)(\sigma-1)}} [(\frac{\varphi}{c})^{\sigma-1} P^{\sigma-1} E]^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}} [\frac{1-\beta}{\alpha} \frac{\xi}{f}]^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} - F_0. \end{cases} \tag{1.112}$$

I show (i) how a firm changes its quality, price, quantity, and revenue with and without a trademark, and (ii) how firms sorts into two groups: the firms with and without a trademark. For the former part, I show the following property.

Proposition 6. *Conditional on φ, I get the following relationship.*

$$p_j^{TM}(\varphi) \lesseqqgtr p_j^{NoTM}(\varphi). \tag{1.113}$$

$$\lambda_j^{TM}(\varphi) \leq \lambda_j^{NoTM}(\varphi). \tag{1.114}$$

$$q_j^{TM}(\varphi) < q_j^{NoTM}(\varphi). \tag{1.115}$$

$$r_j^{TM}(p_j^{TM}(\varphi), \lambda_j^{TM}(\varphi)) < r_j^{NoTM}(p_j^{NoTM}(\varphi), \lambda_j^{NoTM}(\varphi)). \tag{1.116}$$

Proof. I show this proposition step by step.

- $\lambda_j^{TM}(\varphi) \leq \lambda_j^{NoTM}(\varphi)$

  In order to show this, I denote the two cutoff, $\varphi_{\#}^{NoTM}$ which is the highest productivity of a firm without a trademark to offer $\underline{\lambda}$ and $\varphi_{\#}^{TM}$ which is the highest productivity of a firm with a trademark to offer $\underline{\lambda}$, respectively. $\varphi_{\#}^{TM}$ and $\varphi_{\#}^{NoTM}$ are as follows.

$$\underline{\lambda} = [\tfrac{1-\beta}{\alpha}(\tfrac{\sigma-1}{\sigma})^{\sigma}(\tfrac{\varphi_{\#}^{TM}}{c})^{\sigma-1}\tfrac{\xi}{f}P^{\sigma-1}E]^{\frac{1}{\alpha-(1-\beta)(\sigma-1)}} \iff \varphi_{\#}^{TM} = c[\tfrac{1-\beta}{\alpha}(\tfrac{\sigma-1}{\sigma})^{\sigma}\tfrac{\xi}{f}P^{\sigma-1}E]^{\frac{-1}{\sigma-1}}\underline{\lambda}^{\frac{\alpha-(1-\beta)(\sigma-1)}{\sigma-1}}. \tag{1.117}$$

$$\underline{\lambda} = [(\tfrac{1}{1-p}\tfrac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}})^{-\sigma}(\tfrac{\varphi_{\#}^{NoTM}}{c})^{\sigma-1}(\tfrac{1-\beta}{\alpha}P^{\sigma-1}E\tfrac{\xi}{f})]^{\frac{1}{\alpha-(\sigma-1)(1-\beta)}} \iff \varphi_{\#}^{NoTM} = c[\tfrac{1-\beta}{\alpha}(\tfrac{1}{1-p}\tfrac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}})^{-\sigma}\tfrac{\xi}{f}P^{\sigma-1}E]^{\frac{-1}{\sigma-1}}\underline{\lambda}^{\frac{\alpha-(1-\beta)(\sigma-1)}{\sigma-1}}. \tag{1.118}$$

  Since $\frac{\sigma}{\sigma-1} > \frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$, $\varphi_{\#}^{TM} > \varphi_{\#}^{NoTM}$. From this, I consider three cases.

  - Case 1: $\varphi \leq \varphi_{\#}^{NoTM}$

$$\lambda_j^{TM}(\varphi) = \lambda_j^{NoTM}(\varphi) = \underline{\lambda}. \tag{1.119}$$

  - Case 2: $\varphi_{\#}^{NoTM} < \varphi \leq \varphi_{\#}^{TM}$

    Since $\lambda_j^{NoTM}(\varphi)$ starts at $\underline{\lambda}$ and it is an increasing function within this range of φ,

$$\lambda_j^{TM}(\varphi) = \underline{\lambda} \leq \lambda_j^{NoTM}(\varphi). \tag{1.120}$$

  - Case 3: $\varphi_{\#}^{TM} < \varphi$

$$\begin{aligned}\lambda_j^{NoTM}(\varphi) &= [(\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}})^{-\sigma}(\frac{\varphi}{c})^{\sigma-1}(\frac{1-\beta}{\alpha}P^{\sigma-1}E\frac{\xi}{f})]^{\frac{1}{\alpha-(\sigma-1)(1-\beta)}} \\ &> [\tfrac{1-\beta}{\alpha}(\tfrac{\sigma-1}{\sigma})^{\sigma}(\tfrac{\varphi}{c})^{\sigma-1}\tfrac{\xi}{f}P^{\sigma-1}E]^{\frac{1}{\alpha-(1-\beta)(\sigma-1)}} \quad (\because \tfrac{\sigma}{\sigma-1} > \tfrac{1}{1-p}\tfrac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}) \\ &= \lambda_j^{TM}(\varphi).\end{aligned} \tag{1.121}$$

    From these three cases, I show that $\lambda_j^{TM}(\varphi) \leq \lambda_j^{NoTM}(\varphi)$.

- $p_j^{TM}(\varphi) \geq p_j^{NoTM}(\varphi)$

– Case 1: $\varphi \leq \varphi_{\#}^{NoTM}$

$$\begin{aligned} &\frac{p_j^{TM}(\varphi)}{\lambda_j^{TM}(\varphi)} > \frac{p_j^{NoTM}(\varphi)}{\lambda_j^{NoTM}(\varphi)} \\ \Longleftrightarrow\ &p_j^{TM}(\varphi) > p_j^{NoTM}(\varphi) \quad (\because \lambda_j^{TM}(\varphi) = \lambda_j^{NoTM}(\varphi) = \underline{\lambda}). \end{aligned} \tag{1.122}$$

– Case 2: $\varphi_{\#}^{TM} < \varphi$

$$\begin{aligned} p_j^{TM}(\varphi) &= (\frac{\sigma}{\sigma-1})^{\frac{\alpha-\beta-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{c}{\varphi})^{\frac{\alpha-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{\beta}{\alpha-(1-\beta)(\sigma-1)}} \\ &\lesseqgtr (\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}})^{\frac{\alpha-\beta-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{c}{\varphi})^{\frac{\alpha-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}P^{\sigma-1}E]^{\frac{\beta}{\alpha-(1-\beta)(\sigma-1)}} \\ &= p_j^{NoTM}(\varphi). \end{aligned} \tag{1.123}$$

Although I know $\frac{\sigma}{\sigma-1} > \frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$, I do not know the sign of $\alpha - \beta - (\sigma - 1)$. Therefore, it is ambiguous.

– Case 3: $\varphi_{\#}^{NoTM} < \varphi \leq \varphi_{\#}^{TM}$

Although $p_j^{TM}(\varphi) > p_j^{NoTM}(\varphi)$ if φ is close to $\varphi_{\#}^{NoTM}$, I also know that $p_j^{TM}(\varphi) \lesseqgtr p_j^{NoTM}(\varphi)$ if φ is close to $\varphi_{\#}^{TM}$ from Case 2. Therefore, within this range of φ, it is ambiguous.

- $q_j^{TM}(\varphi) \geq q_j^{NoTM}(\varphi)$

– Case 1: $\varphi \leq \varphi_{\#}^{NoTM}$

$$\begin{aligned} q_j^{TM}(\varphi) &= p_j^{TM}(\varphi)^{-\sigma}\lambda_j^{TM}(\varphi)^{\sigma-1}P^{\sigma-1}E \\ &= p_j^{TM}(\varphi)^{-\sigma}\underline{\lambda}^{\sigma-1}P^{\sigma-1}E \\ &< p_j^{NoTM}(\varphi)^{-\sigma}\underline{\lambda}^{\sigma-1}P^{\sigma-1}E \quad (\because p_j^{TM} > p_j^{NoTM}) \\ &= q_j^{NoTM}(\varphi). \end{aligned} \tag{1.124}$$

– Case 2: $\varphi_{\#}^{NoTM} < \varphi \leq \varphi_{\#}^{TM}$

$$\begin{aligned} q_j^{TM}(\varphi) &= (\frac{\sigma-1}{\sigma}\frac{\varphi}{c})^{\sigma}\underline{\lambda}^{(1-\beta)\sigma-1}P^{\sigma-1}E \\ &< [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{-\sigma}(\frac{\varphi}{c})^{\sigma}\underline{\lambda}^{(1-\beta)\sigma-1}P^{\sigma-1}E \\ &< [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{-\sigma}(\frac{\varphi}{c})^{\sigma}\lambda_j^{NoTM}(\varphi)^{(1-\beta)\sigma-1}P^{\sigma-1}E \\ &= [\tfrac{1}{1-p}\tfrac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma(\alpha-\beta)}{\alpha-(\sigma-1)(1-\beta)}}[\tfrac{\varphi}{c}]^{\frac{\alpha\sigma-(\sigma-1)}{\alpha-(\sigma-1)(1-\beta)}}[\tfrac{1-\beta}{\alpha}\tfrac{\xi}{f}]^{\frac{(1-\beta)\sigma-1}{\alpha-(\sigma-1)(1-\beta)}}(P^{\sigma-1}E)^{\frac{(1-\beta)\sigma}{\alpha-(\sigma-1)(1-\beta)}} \\ &= q_j^{NoTM}(\varphi). \end{aligned} \tag{1.125}$$

– Case 3: $\varphi_{\#}^{TM} < \varphi$

$$\begin{aligned} q_j^{TM}(\varphi) &= (\frac{\sigma-1}{\sigma})^{\frac{\sigma(\alpha-\beta)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi}{c})^{\frac{\alpha\sigma-(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(P^{\sigma-1}E)^{\frac{(1-\beta)\sigma}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}]^{\frac{(1-\beta)\sigma-1}{\alpha-(1-\beta)(\sigma-1)}} \\ &< [\tfrac{1}{1-p}\tfrac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma(\alpha-\beta)}{\alpha-(\sigma-1)(1-\beta)}}[\tfrac{\varphi}{c}]^{\frac{\alpha\sigma-(\sigma-1)}{\alpha-(\sigma-1)(1-\beta)}}(P^{\sigma-1}E)^{\frac{(1-\beta)\sigma}{\alpha-(\sigma-1)(1-\beta)}}[\tfrac{1-\beta}{\alpha}\tfrac{\xi}{f}]^{\frac{(1-\beta)\sigma-1}{\alpha-(\sigma-1)(1-\beta)}} \\ &= q_j^{NoTM}(\varphi). \end{aligned} \tag{1.126}$$

- $r_j^{TM}(p_j^{TM}(\varphi), \lambda_j^{TM}(\varphi)) \leq r_j^{NoTM}(p_j^{NoTM}(\varphi), \lambda_j^{NoTM}(\varphi))$

$$\begin{aligned} r_j^{TM}(p_j^{TM}(\varphi), \lambda_j^{TM}(\varphi)) &= [\frac{p_j^{TM}(\varphi)}{\lambda_j^{TM}(\varphi)}]^{1-\sigma}P^{\sigma-1}E \\ &< [\frac{p_j^{NoTM}(\varphi)}{\lambda_j^{NoTM}(\varphi)}]^{1-\sigma}P^{\sigma-1}E \quad (\because \frac{p_j^{TM}(\varphi)}{\lambda_j^{TM}(\varphi)} > \frac{p_j^{NoTM}(\varphi)}{\lambda_j^{NoTM}(\varphi)}) \\ &= r_j^{NoTM}(p_j^{NoTM}(\varphi), \lambda_j^{NoTM}(\varphi)). \end{aligned} \tag{1.127}$$

□

With a trademark, no counterfeit producer enters in the market and an authentic producer can capture the whole market power. Due to no competition, an authentic producer does not have to attract customers by offering higher quality and it has less incentive to provide high quality. Although the marginal costs decreases, it has the whole market power and increases its markup. Thus, the effect of a trademark on the unit-price is ambiguous. Finally, with a trademark, it sets the higher quality-adjusted price. As a result, the quantity and revenue decrease.

Then, I examine the sorting process of which firm uses a trademark. The relationship between a firm's productivity and its trademark use in this mechanism is explained in the next proposition.

Proposition 7.

$$\pi_j^{TM}(p_j^{TM}(\varphi), \lambda_j^{TM}(\varphi)) \geq \pi_j^{NoTM}(p_j^{NoTM(\varphi)}, \lambda_j^{NoTM}(\varphi)) \quad for \quad all \quad \varphi \geq \varphi^{TM}, \tag{1.128}$$

where φ^{TM} *satisfies* $\pi_j^{TM}(p_j^{TM}(\varphi^{TM}), \lambda_j^{TM}(\varphi^{TM})) = \pi_j^{NoTM}(p_j^{NoTM}(\varphi^{TM}), \lambda_j^{NoTM}(\varphi^{TM}))$.

Proof.

$$\pi_j^{TM} - \pi_j^{NoTM} = A \times (\frac{1-\beta}{\alpha}\frac{\xi}{f})^{\frac{(\sigma-1)(1-\beta)}{\alpha-(\sigma-1)(1-\beta)}}(\frac{\varphi}{c})^{\frac{\alpha(\sigma-1)}{\alpha-(\sigma-1)(1-\beta)}}(P^{\sigma-1}E)^{\frac{\alpha}{\alpha-(\sigma-1)(1-\beta)}} - F_{TM}, \tag{1.129}$$

where $A = [(\frac{1-\beta}{\alpha})(\frac{\sigma-1}{\sigma})^{\frac{\alpha\sigma}{\alpha-(\sigma-1)(1-\beta)}}(\frac{\alpha-(\sigma-1)(1-\beta)}{(\sigma-1)(1-\beta)}) - \frac{\alpha-\beta+1}{\alpha}(\frac{1}{1-p}\gamma^{\frac{\alpha}{\alpha-\beta+1}} - 1)(\frac{1}{1-p}\frac{\alpha}{\alpha-\beta+1}\gamma^{\frac{\alpha}{\alpha-\beta+1}})^{\frac{-\alpha\sigma}{\alpha-(\sigma-1)(1-\beta)}}]$. Since $\frac{\sigma}{\sigma-1} > \frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}$, A is always positive, and $\pi_j^{TM} - \pi_j^{NoTM}$ is an increasing function with respect to φ. □

Since an authentic producer with a trademark excludes a counterfeit producer from the market and the market becomes a monopoly, the profit increases with a trademark. However, to earn this higher profit, it needs to incur the cost of obtaining a trademark. If it is less productive, it cannot sell sufficient quantities to cover the fixed cost. Therefore, only productive firms use a trademark to protect their products from counterfeit products and to earn higher profits, and there is a positive correlation between a firm's productivity and its trademark use in the mechanism.

To derive the closed economy equilibrium, I state the conditions for the exit and trademark usage as functions of the exit cutoff, φ^*, and the trademark cutoff, φ^{TM}. In this case, for simplicity, I assume that every surviving firm produces quality, λ_i, which is above the requirement threshold, $\underline{\lambda}$.[21] As I do in the information frictions problem, I assume $\varphi^{TM} > \varphi^*$, which is consistent with my empirical findings.[22] At the exit cutoff φ^*, the firm's profit is zero and the following condition holds.

$$\pi_j^{NoTM}(\varphi^*) = 0 \iff B[(\frac{\varphi^*}{c})^{\sigma-1}P^{\sigma-1}E]^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}]^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} - F_0 = 0, \tag{1.130}$$

[21] Without this assumption, I can get the same predictions.

[22] The same assumption is also made in Bustos (2011). I can support this assumption under further conditions.

where $B = [\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}} - 1][\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma\alpha}{\alpha-(1-\beta)(\sigma-1)}}$. At the trademark cutoff φ^{TM}, the firm's profit is indifferent with and without a trademark, $\pi_j^{TM}(\varphi^{TM}) = \pi_j^{NoTM}(\varphi^{TM})$. I show that φ^{TM} is a function of φ^* and that φ^{TM} and φ^* satisfy the following condition.

$$\pi_j^{TM}(\varphi^{TM}) = \pi_j^{NoTM}(\varphi^{TM}) \iff C(\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}F_0 - F_{TM} = (\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}F_0, \tag{1.131}$$

where $C = \frac{(\frac{\sigma-1}{\sigma})^{\frac{\alpha\sigma}{\alpha-(1-\beta)(\sigma-1)}}(\frac{1-\beta}{\alpha})(\frac{\alpha-(1-\beta)(\sigma-1)}{(1-\beta)(\sigma-1)})}{[\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}-1][\frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}]^{\frac{-\sigma\alpha}{\alpha-(1-\beta)(\sigma-1)}}}$. As in Melitz (2003), the average expected profit level, $\overline{\pi}$, and the exit cutoff, φ^* is determined by the free entry condition and zero cutoff profit conditions.

$$\overline{\pi} = \frac{1}{1-G(\varphi^*)}[\int_{\varphi^*}^{\varphi^{TM}} \pi^{NoTM}(\varphi)dG(\varphi) + \int_{\varphi^{TM}}^{\infty} \pi^{TM}(\varphi)dG(\varphi)], \tag{1.132}$$

$$\overline{\pi} = \frac{\delta f_e}{1-G(\varphi^*)}, \tag{1.133}$$

where f_e is the required cost for entry and $G(\varphi)$ is a cumulative distribution of productivity φ. I assume that $G(\varphi)$ follows a Pareto productivity distribution with $G(\varphi) = 1-\varphi_{min}^k\varphi^{-k}$. With this assumption, I explain $\overline{\pi}$ as follows.[23]

$$\overline{\pi} = \frac{kF_0}{k-\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}[1-(\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-k}] + \frac{kCF_0}{k-\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}(\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-k} - F_0 - F_{TM}(\frac{\varphi^{TM}}{\varphi^*})^{-k}. \tag{1.134}$$

With the assumption of Pareto productivity distribution, I describe φ^* as a function of $\overline{\pi}$:

$$\varphi^* = (\frac{\overline{\pi}}{\delta f_e})^{\frac{1}{k}}. \tag{1.135}$$

I analyze the impact of the cost of obtaining a trademark on the economy. I show how a reduction in the cost, F_{TM}, affects the entry of firms at an intensive margin and their behaviors at an intensive margin in a general equilibrium framework.

Proposition 8. *When F_{TM} increases,*

1. *The fraction of surviving of firms that use a trademark, $(\frac{\varphi^{TM}}{\varphi^*})^{-k}$, decreases, that is, $\frac{\partial\frac{\varphi^{TM}}{\varphi^*}}{\partial F_{TM}} > 0$.*

2. *Expected Profit decreases, that is, $\frac{\partial\overline{\pi}}{\partial F_{TM}} < 0$.*

3. *The exit cutoff decreases, that is, $\frac{\partial\varphi^*}{\partial F_{TM}} < 0$.*

[23]For the average expected profit to be positive, the condition $k - \frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)} > 0$ is required.

4. *The aggregate price index increases, that is,* $\frac{\partial P}{\partial F_{TM}} > 0$.

5. *Unit Price, quality, quantity, revenue and profit without a trademark increases, that is,* $\frac{\partial p_j^{NoTM}}{\partial F_{TM}} > 0$, $\frac{\partial \lambda_j^{NoTM}}{\partial F_{TM}} > 0$, $\frac{\partial q_j^{NoTM}}{\partial F_{TM}} > 0$, $\frac{\partial r_j^{NoTM}}{\partial F_{TM}} > 0$, *and* $\frac{\partial \pi_j^{NoTM}}{\partial F_{TM}} > 0$.

6. *Welfare decreases, that is,* $\frac{\partial W}{\partial F_{TM}} < 0$.

Proof. From the trademark usage cutoff condition, $\pi_j^{TM}(\varphi^{TM}) = \pi_j^{NoTM}(\varphi^{TM})$,

$$\frac{\partial \frac{\varphi^{TM}}{\varphi^*}}{\partial F_{TM}} = \frac{1}{(C-1)F_0(\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}-1}}. \tag{1.136}$$

From the proposition (7), I know that $C > 1$. Therefore, I can derive $\frac{\partial \frac{\varphi^{TM}}{\varphi^*}}{\partial F_{TM}}$¿0. Next, I show $\frac{\partial \overline{\pi}}{\partial F_{TM}} < 0$. Before $\frac{\partial \overline{\pi}}{\partial F_{TM}}$, I derive $\frac{\partial \overline{\pi}}{\partial \frac{\varphi^{TM}}{\varphi^*}}$.

$$\frac{\partial \overline{\pi}}{\partial \frac{\varphi^{TM}}{\varphi^*}} = -k(\frac{\varphi^{TM}}{\varphi^*})^{k-1}[C(\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}F_0 - F_{TM} - (\frac{\varphi^{TM}}{\varphi^*})^{\frac{\alpha(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}}F_0] = 0. \tag{1.137}$$

From this, $\frac{\partial \overline{\pi}}{\partial F_{TM}}$ is as follows.

$$\begin{aligned} \frac{\partial \overline{\pi}}{\partial F_{TM}} &= -(\frac{\varphi^{TM}}{\varphi^*})^{-k} + \underbrace{\frac{\partial \overline{\pi}}{\partial \frac{\varphi^{TM}}{\varphi^*}}}_{=0} \frac{\partial \frac{\varphi^{TM}}{\varphi^*}}{\partial F_{TM}} \\ &= -(\frac{\varphi^{TM}}{\varphi^*})^{-k} \\ &< 0. \end{aligned} \tag{1.138}$$

From (1.138),

$$\begin{aligned} \frac{\partial \varphi^*}{\partial F_{TM}} &= \frac{1}{k\delta f_e}\frac{\partial \overline{\pi}}{\partial F_{TM}}(\frac{\overline{\pi}}{\delta f_e})^{\frac{1}{k}-1} \\ &< 0. \end{aligned} \tag{1.139}$$

From the exit cutoff condition, $B[(\frac{\varphi^*}{c})^{\sigma-1}P^{\sigma-1}E]^{\frac{\alpha}{\alpha-(1-\beta)(\sigma-1)}}[\frac{1-\beta}{\alpha}\frac{\xi}{f}]^{\frac{(1-\beta)(\sigma-1)}{\alpha-(1-\beta)(\sigma-1)}} - F_0 = 0$. Since $\frac{\partial \varphi^*}{\partial F_{TM}} < 0$, $\frac{\partial P}{\partial F_{TM}} > 0$. Since p_j^{NoTM}, λ_j^{NoTM}, q_j^{NoTM}, q_j^{NoTM} and π_j^{NoTM} are increasing functions with respect to P, $\frac{\partial p_j^{NoTM}}{\partial F_{TM}} > 0$, $\frac{\partial \lambda_j^{NoTM}}{\partial F_{TM}} > 0$, $\frac{\partial q_j^{NoTM}}{\partial F_{TM}} > 0$, $\frac{\partial r_j^{NoTM}}{\partial F_{TM}} > 0$, and $\frac{\partial \pi_j^{NoTM}}{\partial F_{TM}} > 0$. Finally, since welfare is defined as $W = \frac{E}{P}$ in this economy and $\frac{\partial P}{\partial F_{TM}} > 0$, $\frac{\partial W}{\partial F_{TM}} < 0$.

□

When the cost of obtaining a trademark declines, firms are more likely to use a trademark and this increases their average expected profit. Then, the zero cutoff profit condition moves rightward, and the exit cutoff, φ^*, increases and the least productive firm decides to exit the market. As the least productive firm exits, the aggregate quality-adjusted price index decreases and a firm without a trademark decrease quality. As the marginal costs decrease, the unit-price also decreases. Finally, a decrease in the aggregate quality-adjusted price index leads to a decrease in quantity sold and revenue of a firm without a trademark.

1.C.2 Testable Predictions

In this subsection, I show that my empirical findings are based on the signaling device mechanism. From the theoretical side, I test several predictions.

First, I predict that a firm with a trademark decreases its quantity and revenue in an alternative hypothesis. This prediction is at odds with my empirical findings because a firm with a trademark increases its quantity and revenue due to quality upgrading from Table 1.5.

Second, I get a different prediction on the quality-adjusted price of non-trademark users, $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}}$ and trademark users. In the signaling device mechanism, $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}} = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta-1}$ and it does not change even when the cost of applying for a trademark decreases. On the other hand, in the protection mechanism, $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}} = \frac{1}{1-p}\frac{\alpha-\beta+1}{\alpha}\gamma^{\frac{\alpha}{\alpha-\beta+1}}\frac{c}{\varphi}(\lambda_j^{NoTM})^{\beta-1}$. Since λ_j^{NoTM} decreases in the protection mechanism, $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}}$ increases. I use the estimate of quality, λ_i, following Khandelwal et al. (2013) and check which mechanism is true for $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}}$. Table 1.C.1 reports the empirical analyses. On average, Chinese exporters statistically significantly decrease its quality-adjusted price by 8.27%. In addition, the effect is different among exporters due to their positions in each targeting country and exporting strategies . If a firm was one of the best 3 or best 10 exporters in country c in 2014, it decreases its adjusted price statistically significantly by 7.81% or 8.75%. The result in columns (3) shows that if a firm exported more than a half of the total export to OAPI countries in 2014, it decreases its quality by 5.75%. These finding are at odds with the prediction in the protection mechanism because a firm uses a trademark to become a monopolist and to increase its quality-adjusted price.

Third, I get a different prediction on the quality-adjusted quantity, $\lambda_j^{NoTM} q_j^{NoTM}$, of a firm. In the signaling device mechanism, a firm with a trademark upgrades quality and sells more quantities, the quality-adjusted quantity increases. On the other hand, in the protection mechanism, a firm with a trademark excludes a counterfeit producer from the market and increases its quality-adjusted price $\frac{p_j^{NoTM}}{\lambda_j^{NoTM}}$, which leads to decrease in $\lambda_j^{NoTM} q_j^{NoTM}$. Table 1.C.2 checks these predictions. On average, Chinese exporters neither increase nor decrease its quality-adjusted quantity statistically significantly. In addition, the effect is different among exporters due to their positions in each targeting country and exporting strategies . If a firm was one of the best 3 or best 10 exporters in country c in 2014, it increases its adjusted quantity by 34.3% or 33.1%. The result in columns (3) shows that if a firm exported more than a half of the total export to OAPI countries in 2014, it decreases its quality by 33.6%. These also supports the signaling device mechanism.

Table 1.C.1: Intensive Margin: Quality-Adjusted Price

VARIABLES	(1)	(2)	(3)
	ln(Quality-Adjusted Quantity)		
$OAPI_c \times After_t$	-0.0827***	-0.0480**	-0.0626**
	(0.0234)	(0.0177)	(0.0274)
$OAPI_c \times After_t \times$ Best 15_{ic}		0.0135	
		(0.0497)	
$OAPI_c \times After_t \times$ Best 10_{ic}		-0.0781***	
		(0.0270)	
$OAPI_c \times After_t \times$ Best 3_{ic}		-0.0875***	
		(0.0306)	
$OAPI_c \times After_t \times \mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$			-0.0575**
			(0.0238)
Mean of Dependent Variable		0.880	
Firm FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Export Information	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes
Firm $\times$ Time FE	Yes	Yes	Yes
R-squared	0.487	0.537	0.501

Note: Country-clustered standard errors are in parentheses. The observation is restricted to a combination of i, c and t where firm i exports its tire in 2014 and 2015 or 2016. Quality is calculated by following Khandelwal et al. (2013). $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after the 1st of March in 2015. Best 3_{ic} is a dummy variable which takes 1 if firm i was one of the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was one of the best 10 exporters in country c in 2014 and Best 15_{ic} is a dummy variable which takes 1 if firm i was one of the best 15 exporters in country c in 2014. $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of the total export of firm i was exported into OAPI countries in 2014. Export Information includes the Chinese port at which a Chinese company exports and the countries at which a Chinese company transits. Export Information includes the Chinese port at which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports and the log of total imports.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 1.C.2: Intensive Margin: Quality-Adjusted Quantity

	(1)	(2)	(3)
VARIABLES	ln(Quality-Adjusted Quantity)		
$OAPI_c \times After_t$	-0.0518	-0.159*	-0.174**
	(0.0544)	(0.0812)	(0.0773)
$OAPI_c \times After_t \times$ Best 15_{ic}		-0.248	
		(0.236)	
$OAPI_c \times After_t \times$ Best 10_{ic}		0.343**	
		(0.146)	
$OAPI_c \times After_t \times$ Best 3_{ic}		0.331**	
		(0.154)	
$OAPI_c \times After_t \times \mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$			0.336***
			(0.111)
Mean of Dependent Variable		9.891	
Firm FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Export Information	Yes	Yes	Yes
Macroeconomic Variables	Yes	Yes	Yes
Firm × Time FE	Yes	Yes	Yes
R-squared	0.534	0.574	0.552

Note: Country-clustered standard errors are in parentheses. The observation is restricted to a combination of i, c and t where firm i exports its tire in 2014 and 2015 or 2016. Quality is calculated by following Khandelwal et al. (2013). $OAPI_c$ takes 1 if country c belongs to the Organisation Africaine de la Propriété Intellectuelle. $After_t$ takes 1 if time t is after the 1st of March in 2015. Best 3_{ic} is a dummy variable which takes 1 if firm i was one of the best 3 exporters in country c in 2014, Best 10_{ic} is a dummy variable which takes 1 if firm i was one of the best 10 exporters in country c in 2014 and Best 15_{ic} is a dummy variable which takes 1 if firm i was one of the best 15 exporters in country c in 2014. $\mathbb{1}\{\text{OAPI Share}_i \geq 50\%\}$ is a dummy variable which takes 1 if more than a half of the total export of firm i was exported into OAPI countries in 2014. Export Information includes the Chinese port at which a Chinese company exports and the countries at which a Chinese company transits. Export Information includes the Chinese port at which a Chinese company exports and the countries through which a Chinese company transits. Macroeconomic variables include the log of GDP, the log of total population, the log of total exports and the log of total imports.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Chapter 2

Global Supply Chain and Corporate Environmental Responsibility

2.1 Introduction

Over the past few decades, global trade has been transformed, and the production of a good or service has been coordinated across countries. According to The World Bank (2020) and Antràs (2021), global value chains (GVCs) expanded rapidly until 2008, and GVCs account for roughly 50% of global trade. Since the growth of international trade has had enormous effects on development in developing countries, GVCs have been recognized as a tool to eradicate poverty in developing countries and linking small farmers in developing countries to multinationals seems a crucial tool to lift millions out of poverty.

Although the linkage in the global supply chain (GSC) seems beneficial to local people in developing countries, the reality is ambiguous. Since a firm selling goods and services to consumers in developed countries often relies on labor and environmental resources in developing countries where local regulations are weak, a multinational in the supply chain also might relocate the process of production from developed countries to developing countries, which involves high emission of pollutants, and employ environmentally unfriendly practices, while it contributes to the eradication of poverty. This is known as the pollution haven hypothesis. On the other hand, environmental concerns associated with globalization may be alleviated in the GSC. Recently, consumers in developed countries have been demanding more environmentally friendly products and stakeholders have been increasingly interested in accountability from multinationals on their environmental practices. Since a leading multinational has its brand reputation to protect, with regards to the demands of customers and stakeholders, it pays much attention to its supply chain. Especially, it introduces the corporate environmental responsibility (CER)[1] and promotes environmentally friendly practices along the supply chain and oversees how its local partner follows environmental standards. I am interested in three questions: (1) Does a leading multinational in the GSC put pressure on the local partner's environmental practices?, (2) Is the role of a supplier in the GSC related?, and (3) what characteristic of a leading multinational affects the pressure? To empirically answer these questions has been challenged by a lack of data and a wide array of endogeneity problems. Understanding the effect of being in the GSC requires data on which firm is linked to a multinational, which has been absent in developing countries. Moreover, as the local firm in the GSC endogenously determine their pollutants emitted, it is difficult for researchers to identify the causal effects.

This paper provides empirical evidence on the relationship between the GSC and the local partner's environmental practices. My empirical analysis is based on the context of local partners in China. This context presents several features that allow my analysis. First, in 2018, China introduced a new environmental tax policy, which levied a tax on businesses and public institutions that discharged pollutants. Since this tax revenue is a part of the provincial fiscal income, the local provincial governments have the autonomy to set their different tax rates. This provincial difference allows me to identify how a firm in China causally responds to a different tax rate. Second, I use the dataset from the Institute of Public & Environmental Affairs (IPE). The IPE is a non-profit environmental research organization in China that builds a database of environmental information by collecting, collating and analyzing government and corporate environmental information. This database allows me to collect valuable information on the pollutants released and the characteristics of a leading multinational in the GSC and its local partner in China.

Section 2.2 describes the institutional setting in China. While China has achieved tremendous economic growth and been among the world's fastest-growing economies, it has also brought environmental costs. Various forms of pollution, including air and water pollution, have increased as China has industrialized, and they have caused widespread environmental health problems. Facing the growing industrial pollution and health problems, the

[1] CER is a part of corporate social responsibility (CSR) and CSR is widely studied in Besley and Ghatak (2007), Bénabou and Tirole (2010), O'Rourke (2014), Masulis and Reza (2015), and Ferrell et al. (2016).

Chinese central government has initiated attempts to reduce environmental pollution.

Until recently, the Chinese central government initiated several attempts to reduce environmental pollution by focusing on (1) concentration controls, which required industrial facilities to control for pollution concentrations and to follow national pollution control standards and (2) emissions target controls, which set compulsory emissions caps as well as reduction targets of regulated pollutants. One of the policies implemented by the central government was a pollutant discharge fee policy, which required firms emitting pollutants to pay a fixed fee amount. While the primary goal of this fee was to mitigate environmental problems, its implementation was not effective due to political reasons.

To overcome this failure, the Chinese National People's Congress issued a new environmental protection tax law in 2016 and put the law into force in 2018. The tax, in general, follows the previous system of pollutant discharge fees but differentiates itself from the fee in the following three aspects. First, under the system, local authorities collect 100 percent of the tax revenue, and the local tax authorities collect the tax by themselves, which incentivizes the local authorities. Second, the violating cost for failure to pay is also enhanced by the law. Under the tax system, failure to pay can result in a fine of up to five times the tax amount. Third, local authorities are also given a certain amount of discretion regarding the tax rate. They can decide what tax rate is applicable for each kind of pollutant, within a range presented by the central government. These features allow me to exploit the different provincial environmental tax rates and investigate how Chinese firms respond to this reform.

My analysis proceeds in four steps. In the first step, I examine the effect of the tax rate on the environmental practices of a local firm. On average, local firms respond to the environmental tax and emit the same amount of pollutants as before the introduction of the environmental tax. I also study whether the environmental tax hurts their economic activity. Since they do not respond to the environmental tax in general, the tax does not affect their revenue and water used. These findings imply that the tax does not incentivize local firms in China or that it is difficult for them to adjust to the tax in the timeframe of a few years.

In the second step, I discuss whether the effect of the environmental tax is heterogeneous across buyers. Especially, I compare how environmental practices are different between local firms with and without being linked to the GSC. Local firms without being linked to the GCS neither change their environmental practices nor economic activities. In contrast, local suppliers being linked to the GCS improve their environmental practices and decrease their pollutants. Furthermore, they expand their economic activities and increase their revenue. My empirical results indicate that global buyers put pressure regarding environmental practices on local firms by incentivizing them in heavily taxed provinces.

In the third step, I identify which firms in the global supply chain are affected by the policy. In the global supply chain, firms are categorized into two groups. Tier 1 producers are those supplying final products for buyers. In contrast, tier 2 producers are those supplying intermediate products for tier 1 producers. I find that the effect of the environmental tax is different between tier 1 and tier 2 producers. The response to the environmental tax is concentrated among tier 2 suppliers. While tier 1 suppliers of global buyers do not respond to the tax in terms of their pollutants and economic activities, tier 2 producers decrease their pollutants and increase their revenue in heavily taxed provinces. These results imply that tier 1 suppliers already display significantly lower levels of pollution before the tax reform and that there is still room for tier 2 producers to decrease their pollution.

In the fourth step, I examine whether global buyers play a role in environmental protection. For this analysis, I use two pieces of information on leading multinationals. The first one is the Corporate Information Transparency Index developed by the IPE, which is a quantitative assessment based on a multinational's environmental management of its supply chain in China. The second one is whether leading multinationals require their suppliers to employ a new environmental management practice after the environmental tax law was enforced. The result shows that a firm being linked to the GSC with high corporate environmental responsibility leads it to put more efforts into decreasing its emission of the pollutants into water. Moreover, I find out that the effects of the tax rate are mainly from a firm employing a new management practice requested by leading multinationals. These results suggest that the corporate environmental responsibility of global buyers being associated with higher environmental standards play a significant role in complementing host countries' policies aimed at curbing pollution.

These findings in the previous steps imply a conflict of interest between multinationals and their local partners. Since CSR influences consumers' purchase decisions and increases their willingness to pay (Kitzmueller and Shimshack, 2012), the multinationals expect the demand increase from these consumers and put pressure on the local firms regarding employing a new environmentally friendly technique and/or management practice.

Under the pollution discharge fee scheme, the implementation was not effective due to political reasons and the local firms were not concerned about their emission of pollutants.

Thus, since employing a new environmentally friendly technique and/or management practice just increases the technique/management adoption costs, the local firms in the GSCs faced the conflict of interest and did not have incentives to respond to their requests.

However, under the current scheme from the pollution discharge fee system to the environmental tax system, the enforcement is enhanced and the polluting firms actually have to pay cost of pollution as taxes. Therefore, since the technique and management practice decrease their pollutants and taxes to pay as a result, the local firms in the GSCs have incentives to employ them, and their incentives are larger in heavily taxed provinces.

In the last step, I examine whether my empirical findings in the previous steps capture spurious impacts. As explained in Section 2.2, local authorities decided the tax rate based on the local socioeconomic context and the polluting firm's situation. Thus, there is a concern that my empirical analysis might suffer from different provincial macroeconomic and political trends. To strengthen my argument further, I check this possibility by investigating dynamic patterns in the pollutants across provinces. For the provincial pollutants, I collect data from the China Statistical Yearbook on Environment. I find the absence of differential trends in all of the outcomes of interests before the introduction of the environmental tax across provinces. This result assuages the above-mentioned concern and shows the validity of my empirical findings in the first four steps.

This paper contributes to different strands of literature. First, this paper contributes to the literature on regulation and economic development. Although much literature has studied the role of regulation on economic development (Besley and Burgess, 2004, Amiti and Konings, 2007, Aghion et al., 2008, Hsieh and Klenow, Hsieh and Klenow, Khandelwal et al., 2013, and De Loecker et al., 2016), evidence on how environmental regulation affects economic development is limited. While He et al. (2020) studies the effect of water quality monitoring system and Fan et al. (2019) shows the effect of strict environmental regulation in China, this paper provides the effect of the environmental tax rate. Second, this paper contributes to the literature on environmental pollution in developing countries. Much literature has examined environmental practices in developing countries (Burgess et al., 2012, Greenstone and Hanna, 2014, Lipscomb and Mobarak, 2016, Tanaka and Teshima, 2017, and Duflo et al., 2018), my analysis adds to this literature in how the tax rate affects environmental pollution in developing countries. Third, this paper contributes to nascent literature on the Global Value Chain in developing countries related to Corporate Social Responsibility. Existing research focuses on the relationship between CSR and welfare/public goods (Dragusanu and Nunn, 2018, Macchiavello and Miquel-Florensa, 2019, and Boudreau, 2019). This is the first study, however, to test the relationship between CSR and environmental pollution in developing countries.

The rest of this paper is organized in the following way. Section 2.2 describes an institutional context and sudden changes of the member compositions. I present my empirical findings in Section 2.3. Section 2.4 concludes.

2.2 Empirical Settings

2.2.1 Economic Growth and Industrial Pollution in China

Since 1979, when economic liberalization began, China has achieved tremendous economic growth and been among the world's fastest-growing economies, with real annual gross domestic product (GDP) growth averaging 9.5% through 2018. Several market reforms contribute to this economic growth. One is reform of state-owned enterprises (SOEs). Based on the arguments that state-owned enterprises were connected to state favoritism and avoided competition, most of the local SOEs were sold into private hands, and the number of SOEs decreased by more than half from approximately 238,000 in 1998 to 116,000 in 2007. Accession into the WTO was also another key factor to economic growth. Due to reduced trade barriers such as tariffs and quotas, the allocation of resources became more efficient, and China's manufacturing sector experienced impressive productivity growth.

While China's economic growth has been sustainable, it has also brought environmental costs. Various forms of pollution, which include air and water pollution, have increased as China has industrialized and they have caused widespread environmental health problems. According to Zheng and Kahn (2017), $PM_{2.5}$ has become the primary air pollutant of concern in many large Chinese cities. In 2013, 99.6 percent of China's population was exposed to $PM_{2.5}$ exceeding the guideline level of the World Health Organization. Moreover, China's combination of coal-burning and rapid industrialization has increased sulfur dioxide (SO2) and nitrogen oxides, which can cause adverse effects on people's health and life expectancy. Water pollution is another serious environmental problem. According to the The World Bank (2007), in the 2000s, 25,000 km of Chinese rivers failed to meet the water quality standards for aquatic life, and about 90 percent of the sections of rivers around urban areas were seriously polluted. Roughly 70 percent of China's rivers also contained water deemed unsafe for human consumption. Severe water pollution has led to tremendous health costs, such as significantly increased rates of chronic intestinal infections and chronic health effects such as heart diseases and cancers.

2.2.2 Environmental Policy in the 9th−12th Five Year Plans

Facing the growing industrial pollution and health problems, the Chinese central government has started its attempts to reduce environmental pollution. In the 9th Five-Year Plan between 1996 and 2000, the government mainly focused on two strategies: (1) concentration controls, which required industrial facilities to control for pollution concentrations and to follow national pollution control standards and (2) emissions target controls, which set compulsory emissions caps as well as reduction targets of regulated pollutants. However, these efforts were not successful in reducing pollutant emissions in the 9th Five-Year Plan.

To overcome the failure in the 9th Five-Year Plan, in the 10th and 11th Five-Year Plan, the government set national reduction target controls. For example, for air and water pollution, the goal in the 10th Five Year Plan was that SO2 and chemical oxygen demand (COD) emissions were 10% lower than that of the baseline year 2000 and the aim in the 11th Year Plan was that SO2 and COD emissions were 10% lower than that of the baseline year 2005. Targets were assigned to provinces, cities, and counties and the goal statements on emissions reductions were signed between each provincial government and the government. Since the accomplishment directly affected the performance and promotion of heads of local governments, the local officials put much efforts into fulfilling their duties relating to the emissions mandates. As a result, due to these efforts, the 10% reduction target of two COD and SO2 was achieved.

Based on the success in the previous Five-Year Plan, the government set more stringent goals. For air and water pollution, the goal in the 12th Five Year Plan was that SO2 and COD emissions were 8% lower than that of the baseline year 2010. Furthermore, to supplement implementation to reduce pollutant emissions and to obtain reliable and high-frequency information on industrial emissions, the provincial officials required firms to use a new monitoring system and to upload hourly pollutant-specific concentration data to an online platform.

2.2.3 Environmental Protection Tax

Along with these environmental policies, China implemented a pollutant discharge fee policy, which required firms emitting pollutants to pay a fixed fee amount. The primary goal of this fee was to mitigate environmental problems, but its implementation was not effective due to political reasons. First, 10% of the fee collected was allocated to the central government, which reduced the local officer's incentive to collect the fee. Second, the fee was collected by the environmental officials, but the officials did not have much authority regarding the collection of fees, and its enforcement was weak. Third, the fee system made no distinction between light and heavy polluters, meaning that firms had no incentive to cut down on their emissions as they had to pay a uniform fee regardless. Fourth, since, under the fee system, failure to pay could result in a fine of up to only three times the fee. Moreover, given its weak enforcement, firms did not have an incentive to pay the fee.

In order to handle the problem caused by this system, the Chinese National People's Congress issued a new environmental protection tax law in 2016 and put the law into force in 2018. The newly passed environmental protection tax applies to the same four categories as the pollutant discharge fee, namely water pollution, air pollution, noise pollution, and solid wastes. The tax, in general, follows the previous system of pollutant discharge fees but differentiates itself from the fee in the following three aspects. First, local authorities are given more power to implement this system. Under the system, local authorities collect 100 percent of the tax revenue, and the local tax authorities collect the tax by themselves. This incentivizes the local authorities to put more effort into its collection. Second, the violating cost for failure to pay is also enhanced by the law and more serious for the polluting firms. Under the tax system, failure to pay can result in a fine up to five times the tax. Moreover, the failure of officials to meet the responsibilities of the punishment lose promotion opportunities and may even be punished with fines. Third, local authorities are also given a certain amount of discretion regarding the tax rate. They can decide what tax rate is applicable for each kind of pollutant, within a range presented by the central government. This flexibility allows for local governments to consider the local socioeconomic context and the polluting firm's situation.

Table 2.1 and 2.2 list the environmental tax rate in 2018 and 2019. From these tables, I find that there are large variations in the adopted environmental tax policies across local governments. For example, since Beijing and Tianjin implemented strict policies on environmental problems, the environmental tax rates on pollutants in these regions were quite high. In contrast,the environmental tax rates were low in areas like Liaoning and Jilin where environmental pollutants were not serious problems. Moreover, even in the regions where local governments imposed the same tax rate on one pollutant, the tax rate on other pollutants were different. Figure 2.1−2.4 show the maps of municipalities by the environmental tax rates. On these maps, I observe different tax rates not only in inner regions but also along coastal lines. Exploiting these environmental tax rates, I examine how firms responded to the tax reform.

2.2.4 Data Sources

For this study, I use two micro-level data sources: the Chinese Pollutant Release and Transfer Register (PRTR) Database and the Green Supply Chain Database. These two databases are from the Institute of Public & Environmental Affairs (IPE). The IPE is a non-profit environmental research organization in China and builds a database of environmental information by collecting, collating and analyzing government and corporate environmental information. I combine these two datasets for my empirical analyses.

PRTR Database

A pollutant release and transfer register (PRTR) is a system for collecting and disseminating information on emissions of hazardous substances to the environment. Hazardous substances include chemical substances and pollutants released to air, water and soil. The PRTR data collection methods for individual facility emissions typically utilize questionnaires sent to individual facilities or firms. The answers are validated upon receipt by the competent authorities and published as soon as they are available. The purpose of this system is the public disclosure of the names of key pollutants and characteristic pollutants, discharge mode, number and distribution of emissions outlets, emissions concentration and total volume, situations of emissions exceeding standards, as well as implemented pollutant emissions standards and approved emissions totals.

The IPE developed this PRTR system. The IPE's PRTR database includes a more comprehensive set of pollutants, including not only harmful chemicals, but also conventional pollutants, as well as water consumption, water efficiency, energy efficiency, and carbon emissions information.

Green Supply Chain Database

The IPE's Green Supply Chain database includes information on leading multinationals in China. In this dataset, a leading multinational discloses its supplier list, and I can link its supplier list to the environmental data. From the product scope of the supplier, I identify the position of each supplier in the supply chain. This dataset only includes two sets of Chinese firms: (i) the one without being linked to the GSC before and after the introduction of the environmental tax, and (ii) the one with being linked to the GSC before and after the tax policy. Thus, my empirical analysis sheds light on how two groups behave differently before and after the tax policy when multinationals in the GSC put pressure on their local partners' environmental practices on the intensive margin.

This database also includes the Corporate Information Transparency Index (CITI), which is a quantitative assessment based on a multinational's environmental management of its supply chain in China, jointly developed by the IPE and the Natural Resources Defense Council (NRDC) in 2013. The index uses government supervision data, online monitoring data, third party environmental audits, and other public information to assess dynamically the environmental performance of a multinational's supply chain. The evaluation examines the following five areas: (1) how the multinationals respond to environmental violations by suppliers, (2) how they screen their suppliers to ensure their environmental compliance, (3) whether they promote green supply chain expansion upstream to resolve high impact pollution issues, (4) whether they push suppliers to disclose energy conservation and emissions reduction targets, as well as pollution emissions transfer data, and (5) whether they push consumers to pay attention to the environmental impacts of product life-cycles. The score ranges from 0 to 100.

To carry out empirical analyses, I combine the 2015−2019 IPE's PRTR data with the IPE's Green Supply Chain data.

2.3 Empirical Findings

I exploit the different provincial environmental tax rate and look at the effect of the tax rate on the environmental practices of a firm at an overall level. First, I run the following regression:

$$ln(y_{ijct}) = \beta After_t \times ln(tax_c) + \eta_i + \lambda_{jt} + \varepsilon_{ict}, \tag{2.1}$$

where y_{ijct} is an outcome of interest of firm i in industry j at city c and time t, and it includes COD, NH3N, water used, water used per 10,000 RMB of goods produced, revenue, COD/revenue, NH3N/revenue, COD/water and NH3N/water. $After_t$ is a dummy variable, which takes 1 if time t is after 2018, when the tax rate took effect. tax_c is the environmental tax rate at city c. η_i is an individual fixed effect and λ_{jt} is an industry-time fixed effect. Table 2.3 reports this overall analysis. Although a firm in a heavily taxed province decreases its COD and NH3N pollution and its intensity of COD into water, none of the coefficients are statistically significant. There are several possibilities to interpret these results. For example, one interpretation is that the environmental tax rate does not incentivize local firms in China. Another interpretation is that it is difficult for them to adjust to the tax in the short timeframe of a few years.

I also examine whether the provincial environmental tax rate hurts local firms' economic activities. For the analysis, I use water used, water used per 10,000 RMB of goods produced, revenue, COD/revenue, NH3N/revenue, COD/water and NH3N/water as the outcome of interests. The result is shown in Table 2.4. Although a firm in a heavily taxed province decreases its revenue, the coefficient is not statistically significant. Moreover, it does not change its intensity of pollutants per revenue. These results imply that since they do not respond to the environmental tax in general, the tax does not affect their revenue and production process.

Next, I discuss whether the effect is heterogeneous across firms. Especially, I look at whether the effect is different between a firm with and without being linked to the GSC. For this analysis, I run the following regression:

$$ln(y_{ijct}) = \beta After_t \times ln(tax_c) + \gamma After_t \times ln(tax_c) \times GSC_i + \eta_i + \lambda_{jt} + GSC_i \times \kappa_{jt} + \varepsilon_{ijct} \tag{2.2}$$

where GSC_i is a dummy variable, which takes 1 if firm i is linked to a multinational in the GSC. The result is reported in Table 2.5. The effects of the environmental tax on all dependent variables are heterogeneous among the firm with and without being linked to the GSC. The effect on the firm without the linkage is similar to the one in Table 2.3. Although it decreases its pollution in a heavily taxed province, none of the coefficients are statistically significant. In contrast, the effect on the firm with the linkage is different. In a heavily taxed province, the firm being linked to the GSC statistically significantly decreases its emission of COD and the intensity in the used water. Furthermore, we observe different responses of firms to their economic activities. As I see in Table 2.6, while local firms without being linked to the GSC do not statistically change their economic activities, the ones with being linked to the GSC increase their revenue and decrease their water used to produce 10,000 RMB of goods and their intensity of COD pollutants per revenue. This result suggests that the local supplier improves its environmental technology and/or leading multinationals respond to its effort by requesting more orders.

Another interesting question is whether the effect differs in the position in the supply chain. In the global supply chain, firms are categorized into two groups. Tier 1 producers are those supplying final products for buyers. In contrast, tier 2 producers are those supplying intermediate products for tier 1 producers. I compare how environmental practices are different between tier 1 and tier 2 producers in the supply chain. For the analysis, I run the following heterogeneous regression:

$$ln(y_{ijct}) = \beta After_t \times ln(tax_c) + \gamma After_t \times ln(tax_c) \times Tier1_i + \delta After_t \times ln(tax_c) \times Tier2_i + \eta_i + \lambda_t + GSC_i \times \kappa_t + \varepsilon_{ipt} \tag{2.3}$$

where $Tier1_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC as a tier 1 producer, i.e., a firm producing a final product and $Tier2_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC as a tier 2 producer, i.e., a firm producing an intermediate product primarily for a tier 1 producer. The result is reported in Table 2.7. Overall, the effects of the tax rate on environmental practices are concentrated among tier 2 producers. They statistically significantly reduce their emission of COD and the intensity in the used water. The changes of tier 2 producers in environmental practices affect their economic activities. In Table 2.8, they also increase their revenue and decrease their water used to produce 10,000 RMB of goods and their intensity of COD pollutants per revenue. This result can be interpreted as a tier 2 producer being involved in more polluting businesses and leading multinationals putting pressure on their suppliers to reduce pollutants in heavily taxed provinces.

Finally, I investigate which characteristics of a leading multinational plays a role in this environmental protection. From the IPE's Green Supply Chain data, I use two pieces of information on leading multinationals: (1) the CITI score and (2) whether or not leading multinationals require their suppliers to employ a new environmental management practice after the tax law was enforced. The specifications are as follows:

$$ln(y_{ipt}) = \beta After_t \times ln(tax_p) + \gamma After_t \times ln(tax_p) \times ln(CITIScore_i) + \eta_i + \lambda_t + GSC_i \times \kappa_t + \varepsilon_{ipt} \tag{2.4}$$

$$ln(y_{ipt}) = \beta After_t \times ln(tax_p) + \gamma After_t \times ln(tax_p) \times GSC_i + \delta After_t \times ln(tax_p) \times GSC_i \times Manage_i + \eta_i + \lambda_t + GSC_i \times \kappa_t + \varepsilon_{ipt} \tag{2.5}$$

where $CITIScore_i$ is the 2016 CITI score of a leading multinational to which firm i is linked, and $Manage_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC requiring a new environmental management practice of their local suppliers. Table 2.9 and 2.10 show heterogeneity across multinationals' corporate environmental responsibilities. The results show that a firm linked to the GSC with high corporate environmental responsibility statistically significantly reduces the COD emission and water used to produce 10,000 RMB of goods, and increases its revenue. This indicates that a leading multinational with high corporate environmental responsibility put pressure and local partners are incentivized with an increase in its revenue to improve their environmental practices and production process. Table 2.11 and 2.12 provide the results for a new environmental management practice requested. The results show that especially a firm employing a new management practice in the supply chain responds to the environmental tax by decreasing its emission of COD. In addition, it changes its economic activity by increasing its revenue and decreasing COD per revenue and water used for 10,000 RMB of goods. These results indicate that the corporate environmental responsibility of global buyers being associated with higher environmental standards plays a significant role in complementing host countries' policies aimed at curbing pollution.

These results in Tables 2.5−2.12 imply a conflict of interest between multinationals and their local partners. Although the multinationals expect the demand increase from these consumers (Kitzmueller and Shimshack, 2012) and put pressure on the local firms regarding employing a new environmentally friendly technique and/or management practice, the local firms in the GSCs faced the conflict of interest and did not have incentives to respond to their requests under the pollution discharge fee scheme. However, under the current scheme from the pollution discharge fee system to the environmental tax system, the enforcement is enhanced and the polluting firms actually have to pay cost of pollution as taxes. Therefore, since the technique and management practice decrease their pollutants and taxes to pay, the local firms in the GSCs have incentives to employ them, and their incentives are larger in heavily taxed provinces.

2.3.1 Parallel Trends

I exploit the different provincial environmental tax rate in a regression framework. However, since local authorities decided the tax rate based on the local socioeconomic context and the polluting firm's situation, my specification in the difference in differences analyses might capture different provincial macroeconomic trends. I consider the following specification to check whether my empirical findings in the previous section suffer from this concern:

$$ln(y_{pt}) = \sum_j \beta_j d_{jt} \times ln(tax_p) + \eta_p + \lambda_t + \varepsilon_{pt} \tag{2.6}$$

where y_{pt} is an outcome of province p which includes COD and NH3N. d_{jt} is a dummy variable which takes 1 if j equals to t. Finally, η_p is a province fixed effect and λ_t is a time fixed effect. If all of β_j for j being before 2018 are not statistically different from 0, my empirical findings do not suffer from different macroeconomic trends. For the provincial COD and NH3N, I collect data from the China Statistical Yearbook on Environment. Since the tax rate is different between cities in some provinces, I follow Chen et al. (2018) and calculate the provincial tax rate as follows:

$$tax_p = \sum_c tax_c \times \frac{y_{c,2008}}{\sum_c y_{c,2008}} \tag{2.7}$$

where the second term on the right-hand side is a measure of the city's proportion of the province's total emissions in 2008.

Figure 2.5 and 2.6 investigate this concern. These figures show dynamic patterns in provincial emission of COD and NH3N just before the enforcement of the environmental protection tax law. These figures show the absence of differential trends in all of the dependent variables. In these figures, the coefficients, β_j, on all dependent variables before the introduction of the tax are closed to zero, and none of them are statistically significant.

2.4 Conclusion

Over the past few decades, global trade has been transformed, and the production of a good or service has been coordinated across countries. Although the linkage in the GSC seems beneficial to local people in developing countries, the reality is ambiguous. From the perspective of the pollution haven hypothesis, a multinational in the GSC also might relocate the process of production, which involves high emission of pollutants, from developed countries to developing countries and employ environmentally unfriendly practices. On the other hand, from the viewpoint of corporate environmental responsibility, a multinational in the GSC pays attention to its supply chain with regard to its environmental practices.

This paper studies the relationship between the global supply chain and corporate environmental responsibility. By exploiting a new environmental tax policy in China, I tackle three questions. First, I investigate whether a Chinese firm responds to this tax policy. In a heavily taxed province, a Chinese firm in the global supply chain reduces the amount of water pollution and its intensity, and increases its revenue. Second, I identify which firm in the global supply chain is affected by this policy. A tier 2 supplier, which provides an intermediate good to a multinational, responds to this policy while a tier 1 supplier does not. Third, I examine whether a multinational plays a role in this environmental protection. The result shows that the new tax policy has a larger effect on a Chinese supplier linked to a multinational with high corporate environmental responsibility.

My empirical analysis suggests important policy implications for policymakers. While there is a concern that multinationals in developed countries might relocate the process of production, which involves high emission of pollutants, from developed countries to developing countries and employ environmentally unfriendly practices, the evidence points out that corporate environmental responsibility of global buyers is a potentially important dimension of clearing this concern. To overcome environmental problems in developing countries, policymakers should focus on how to strengthen the relationship between local firms and global buyers with high corporate environmental responsibility.

Since my analysis focuses on the relationship between the GSC and the local partner's environmental practices on the intensive margin, research on how multinationals break off their relationships with existing partners and form new relationships with new ones at the extensive margin in response to the local environmental policy could be valuable. Moreover, to understand an underlying mechanism and suggest welfare implications further, future work on a theoretical framework which incorporates my empirical findings and its welfare analysis could be important to open new avenues of economic research.

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Tables

Table 2.1: Environmental Tax Rates in 2018

Municipalities and Provinces	SO2 tax	NOX tax	COD tax	NH3N tax
Beijing	12	12	14	14
Shanghai	6.65	7.6	5	4.8
Tianjin	6	8	7.5	7.5
Chongqing	3.5	3.5	3	3
Hebei	4.8−9.6	4.8−9.6	5.6−11.2	5.6
Henan	4.8	4.8	5.6	5.6
Shandong	6	6	3	3
Shanxi	1.8	1.8	2.1	2.1
Liaoning	1.2	1.2	1.4	1.4
Jilin	1.2	1.2	1.4	1.4
Zhejiang	1.2	1.2	1.4	1.4
Jiangsu	4.8−8.4	4.8−8.4	5.6−8.4	5.6−8.4
Fujian	1.2	1.2	1.5	1.5
Jiangxi	1.2	1.2	1.4	1.4
Guangdong	1.8	1.8	2.8	2.8
Hainan	2.4	2.4	2.8	2.8
Hunan	2.4	2.4	3	3
Hubei	2.4	2.4	2.8	2.8
Sichuan	3.9	3.9	2.8	2.8
Guizhou	2.4	2.4	2.8	2.8
Yunnan	1.2	1.2	1.4	1.4
Shaanxi	1.2	1.2	1.4	1.4
Guangxi	1.8	1.8	2.8	2.8
Heilongjiang	1.8	1.8	2.1	2.1
Gansu	1.2	1.2	1.4	1.4
Qinghai	1.2	1.2	1.4	1.4
Inner Mongolia	1.2	1.2	1.4	1.4
Anhui	1.2	1.2	1.4	1.4
Ningxia	1.2	1.2	1.4	1.4
Xinjiang	1.2	1.2	1.4	1.4

Table 2.1 lists the environmental tax rates across municipalities and provinces in 2018. The unit of each environmental tax rate is yuan per unit of each pollutant. Instead of the pollutant discharge fee policy, which required firms emitting pollutants to pay a fixed fee amount, the Chinese National People's Congress put into force the environmental protection tax law applying to the four categories: sulfur dioxide (SO2), nitrogen oxides (NOx), the chemical oxygen demand (COD) and ammoniacal nitrogen (NH3N).

Table 2.2: Environmental Tax Rates in 2019

Municipalities and Provinces	SO2 tax	NOX tax	COD tax	NH3N tax
Beijing	12	12	14	14
Shanghai	7.6	8.85	5	4.8
Tianjin	6	8	7.5	7.5
Chongqing	3.5	3.5	3	3
Hebei	4.8−9.6	4.8−9.6	5.6−11.2	5.6
Henan	4.8	4.8	5.6	5.6
Shandong	6	6	3	3
Shanxi	1.8	1.8	2.1	2.1
Liaoning	1.2	1.2	1.4	1.4
Jilin	1.2	1.2	1.4	1.4
Zhejiang	1.2	1.2	1.4	1.4
Jiangsu	4.8−8.4	4.8−8.4	5.6−8.4	5.6−8.4
Fujian	1.2	1.2	1.5	1.5
Jiangxi	1.2	1.2	1.4	1.4
Guangdong	1.8	1.8	2.8	2.8
Hainan	2.4	2.4	2.8	2.8
Hunan	2.4	2.4	3	3
Hubei	2.4	2.4	2.8	2.8
Sichuan	3.9	3.9	2.8	2.8
Guizhou	2.4	2.4	2.8	2.8
Yunnan	2.8	2.8	3.5	3.5
Shaanxi	1.2	1.2	1.4	1.4
Guangxi	1.8	1.8	2.8	2.8
Heilongjiang	1.8	1.8	2.1	2.1
Gansu	1.2	1.2	1.4	1.4
Qinghai	1.2	1.2	1.4	1.4
Inner Mongolia	1.2	1.2	1.4	1.4
Anhui	1.2	1.2	1.4	1.4
Ningxia	1.2	1.2	1.4	1.4
Xinjiang	1.2	1.2	1.4	1.4

Table 2.2 lists the environmental tax rates across municipalities and provinces in 2019. The unit of each environmental tax rate is yuan per unit of each pollutant. Instead of the pollutant discharge fee policy, which required firms emitting pollutants to pay a fixed fee amount, the Chinese National People's Congress put into force the environmental protection tax law applying to the four categories: sulfur dioxide (SO2), nitrogen oxides (NOx), the chemical oxygen demand (COD) and ammoniacal nitrogen (NH3N).

Table 2.3: Environmental Tax and Pollutant Emissions

	(1)	(2)	(3)	(4)
VARIABLES	ln(COD)	ln(NH3N)	ln(COD/Water)	ln(NH3N/Water)
$After_t \times ln(tax_c)$	-0.192	-0.0304	-0.0789	0.0825
	(0.132)	(0.149)	(0.0476)	(0.154)
Observations	1,680	1,680	1,680	1,680
R-squared	0.920	0.807	0.700	0.630

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. COD/Water is COD emission per tonne of water. NH3N/Water is NH3N emission per tonne of water. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.4: Environmental Tax and Economic Activities

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Water)	ln(Water/10K RMB)	ln(Revenue)	ln(COD/Revenue)	ln(NH3N/Revenue)
$After_t \times ln(tax_c)$	-0.0391	0.0108	-0.0499	-0.142	0.0196
	(0.0579)	(0.0782)	(0.0607)	(0.153)	(0.185)
Observations	1,680	1,680	1,680	1,680	1,680
R-squared	0.893	0.750	0.753	0.770	0.724

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. Water is the amount of water used. Water/10K RMB is the amount of water used per 10,000 RMB of goods produced. Revenue is a firm's revenue. COD/Revenue is COD emission divided by revenue. NH3N/Revenue is NH3N emission divided by revenue. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.5: Environmental Tax, Pollutant Emissions and Supply Chain Linkages

	(1)	(2)	(3)	(4)
VARIABLES	ln(COD)	ln(NH3N)	ln(COD/Water)	ln(NH3N/Water)
$After_t \times ln(tax_c)$	-0.112	-0.112	-0.0184	-0.0180
	(0.135)	(0.114)	(0.0794)	(0.140)
$After_t \times ln(tax_c) \times GSC_i$	-0.190*	0.221	-0.147	0.262
	(0.103)	(0.176)	(0.150)	(0.262)
Observations	1,680	1,680	1,680	1,680
R-squared	0.920	0.807	0.701	0.630

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. COD/Water is COD emission per tonne of water. NH3N/Water is NH3N emission per tonne of water. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. GSC_i is a dummy variable, which takes 1 if firm i is linked to the GSC.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.6: Environmental Tax, Economic Activities and Supply Chain Linkages

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Water)	ln(Water/10K RMB)	ln(Revenue)	ln(COD/Revenue)	ln(NH3N/Revenue)
$After_t \times ln(tax_c)$	-0.0170	0.121	-0.138	0.0261	0.0248
	(0.0332)	(0.0892)	(0.0898)	(0.171)	(0.173)
$After_t \times ln(tax_c) \times GSC_i$	-0.0504	-0.303**	0.253*	-0.443***	-0.0274
	(0.104)	(0.110)	(0.131)	(0.149)	(0.239)
Observations	1,680	1,680	1,680	1,680	1,680
R-squared	0.894	0.750	0.754	0.771	0.724

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. Water is the amount of water used. Water/10K RMB is the amount of water used per 10,000 RMB of goods produced. Revenue is a firm's revenue. COD/Revenue is COD emission divided by revenue. NH3N/Revenue is NH3N emission divided by revenue. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. GSC_i is a dummy variable, which takes 1 if firm i is linked to the GSC.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.7: Environmental Tax, Pollutant Emissions and Positions in Global Supply Chain

	(1)	(2)	(3)	(4)
VARIABLES	ln(COD)	ln(NH3N)	ln(COD/Water)	ln(NH3N/Water)
$After_t \times ln(tax_c)$	-0.112	-0.112	-0.0191	-0.0183
	(0.135)	(0.114)	(0.0789)	(0.140)
$After_t \times ln(tax_p) \times Tier\ 1$	-0.175	0.0968	0.106	0.377
	(0.130)	(0.206)	(0.174)	(0.374)
$After_t \times ln(tax_p) \times Tier\ 2$	-0.198*	0.290	-0.289*	0.199
	(0.103)	(0.183)	(0.144)	(0.225)
Observations	1,680	1,680	1,680	1,680
R-squared	0.920	0.807	0.702	0.630

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. COD/Water is COD emission per tonne of water. NH3N/Water is NH3N emission per tonne of water. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. $Tier1_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC as a tier 1 producer, i.e., a firm producing a final product and $Tier2_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC as a tier 2 producer, i.e., a firm producing an intermediate product primarily for consumption by a tier 1 producer.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.8: Environmental Tax, Economic Activities and Positions in Global Supply Chain

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Water)	ln(Water/10K RMB)	ln(Revenue)	ln(COD/Revenue)	ln(NH3N/Revenue)
$After_t \times ln(tax_c)$	-0.0165	0.121	-0.138	0.0255	0.0246
	(0.0335)	(0.0893)	(0.0900)	(0.171)	(0.173)
$After_t \times ln(tax_p) \times Tier\ 1$	-0.221	-0.286	0.0653	-0.240	0.0351
	(0.166)	(0.198)	(0.188)	(0.230)	(0.337)
$After_t \times ln(tax_p) \times Tier\ 2$	0.0449	-0.313***	0.358***	-0.556***	-0.0617
	(0.0830)	(0.0815)	(0.121)	(0.132)	(0.218)
Observations	1,680	1,680	1,680	1,680	1,680
R-squared	0.894	0.750	0.754	0.771	0.724

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. Water is the amount of water used. Water/10K RMB is the amount of water used per 10,000 RMB of goods produced. Revenue is a firm's revenue. COD/Revenue is COD emission divided by revenue. NH3N/Revenue is NH3N emission divided by revenue. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. $Tier1_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC as a tier 1 producer, i.e., a firm producing a final product and $Tier2_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC as a tier 2 producer, i.e., a firm producing an intermediate product primarily for consumption by a tier 1 producer.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.9: Environmental Tax, Pollutant Emissions and Corporate Environmental Responsibility

	(1)	(2)	(3)	(4)
VARIABLES	ln(COD)	ln(NH3N)	ln(COD/Water)	ln(NH3N/Water)
$After_t \times ln(tax_c)$	-0.110	-0.0145	-0.00645	0.0894
	(0.144)	(0.103)	(0.100)	(0.122)
$After_t \times ln(tax_p) \times ln(CITIScore_i)$	-0.0492**	0.0327	-0.0624	0.0191
	(0.0234)	(0.0457)	(0.0375)	(0.0566)
Observations	1,457	1,457	1,457	1,457
R-squared	0.936	0.830	0.739	0.672

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. COD/Water is COD emission per tonne of water. NH3N/Water is NH3N emission per tonne of water. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. $CITIScore_i$ is the 2016 CITI score of a leading multinational to which firm i is linked. * Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.10: Environmental Tax, Economic Activities and Corporate Environmental Responsibility

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Water)	ln(Water/10K RMB)	ln(Revenue)	ln(COD/Revenue)	ln(NH3N/Revenue)
$After_t \times ln(tax_c)$	0.00521	0.128	-0.123	-0.00645	0.0894
	(0.0293)	(0.112)	(0.109)	(0.100)	(0.122)
$After_t \times ln(tax_p) \times ln(CITIScore_i)$	0.00291	-0.0660**	0.0689***	-0.0624	0.0191
	(0.0237)	(0.0283)	(0.0237)	(0.0375)	(0.0566)
Observations	1,457	1,457	1,457	1,457	1,457
R-squared	0.920	0.787	0.795	0.739	0.672

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. Water is the amount of water used. Water/10K RMB is the amount of water used per 10,000 RMB of goods produced. Revenue is a firm's revenue. COD/Revenue is COD emission divided by revenue. NH3N/Revenue is NH3N emission divided by revenue. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. $CITIScore_i$ is the 2016 CITI score of a leading multinational to which firm i is linked.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.11: Environmental Tax, Pollutant Emissions and New Environmental Management Practices

	(1)	(2)	(3)	(4)
VARIABLES	ln(COD)	ln(NH3N)	ln(COD/Water)	ln(NH3N/Water)
$After_t \times ln(tax_c)$	-0.114	-0.112	-0.0200	-0.0182
	(0.134)	(0.115)	(0.0790)	(0.142)
$After_t \times ln(tax_p) \times GSC_i$	0.181	0.231	0.264	0.314
	(0.241)	(0.458)	(0.299)	(0.555)
$After_t \times ln(tax_p) \times GSC_i \times Manage_i$	-0.193*	0.221	-0.151	0.262
	(0.106)	(0.178)	(0.155)	(0.264)
Observations	1,680	1,680	1,680	1,680
R-squared	0.920	0.807	0.701	0.630

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. COD/Water is COD emission per tonne of water. NH3N/Water is NH3N emission per tonne of water. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. $Manage_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC requiring a new environmental management practice of their local suppliers.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 2.12: Environmental Tax, Economic Activities and New Environmental Management Practices

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Water)	ln(Water/10K RMB)	ln(Revenue)	ln(COD/Revenue)	ln(NH3N/Revenue)
$After_t \times ln(tax_c)$	-0.0141	0.120	-0.134	0.0202	0.0203
	(0.0320)	(0.0892)	(0.0905)	(0.172)	(0.175)
$After_t \times ln(tax_p) \times GSC_i$	-0.776	0.0961	-0.872	1.053	1.126
	(0.765)	(0.463)	(0.935)	(0.951)	(0.942)
$After_t \times ln(tax_p) \times GSC_i \times Manage_i$	-0.0442	-0.307***	0.263*	-0.456***	-0.0358
	(0.112)	(0.107)	(0.132)	(0.153)	(0.246)
Observations	1,680	1,680	1,680	1,680	1,680
R-squared	0.894	0.750	0.754	0.771	0.724

Note: Provincial-clustered standard errors are in parentheses. COD is the chemical oxygen demand emission. NH3N is ammoniacal nitrogen emission. Water is the amount of water used. Water/10K RMB is the amount of water used per 10,000 RMB of goods produced. Revenue is a firm's revenue. COD/Revenue is COD emission divided by revenue. NH3N/Revenue is NH3N emission divided by revenue. $After_t$ is a dummy variable, which takes 1 if time t is after 2018 when the tax rate took effect. Tax_c is the environmental tax rate at city c. $Manage_i$ is a dummy variable, which takes 1 if firm i is linked to the GSC requiring a new environmental management practice of their local suppliers.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Figures

Figure 2.1: Map of Municipalities by the Environmental Tax Rate on SO2

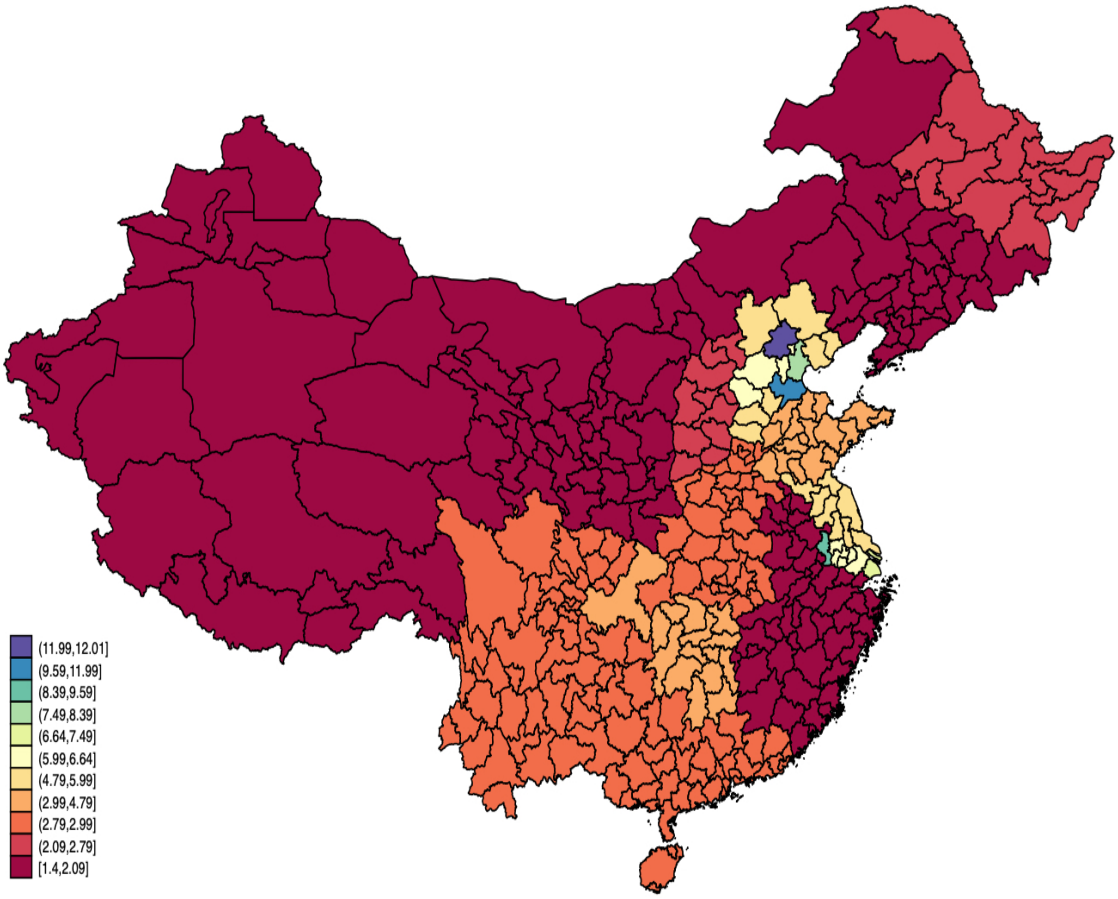

Figure 2.1 shows the maps of municipalities and cities by the environmental tax rate on Sulfur dioxide (SO2). The Chinese National People's Congress issued a new environmental protection tax law in 2016 and put the law into force in 2018. The environmental tax on SO2 was determined by the local provincial and municipal authorities within a range presented by the central government. The lowest tax rate is 1.2 yuan per unit in Lianing, Jilin, Zhejiang, Fujian, Jiangxi, Gansu, Zinghai, Inner Mongolia, Anhui, Nigxia and Xinjiang while the highest tax rate is 12 yuan per unit in Beijing.

Figure 2.2: Map of Municipalities by the Environmental Tax Rate on NOX2

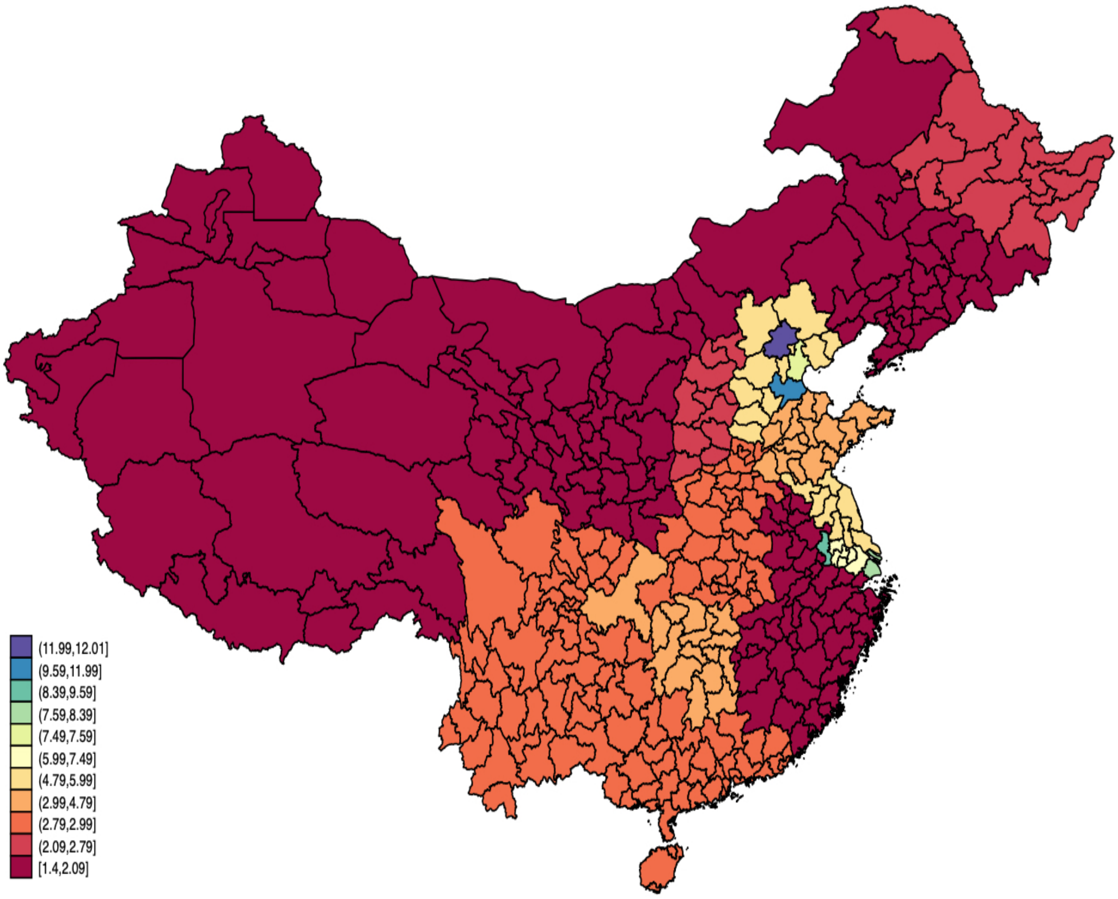

Figure 2.2 shows the maps of municipalities and cities by the environmental tax rate on nitrogen oxides (Nox). The Chinese National People's Congress issued a new environmental protection tax law in 2016 and put the law into force in 2018. The environmental tax on SO2 was determined by the local provincial and municipal authorities within a range presented by the central government. The lowest tax rate is 1.2 yuan per unit in Lianing, Jilin, Zhejiang, Fujian, Jiangxi, Gansu, Zinghai, Inner Mongolia, Anhui, Nigxia and Xinjiang while the highest tax rate is 12 yuan per unit in Beijing.

Figure 2.3: Map of Municipalities by the Environmental Tax Rate on COD

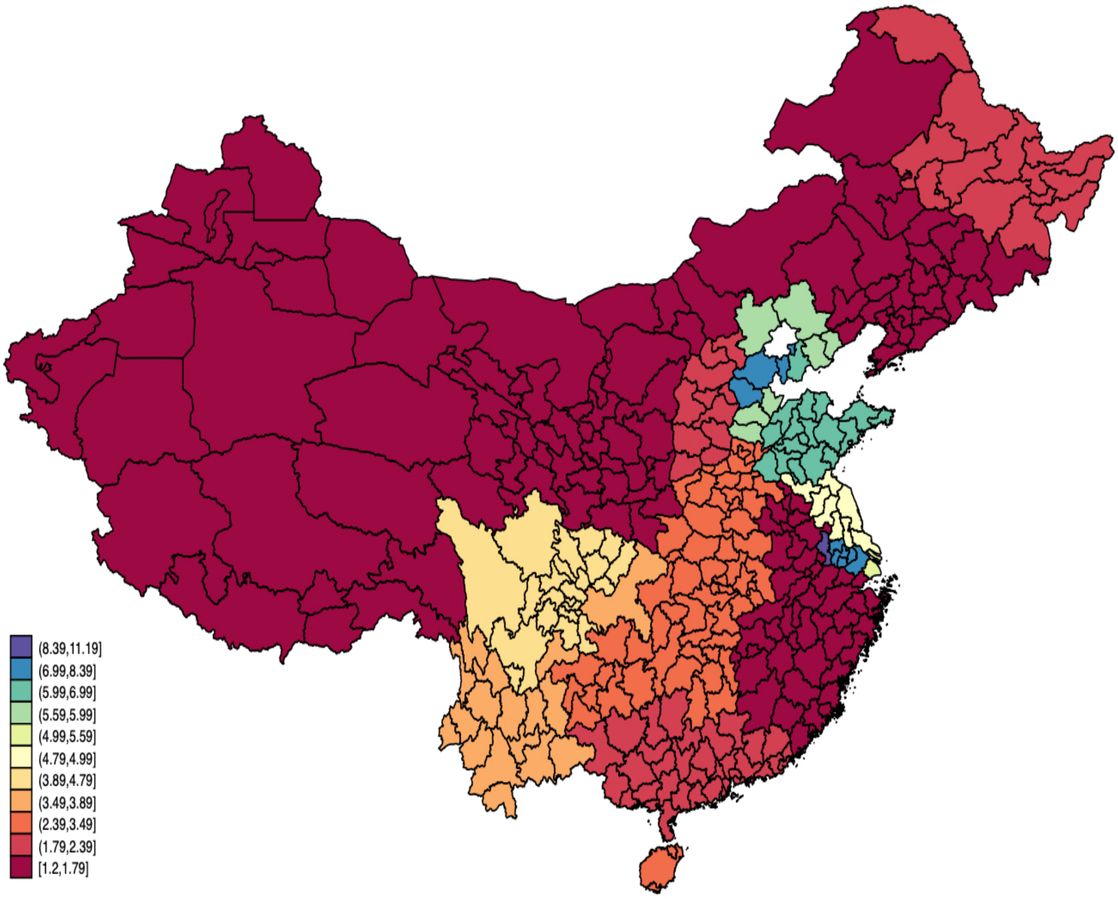

Figure 2.3 shows the maps of municipalities and cities by the environmental tax rate on the chemical oxygen demand (COD). The Chinese National People's Congress issued a new environmental protection tax law in 2016 and put the law into force in 2018. The environmental tax on SO2 was determined by the local provincial and municipal authorities within a range presented by the central government. The lowest tax rate is 1.4 yuan per unit in Lianing, Jilin, Zhejiang, Fujian, Jiangxi, Gansu, Zinghai, Inner Mongolia, Anhui, Nigxia and Xinjiang while the highest tax rate is 14 yuan per unit in Beijing.

Figure 2.4: Map of Municipalities by the Environmental Tax Rate on NH3N

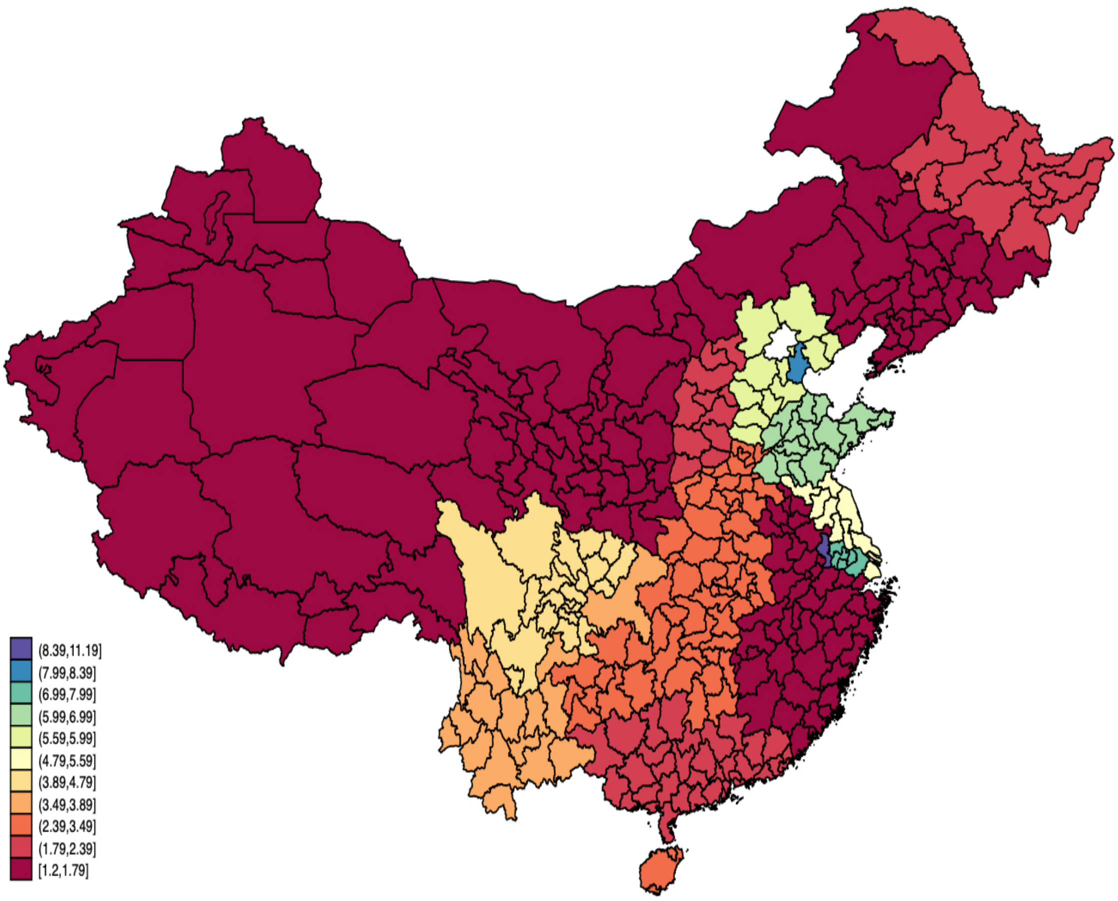

Figure 2.4 shows the maps of municipalities and cities by the environmental tax rate on ammoniacal nitrogen (NH3N). The Chinese National People's Congress issued a new environmental protection tax law in 2016 and put the law into force in 2018. The environmental tax on SO2 was determined by the local provincial and municipal authorities within a range presented by the central government. The lowest tax rate is 1.4 yuan per unit in Lianing, Jilin, Zhejiang, Fujian, Jiangxi, Gansu, Zinghai, Inner Mongolia, Anhui, Nigxia and Xinjiang while the highest tax rate is 14 yuan per unit in Beijing.

Figure 2.5: Parallel Trend Assumption: ln(COD)

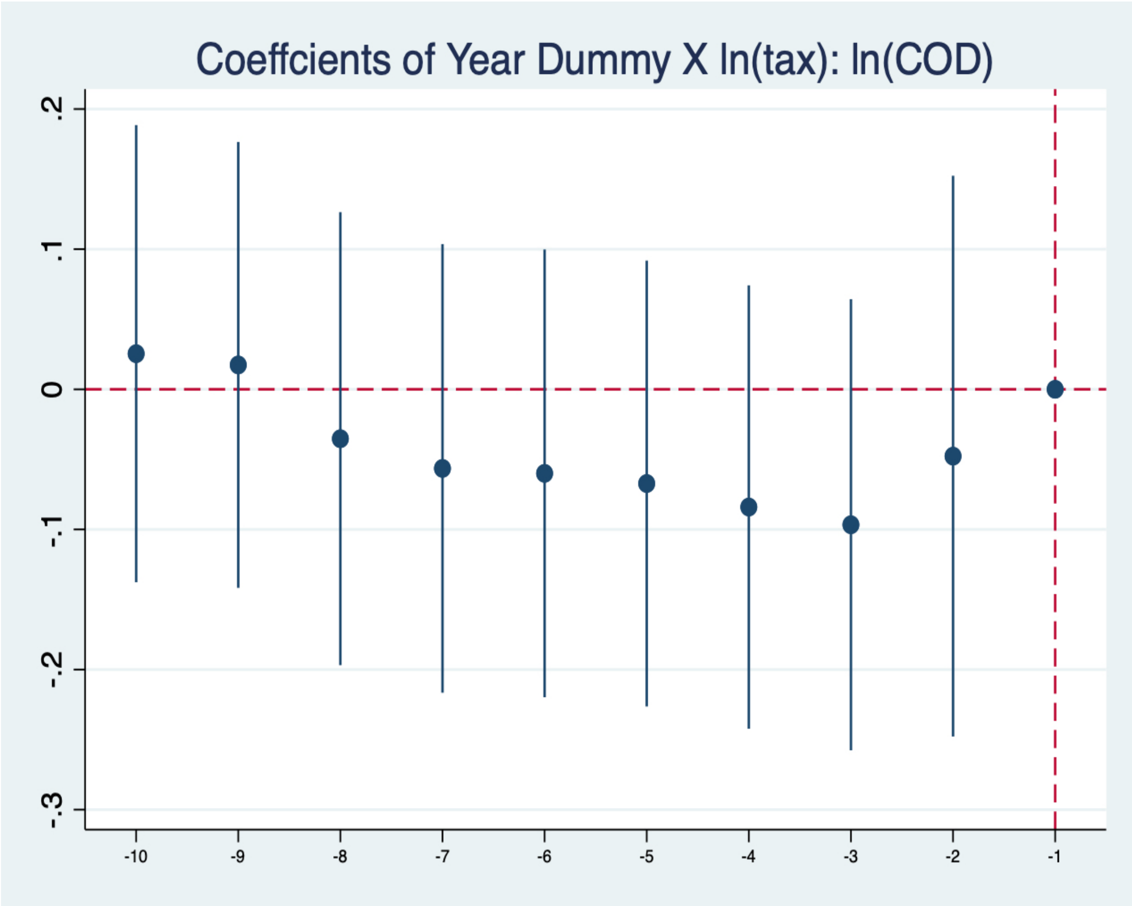

Figure 2.5 investigates pre-trends for the log of COD following the specification described in section 2.3.1. For the estimation, we follow the approach used in Chen et al. (2018). For the provincial COD, I collect data from the China Statistical Yearbook on Environment. This figure investigates dynamic patterns before the time when the Chinese National People's Congress put the environmental protection tax law into force in 2018. The figure reports the estimated all of β_j for j being before 2018 and shows the absence of differential trends in COD emission at provincial levels in the years before the enforcement of the environmental protection tax law.

Figure 2.6: Parallel Trend Assumption: ln(NH3N)

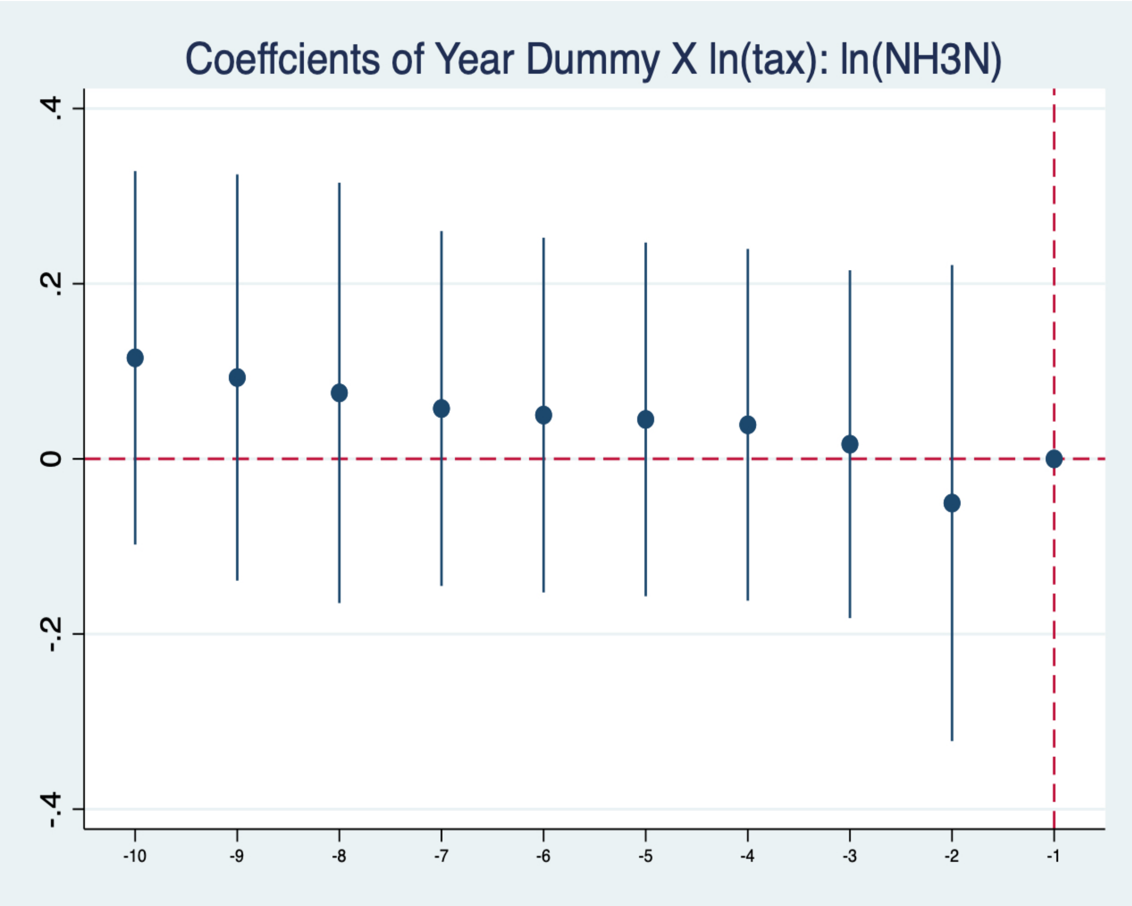

Figure 2.6 investigates pre-trends for the log of NH3N following the specification described in section 2.3.1. For the estimation, we follow the approach used in Chen et al. (2018). For the provincial NH3N, I collect data from the China Statistical Yearbook on Environment. This figure investigates dynamic patterns before the time when the Chinese National People's Congress put the environmental protection tax law into force in 2018. The figure reports the estimated all of β_j for j being before 2018 and shows the absence of differential trends in NH3N emission at provincial levels in the years before the enforcement of the environmental protection tax law.

Chapter 3

Infrastructural Instability and Trade Practices: Evidence from Myanmar

3.1 Introduction

A large body of research suggests that exporting has significant effects on firms in developing countries. One proposed mechanism is that firms can undertake fixed investment costs by exporting their products to foreign markets and increasing their sales (Melitz, 2003, Yeaple, 2005, Helpman et al., 2010 and Bustos, 2011). Another possible mechanism is that firms can increase their productivity by learning-by-exporting (Clerides et al., 1998, De Loecker, 2007, Harrison and Rodriguez-Clare, 2010 and Atkin et al., 2017). Empirical evidence shows that by exporting, firms in developing countries adopt their upgraded technology (Lileeva and Trefler, 2010 and Bustos, 2011), offer high product quality (Atkin et al., 2017), and improve their labor working conditions (Tanaka, 2020). It is widely believed that exporting generates efficiency gains which narrow the gap between developed and developing countries and that international trade has been recognized as a tool to eradicate poverty in developing countries.

However, it is not easy for firms to start exporting. First, since buyers and sellers are in different locations, search and contracting problems arise in international trade (Allen, 2014, Dasgupta and Mondria, 2018, Steinwender, 2018 and Akerman et al., 2021). Since trade costs are high and information frictions are serious due to weak contract enforcement institutions and limited access to information technology (Startz, 2021), these problems are particularly enhanced in developing countries. Second, immature financial market imperfections impede participation of international trade (Antras et al., 2009, Antras and Caballero, 2009, Manova, 2013, Feenstra et al., 2014 and Chaney, 2016). Third, due to limited availability of reliable goods (Nyqvist et al., 2020, Bai, 2021 and Michelson et al., 2021), firms cannot meet the required standards for their exports to access to high-income markets. For these reasons, exporting in developing countries is plagued with difficulty.

One related but unexplored area is infrastructural instability in developing countries. Although infrastructure investment has been widely acknowledged as a means of poverty reduction among policymakers, the focus has been on economic growth and industrial development. Since multinationals and FDIs determine their locations according to the institutional quality (Du et al., 2008), infrastructural instability in developing countries is of crucial concern for linking firms in developing countries with firms in developed countries. Thus, research on investigating the effect of infrastructure instability in international trade can have profound implications for the benefits of infrastructural investment for policymakers.

Despite its significant policy importance, the relationship between infrastructural instability and export practices has not been examined empirically due to several empirical challenges. First, time variation in short term periods on infrastructural instability has been hardly observed. For the analysis, it is hard to separate out infrastructural instability from other macroeconomic factors in standard contexts. Second, the mechanism behind how infrastructural instability works is ambiguous. For instance, firms could significantly stop their production process and reduce their outputs. In contrast, electricity shortages might affect input choices and productivity, which might change their materials costs. Identifying its role of infrastructural instability is key to public policy, but it is hard under these circumstances.

This paper provides empirical evidence on the effect of infrastructural instability on export practices. My study is grounded in the context of the relationship between electricity and garment exporters in Myanmar. This setting offers me two interesting features to investigate the relationship. First, I observe the seasonal variation in the number of blackouts and blackout duration caused by infrastructural instability in electricity. Second, since the garment producers in Myanmar import inputs for their exports, blackouts only increase their operational costs, and I can identify how this increase affects their export practices. Based on these features, I compare how the export practices of sellers in Myanmar are different between dry and wet seasons.

In section 3.2.1 and 3.2.2, I begin by describing the institutional setting in Myanmar. In Myanmar, as economic growth has been achieved, the electricity demand has increased rapidly in recent years. Due to this demand increase, the supply side is positioned as an important issue. Since many facilities were built more than 50 years ago, there are not enough facilities to supply power to meet demand. Especially, the problem of the gap between power supply and demand is rooted in transmission/distribution loss due to the vulnerable facility. Thus, whether there is any power outage is determined by the power demand. The power demand of households in Yangon is high during the wet season when the temperature rises. The power outages caused by this high demand during the wet season hurt the firm growth. For example, in blackouts, firms stop their production processes or use their own backup generators, which increase their operating costs. Thus, the blackout is the main obstacle faced by exporters.

Section 3.2.3 and 3.2.4 describe the garment sector in Myanmar. Myanmar's export garment industry has emerged as a cost-competitive source for international buyers and retailers. The vast majority of Myanmar-based suppliers are Cut-Make-Pack (CMP) producers. In the CMP manufacturing, the international buyers provide fabric, raw materials and product specifications so that suppliers can use them to assemble garment products. CMP producers in Myanmar have a comparative advantage of CMP production due to the tariff system in Myanmar. The tax policy in Myanmar exempts the import tax only if the import is for the provision of a CMP service.

For this study, my main source of data consists of all the monthly transaction-level export and import records from the Myanmar Garment Manufacturers Association. These records include information on the product transacted, its value and its volume, the date of records, the lead time, as well as the names of garment producers in Myanmar and the international buyers.

The empirical analysis proceeds in three steps in Section 3.3. In the first step, I describe the export practices of sellers in the Myanmar garment sector. As it is described in Section 3.2, firms' operating costs increase due to the frequent power outages during the wet season. I study how this affects the export practices of sellers. I find that sellers and buyers decrease the number of orders and the amount of their trade. Furthermore, at an order level, sellers' margins are squeezed in seasons of frequent power outages. This result suggests that an increase in the operating costs hinders their export activities.

In the second step, I investigate whether the export practices of sellers are heterogeneous across orders for buyers' characteristics. Especially, I examine the international buyers' sourcing strategies and positions.

In sourcing strategies, there are two different approaches: a spot sourcing strategy and a relational sourcing strategy. Under spot sourcing, buyers squeeze suppliers' margins while buyers incentivize suppliers under relational sourcing. I examine whether the buyers' approach is an influential factor in the case where infrastructure is weak. My empirical findings show that on average, buyers that source rationally pay incentives to alleviate infrastructural instability, and they increase their incentive structures in the wet season.

In uncompetitive markets in developing countries, the large international buyers may exploit their market power to squeeze the downstream suppliers' margin. I investigate whether this is intensified in the wet season in my context. I find that these buyers retrieve their loss by squeezing the suppliers' margins further in the wet season.

In the third step, I also examine whether the export practices of sellers are heterogeneous across sellers' locations. In Myanmar, the problem of frequent electricity shortages is rooted in distribution loss due to the aging supply facilities. I examine whether the distribution loss is of critical concern for export practices of sellers by exploiting the creation of a new gas-fueled in Yangon. In 2017, a new gas-fueled generator was created in Thaketa township and started to supply electricity to households and firms across all regions in Yangon. I compare the trading patterns in the same district of Thaketa township or in the township directly connected to Thaketa township via the transmission line with those in other regions in Yangon in the dry and wet seasons. I find that the new generator in Thaketa township helps sellers to follow the similar trading patterns even during the wet season. This finding implies that the distance to an electric power plant is significant in allowing sellers to avoid the distribution loss caused by aging supply facilities.

To the best of my knowledge, this paper provides the first empirical evidence on the relationship between infrastructural instability and export practices. Thus, this paper contributes to different strands of literature. First, this paper contributes to the literature on infrastructure in developing countries. Although much literature has studied the effect of electricity on economic development (Rud, 2012, Lipscomb et al., 2013, Fisher-Vanden et al., 2015, Allcott et al., 2016 and Kassem, 2020), evidence on how electricity affects international trade is limited. This paper provides empirical evidence by exploiting time variation on the number of power outages.

Second, this paper contributes to the literature studying the constraints to exports in developing countries. Much literature has pointed out the constraints to exports (Antras et al., 2009, Antras and Caballero, 2009, Manova, 2013, Feenstra et al., 2014, Chaney, 2016, Dasgupta and Mondria, 2018, Steinwender, 2018, Bai et al., 2019, Akerman et al., 2021 and Startz, 2021). My analysis adds to this literature in whether electricity is the constraint to exports in developing countries.

Third, this paper contributes to the literature on international buyers' approach. An emerging bulk of work focus on how business relationships matter (Baker et al., 2002, Board, 2011, Antras et al., 2017, Atkin et al., 2017, Schott et al., 2019 and Cajal-Grossi et al., 2020). This paper investigates by investigating how business relationships are related to weak infrastructure in international trade.

3.2 Empirical Settings

3.2.1 Electricity in Myanmar

Energy fuels industry and manufacturing, improves livelihoods, and connects markets. Consuming more energy plays an essential part in achieving economic growth in a modern economy. Figure 3.1 shows per capita electric consumption in Myanmar over the past 15 years. Electric energy consumption per capita has tripled from roughly 70 kilowatt-hours in 2000 to 210 kilowatt-hours in 2014. This increase is consistent with the increase in access to electricity. Figure 3.1 shows the percentage of population with access to electricity in Myanmar. In early 2000s, only 45% of the whole population had access to electricity. This rate has increased over the past 20 years, and the country-wide electrification access was above 65% in 2018. However, there is substantial variation in the electrification rate across regions. According to Asian Development Bank (2012) and Nam et al. (2015), Yangon has an electrification rate of almost 80%, while the rural average is as low as 16%.

In Myanmar, the electricity mix is determined by its natural resources. According to Japan International Cooperation Agency (2018), in 2014, the existing capacity of electricity reached 4,422 megawatts (MW), and electricity production was 12,200 gigawatt-hours (GWh). In these existing capacity and electricity generation, hydropower is the main source of fuel for electricity, which is followed by natural gas and coal. In 2014, 68 % of the total capacity came from hydropower, and the shares of gas and coals were 28% and 3%, respectively. In contrast, the share of hydropower in the total generation was 72%, while the share of gas contributed to 23% and the share of coal was 5%.

The Ministry of Electric Power and Energy (MOEPE) is in charge of streamlining government activity regarding electricity. On the baseline, the structure of the electricity sector is made up of three different layers: generation, transmission, and distribution of electricity. Although recent changes in legislation encourage participation from the private sector, the large majority of these layers are state-led. Electricity is generated by three state-led and private enterprises: the Electricity Power Generation Enterprise (EPGE), the Electricity Supply Enterprise (ESE) and independent power producers (IPP). Electricity transmission is manipulated only by the Electricity Power Generation Enterprise (EPGE). Electricity distribution varies across regions. In two major cities, Yangon and Mandalay, electricity distribution is under the control of two enterprises: the Yangon Electricity Supply Cooperation (YESC) and the Mandalay Electricity Supply Cooperation (MESC). In contrast, the Electricity Supply Enterprise (ESE) is responsible for the distribution of electricity in other regions.

3.2.2 Blackouts in Urban Areas

A large amount of power is supplied in urban areas. For example, since Yangon is the economic center of Myanmar, in 2012, the peak power supply in the whole of Myanmar totaled about 1,800MW, of which about 44% (about 790MW) was supplied to Yangon City (Japan International Cooperation Agency, 2018). Since electric power supply hardly meets demand in urban areas where a large amount of power is demanded in Myanmar, blackouts stop the economic production process and hurt the economic growth.

The blackout comes from the problems in the two sides which interact with each other: the demand side and the supply side. On the supply side, degradation of facilities is an obstacle to effective power generation, transmission and distribution. Aging existing power facilities, which were built more than 50 years ago, cannot supply enough power to meet demand. Substation facilities are also degraded, which causes problems related to transmission/distribution loss, due to vulnerable transmission/distribution facilities. According to Japan International Cooperation Agency (2018), in 2015, electricity losses in Myanmar fell to around 21% with 3.3% in the transmission loss 7% and $15 - 18\%$ in the power distribution loss. Moreover, since aging facilities have been used under overload conditions for a long time, there are serious concerns over trouble occurrence. Under these challenging circumstances, there is high need for improving efficiency and enhancing electric power supply reliability.

On the demand side, forecasting electricity demand is difficult due to three different reasons. First, as the economic growth has been achieved, households are more likely to acquire energy-using assets, but their decision-making takes place in a non-linear way (Gertler et al., 2016). Second, the current electricity scheme in Myanmar makes the situation complicated. The electricity charges for households and firms are cheap in Myanmar. According to Dobermann (2016), per kilowatt-hour, the average cost in Myanmar is 2.8 cents, compared to an ASEAN average of around 11.3 cents per kilowatt-hour. This low electricity cost boost the electricity demand. Third, the electricity demand fluctuates seasonally. Notably, the power demand is high during the wet season when the temperature rises. These three factors make it hard for the electricity suppliers to meet the electricity demand.

The problems on the supply and demand sides cause frequent blackouts. Figure 3.3 shows the monthly number of blackouts and average blackout duration in 2015−2016. This table shows the seasonal variation in the number of blackouts and blackout duration. During the dry season, when it is from November to April in Myanmar, the number of blackouts is about 200−400 per month and the average blackout duration is 3−4 hours. However, this trend is different from the one during the wet season. In the wet season, when the electricity demand is high, the number of blackouts and blackout duration increase. On average, in May−October, the power outages happen 400−600 times and they require an average of about 8 to 9 hours until recovery. This table shows that the larger number of blackouts and the longer blackout duration during the wet season hurt the firm growth. For example, in blackouts, firms stop their production process or use their own backup generators, which increase their operating costs. Thus, the blackout is the main obstacle faced by exporters.

In section 3.3, exploiting this time variation on the operation costs including the electric ones, I investigate the relationship between infrastructural instability and export practices.

3.2.3 The Myanmar's garment sector

Many developing countries have used export-oriented production as a pathway for national economic development. Garments play an especially significant role in economic development in Myanmar. Since global buyers have increasingly looked for alternative garment sourcing locations where local wage levels are lower, as wages in China have risen, Myanmar's export garment industry has emerged as a cost-competitive source for international buyers and retailers. In 2012, garments were the country's third-largest export in terms of value, after natural gas and timber (Kudo, 2013).

To export garments, the vast majority of Myanmar-based suppliers are Cut-Make-Pack (CMP) producers. Their buyers provide fabric, raw materials and product specifications so that they can use them to assemble garment products. For CMP producers, their profit margins are created from lower production costs (either by squeezing wages, reducing input costs or making production more efficient). Exporters in Myanmar have a comparative advantage of CMP production compared with other garment productions due to the tariff system in Myanmar. The tax policy in Myanmar exempts the import tax only if the import is for the provision of a CMP service. If it is for other garment productions, importers have to pay the import tax.

Producers in Myanmar have exported their garments to diverse international buyers. This diverse composition in Myanmar comes from the economic sanctions of North American and European countries at the beginning of the 21st century. Before the sanctions, by exploiting the cheap labor cost, Myanmar exported garments to mainly the United States (US) and European Union (EU) markets. According to Kudo (2013), Myanmar's export garment industry produced mainly for the US (more than 50% of production in the year 2000) and EU markets (nearly 40% in the same year) via locally-owned garment factories and the foreign-owned factories of Hong Kong, Japanese, South Korean, and Taiwanese investors.

This export trend changed in 2003, when the US government enacted the Burmese Freedom and Democracy Act and imposed economic sanctions on the country to put pressure on the ruling military regime in Myanmar. Once the sanctions took full effect, all Myanmar exports were banned from entering the US. Following the US sanctions, most European countries also stopped sourcing from Myanmar. By 2005, the export value of garments made in Myanmar was 38% of the 2001 value. Myanmar's garment manufacturers lost their major markets and had to develop alternative trading partners in East Asian countries.

A semi-civilian government was established and announced its plan for gradual economic and political reforms in Myanmar in 2011. Responding to the reforms, the international community adopted the progressive lifting of trade restrictions and restored trade relationships with Myanmar. In 2013, the EU suspended its economic sanctions on Myanmar and reinstated duty-free and quota-free access to imports from the country. The US lifted its import ban on most goods, including garments, in 2012 and ended all sanctions in 2016. These triggered an influx of European and North American buyers into Myanmar again.

Figure 3.4 shows the trend of the textile and clothes exports to 5 major trading partners between 2010 and 2018. During the economic sanctions, the exporters established trade linkages mainly with East Asian countries. Japan and South Korea were the two main trading partners. In 2010 and 2011, Myanmar exported 20 and 35 million USD of textiles and clothes to Japan and South Korea. These were 55% and 70% of the total exports, respectively. However, after the economic sanction, Myanmar faced a new trading environment. Especially, Myanmar increased its export to the United Kingdom, Germany and the United States. In 2018, Myanmar exported 100 million USD of the total exports to these three countries and the share was 24%. Faced with this influx of buyers in the EU and the US, the share of the total exports to Japan and South Korea was reduced to 34% in 2018.

The diverse composition of buyers in Myanmar's export garment industry is an ideal setting for me to identify how different international buyers react to buyers in the seasons of the frequent outages.

3.2.4 The Myanmar Garment Manufacturers Association

The Myanmar Garment Manufacturers Association (MGMA) is the business association for the Myanmar garment sector. The MGMA was established to supports garment producers, and the MGMA membership included over 550 active member companies in 2019. Recently, the MGMA created an online import license application system for the member companies to process their import license applications faster and more efficiently. This system is designed to electronically link the MGMA member companies, the MGMA and the Ministry of Commerce. The online system has been used since 2018, and replaces the old paper-based system. This system has an impact on two fronts. Firstly, it creates an automated recommendation for an application to be approved or rejected, which makes the otherwise inefficient licensing procedure much more time-efficient. Secondly, the system automatically generates and stores valuable data on the import and export activities of all garment factories. Factory users are able to trace the 'current status' of their import license application easily and quickly via the online system. It also ensures greater accuracy and transparency of the process.

This allows me to analyze this import and export data to identify the production and trade behaviors of garment firms, which sheds significant light on the relationship between their behaviors and the infrastructural instability in developing countries.

3.3 Data and Empirical Findings

3.3.1 Data Sources

For this study, my main source of data consists of all the transaction-level export and import records from the MGMA between 2018 and 2019. These records include information on the product transacted, its value and its volume, the date of records, the lead time, as well as the names of garment producers in Myanmar and the international buyers.

As in Section 3.2.3, since suppliers in Myanmar engage in Cut-Make-Pack (CMP) procedures, the international buyers provide fabric and raw materials to assemble garment products. This feature enables me to link material input use to output. By aggregating transaction-level records at each export order level, I construct information on the buyer's identity and destination country, product description, the value and volume of the export, the seller's identity, and the value and volume of the imported. Moreover, since the international buyers provide the materials, the blackouts only affect the operational costs. Thus, these features of this data allow me to analyze how an increase in the operational costs caused by the blackouts affect the trading practices of the sellers facing different buyers.

Table 3.1 provides descriptive statistics for the transaction-level export and import records of sellers from the MGMA between 2018 and 2019. In these two years, 191 garment producers used this online license application system. On average, the seller exports 2.2 different products (HS 4-digit product categories level) and trade with 1.16 buyers over the sample period. In contrast, buyers are more diversified compared with sellers. Table 3.2 provides descriptive statistics for the transaction records of buyers. In the two years, 179 international buyers order products in total. The average buyer sources 2.3 products from 1.25 sellers. My sample includes 4667 orders and 223 buyer-seller trade pairs.

3.3.2 Empirical Findings

This section investigates how trading patterns are different between dry and wet seasons. First, by exploiting the seasonal variation on outages, I document that garment producers in Myanmar decrease their exports in the wet season. I then leverage the export and import records to show that buyers adopting relational sourcing strategies offer sellers higher incentives to offset the increase in their operational costs. Finally, by focusing on the sellers' locations, I find that sellers in a neighborhood of a new gas-fueled generator follow different trading patterns during the wet season.

Infrastructural Instability and Trading Practices

I exploit the seasonal variation in the number of outages and look at how garment producers change their trading patterns facing an increase in their operational costs during the wet season. First, I examine how trading practices of sellers and buyers are different between dry and wet seasons. For this analysis, I aggregate all the transaction-level records at buyers' and sellers' levels at each month and consider the following baseline specifications:

$$ln(y_{st}) = \beta WetSeason_t + \eta_s + \lambda_y + \varepsilon_{st}, \tag{3.1}$$

$$ln(y_{bt}) = \beta WetSeason_t + \eta_b + \lambda_y + \varepsilon_{bt}, \tag{3.2}$$

where y_{st} and y_{bt} are outcomes of seller s and buyer b at time t, respectively. For the seller, the outcomes of interest include the number of orders a seller receives, the number of buyers from which a seller receives orders, and the number of HS 4-digit product categories a seller makes. In contrast, for the buyer, they include the number of orders a buyer places, the number of sellers to which a buyer places orders, and the number of HS 4 digits product categories a buyer orders. Wet Season takes 1 if time t is in the wet season (from May to October).

Table 3.3 provides empirical findings of trading practices of sellers. In the wet season, they decrease their export quantity and value in total by 43% and 51.5%, respectively. These decrease partially come from the orders sellers receive. The decrease in the number of orders they receive is 32.7%. However, sellers do not statistically significantly change the number of buyers from which they receive orders and the number of HS 4-digit product categories they make. I find the similar results for trading practices of buyers. In Table 3.4, buyers in the wet season decrease the aggregate value and quantity by 37.3% and 44.1%. These results are consistent with the 20.3 % decrease in the number of orders buyers place. Although the buyers neither statistically increase nor decrease the number of HS 4-digit product categories they place, they increase the number of sellers to which they place orders. These results imply that an increase in the operational costs caused by the frequent electricity outages has a serious impact on trading practices of both sellers and buyers at an aggregate level.

Then, I investigate how trading practices are different at an order level between these two seasons. I consider the following baseline specification:

$$ln(y_{sbjot}) = \beta WetSeason_t + \eta_s + \chi_j + \lambda_y + X_{ot}\gamma + \xi_d + \varepsilon_{sbjot}, \tag{3.3}$$

where y_{sbjot} is an outcome of order o of product j (HS 4-digit product categories) manufactured by seller s for buyer b at time t, and it includes the export value, volume and unit price, the lead time per volume, and the input price of the export. η_s is an individual fixed effect that absorbs seller specific shocks including the seller specific productivity. χ_j is an HS code fixed effect that captures product-specific factors. λ_y is a yearly time fixed effect that incorporates annual macroeconomic shocks, and ξ_d is a destination-specific shock that occupies buyer-country specific factors. Finally, X_{ot} is a control variable which includes order-level information.

Table 3.5 reports the results based on this specification. This shows that garment producers in Myanmar are affected by frequent outages in the wet season. In the wet season, they decrease their export quantity and value by 11.8% and 14%, respectively. A decrease in their export quantity is associated with an increase in the lead time per quantity. This suggests that the frequent outages disrupt the garment exporter's production process. Moreover, the input unit price doe not change and is irrelevant to the frequent outages. This shows that the outages in Myanmar do not affect the international buyers and the value of the imported input per volume in particular. Finally, their export output-input price ratio also decreases by 6%. This indicates that the international buyers have strong bargaining powers and squeeze suppliers' margins in the wet season.

One crucial concern in these results is that garment sellers might choose their locations according to infrastructural instability. Due to this possibility, our specification might capture the self-selection effect. For robustness checking, I investigate whether sellers consider electricity shortages when they select their locations.

As described in Section 3.2, power outages are determined by aging supply facilities and an increase in the electricity demand. Since supply facilities were not degraded and the electricity demand was low in the past, the problem of blackouts was not serious until recent years. Thus, if sellers consider electricity shortages when they select their locations, new sellers select different locations compared with other sellers. Since most of the sellers in my sample are in Yangon, I examine whether the located districts are different between new and old suppliers.

Table 3.6 reports this analysis. I define a new seller based on the following categories:

whether the seller was established after 2005, 2010 or 2015. In Table 3.6, I do not find a statistically significant difference on the located district. I also check whether the established year has any effect on the located district, and do not find the statistically significant effect. These findings assuage the concern and show that my analysis is not contaminated by the self-selection effect.

Heterogeneity Analyses

From Tables 3.3−3.5, the frequent outages disrupt the garment exporter's production process, and the international buyers squeeze suppliers' margins at an order level in the season of frequent power outages. Thus, for sellers, the type of the international buyers and the formed relationships are important to manage their loss. For this purpose, I look at how what characteristics in trading practices is significant during the wet season. Especially, I focus on the international buyers' sourcing strategies and positions.

Recent study (Cajal-Grossi et al., 2020) shows that international buyers adopting relational sourcing strategies pay higher markups and prices to incentivize suppliers to undertake non-contractible actions. I investigate whether this holds nor not to cover the squeezed margins in the wet season even in the context of infrastructural instability. First, I document variation in buyers' approach to sourcing and introduce a metric of buyers' sourcing strategies along the lines of Schott et al. (2019) and Cajal-Grossi et al. (2020). Second, I examine whether the effect of the outages is different across orders for buyers adopting different sourcing strategies.

In emerging markets facing a lack of contract enforcement, as in Myanmar, how international buyers source products from sellers is important. There are two completely different sourcing models in the garment industry: a spot sourcing strategy and a relational sourcing strategy. On the one hand, in the spot sourcing strategy, buyers make short-term orders from the lowest bidders without bearing any costs of non-compliance. On the other hand, in the relational sourcing strategy, buyers make orders from a few suppliers and form a long-term relationship with them. Under spot sourcing, buyers squeeze suppliers' margins while buyers incentivize suppliers under relational sourcing.

Following Cajal-Grossi et al. (2020), I measure buyer's sourcing strategies.[1] I normalize the number of sellers the buyer trades with, by the number of shipments the buyer re-

[1] Schott et al. (2019) use transaction-level U.S. import data to classify importers according to their procurement styles. Cajal-Grossi et al. (2020) builds on their approach to measure buyer's sourcing strategies in their sample.

ceives in each product, to construct a weighted average for each buyer across all products. This measure suggests that buyers reliant on spot sourcing tend to spread out their shipments across multiple suppliers, while relational buyers concentrate them on a set of core suppliers.

Table 3.7 shows the descriptive statistics of this measure and the buyer's market share and sourcing following Cajal-Grossi et al. (2020) across the top 100 and all buyers. In my sample, the market is not concentrated on a few international buyers and buyers exhibit significant differences in their approach to sourcing. Also, figure 3.5 shows the correlation between the market share and the sourcing strategy. From this figure, I find that there is a small negative correlation between these measures and that even buyers of similar size can significantly differ in their sourcing strategies.

From now on, I investigate whether the effect of the outages is different across orders for buyers adopting different sourcing strategies. For this analysis, I run the following regression:

$$ln(y_{sbjot}) = \beta WetSeason_t + ln(Relational_b) + WetSeason_t \times ln(Relational_b) + \eta_s + \chi_j + \lambda_y + X_{ot}\gamma + \xi_d + \varepsilon_{sbjot}, \quad (3.4)$$

where $ln(Relational_b)$ is the log of the baseline metric of buyer's sourcing. One concern in this analysis is that the effect of the sourcing strategy captures unobserved buyer-related, relationship-related and market-related factors. To assuage this raised concern, I follow Cajal-Grossi et al. (2020) and include the following controls in the specification; controls include three buyer-related, relationship-related and market-related covariates. According to Cajal-Grossi et al. (2020), relational sourcing is unconditionally correlated with the buyer's size and its age in the market in particular. Therefore, I control for the overall size of the buyer and the age of the buyer at the time of the order as buyer-related covariates. I also add controls for buyer-seller-pair characteristics. The size and age of the buyer-seller relationship could correlate with orders due to reputation, scale effects or demand assurance mechanisms. To account for these and other potential confounders, I also include controls for the size and the age of the relationship at the time of the order, the share of the seller in the buyer's trade and share of the buyer in the seller's trade as relational-related covariates. Finally, I include a control for the market structure. The market concentration could affect transactions through other channels, such as market power and market competition. Thus, I also include Herfindhal index which describes how concentrated the trade in a relationship is at the time of order.

Table 3.8 reports the results of this specification and shows that the buyers sourcing strategies are associated with the infrastructural instability in Myanmar. The effect on the firm is similar to the one in Table 3.5. in the wet season, garment producers in Myanmar decrease their export quantity and value, and their margins are squeezed by their international buyers. However, buyers that adopt relational sourcing strategies mitigate these effects. In Table 3.8, 1% increase in the buyer's sourcing strategy measure is positively associated with a 0.54% increase in the export value, 0.73% increase in the output price and 0.7% increase in the output-input price ratio. These patterns are not explained by individual characteristics of the seller and the product or the destination country in which the buyer is located. These results are consistent with the findings of Cajal-Grossi et al. (2020), which implies that the international buyers adopting relational sourcing pay incentives to suppliers in the markets facing a lack of contract enforcement.

The international buyers adopting relational sourcing add more incentive structures in the wet season. In addition to the incentives they pay in the dry season, they also make fewer orders with higher output and input prices and longer lead times in the wet season. Although the increase in the input price is larger than the one in the output price, the output-input price ratio does not statistically significantly decrease. These findings imply that the international buyers adopting relational sourcing increase the incentives with ordering high-quality products for longer periods in the wet season.

Then, I turn my focus toward the international buyers' positions. In uncompetitive market structures in developing countries (Antras and Costinot, 2011 and Atkin and Donaldson, 2015), there is a room for abuse of upstream market power which results in inefficiencies by causing the misallocation. For example, the large international buyers might exploit their strong market powers to squeeze the downstream suppliers' margins. I investigate whether that exploitative motivation by the large international buyers is enhanced in the wet season when their trading practices are heavily affected by frequent outages. For the analysis, I consider the following specification:

$$ln(y_{sbjot}) = \beta WetSeason_t + Best10_b + WetSeason_t \times Best10_b + \eta_s + \chi_j + \lambda_y + X_{ot}\gamma + \xi_d + \varepsilon_{sbjot}, \quad (3.5)$$

where $Best10_b$ is a dummy variable which takes 1 if buyer b is in the best 10 international buyers in the sample period. The results are shown in Table 3.9. The effect of the wet season reported in Table 3.5 mainly comes from the sellers which receive orders from the best 10 international buyers. The best 10 international buyers place fewer orders with longer lead times by decreasing their trade value and quantity and increase . Moreover, they squeeze the suppliers' margins only by increasing the unit input prices of orders. In contrast, other buyers only decrease the unit output and input prices. These results suggest that the orders from the top international buyers are affected and these buyers retrieve their loss by squeezing the suppliers' margins further in the wet season.

Lastly, I also look at whether the geological location of the sellers is significant for trading practices during the wet season. As it is written in Section 3.2.2, the problem causing electricity shortages on the supply side is the power distribution loss due to aging facilities. I examine whether the distribution loss induces different trading patterns of sellers by exploiting one interesting event in 2017. In 2017, a new gas-fueled generator was created in Thaketa township and started to supply electricity to households and firms across all regions in Yangon. If the distribution loss is of serious concern for linking sellers with international buyers, the trading patterns in a region closer to Thaketa township is different from the ones in other regions, especially in the wet season. I investigate this possibility based on the two criteria: districts in Yangon and townships directly connected to Thaketa township via 66kV transmission line. The YESC divides the whole Yangon into five regions to distribute electricity, which is mainly consistent with the definition of the Yangon City Development Committee (Figure 3.6). Moreover, within each district, the YESC transmit electricity to each substation (Figure 3.7). For the empirical analysis, I use these two criteria and consider the following specifications:

$$ln(y_{sbjot}) = \beta WetSeason_t + WetSeason_t \times Eastern_s + \eta_s + \chi_j + \lambda_y + X_{ot}\gamma + \xi_d + \varepsilon_{sbjot}, \quad (3.6)$$

$$ln(y_{sbjot}) = \beta WetSeason_t + WetSeason_t \times Connected_s + \eta_s + \chi_j + \lambda_y + X_{ot}\gamma + \xi_d + \varepsilon_{sbjot}, \quad (3.7)$$

where $Eastern_s$ is a dummy variable, which takes 1 if seller s is in the eastern district in Yangon to which Thaketa township belongs, and $Connected_s$ is a dummy variable, which takes 1 if seller s is in the township directly connected to Thaketa township via 66kV transmission line. The results in Table 3.10 and 3.11 report that sellers in different regions follow different trading patterns. Sellers neither in the eastern district nor in the township directly connected to Thaketa township via 66kV transmission line decrease their export value and quantity with their smaller margins and longer lead time in the wet season. In contrast, a new generator in Thaketa township helps a garment producer in Myanmar follow the similar trading patterns even during the wet season. Compared with the sellers in other regions, the sellers in the eastern district or in the township directly connected sell more quantities and increase their export value and their output-input price ratio with less lead time. These results imply that the distribution loss of electricity caused by the aging supply facilities is a crucial concern for sellers and that a new generator in Thaketa township plays a role in alleviating the halting of the production process caused by electricity shortages.

3.4 Conclusion

Although exporting has significant effects on firms and generates efficiency gains that narrow the gap between developed and developing countries, it is not easy for firms in developing countries to start exporting due to several challenges. One important area in their hardships is infrastructural instability. Since infrastructural instability reduces outputs and revenue by affecting input choices and productivity, infrastructural instability in developing countries is of crucial concern for linking domestic firms with foreign buyers.

This paper studies how trading practices are affected by the infrastructural instability in the context of the garment exporters in Myanmar. In this setting, I primarily focus on electricity shortages since we observe the seasonal variation in the number of blackouts and blackout duration and electricity shortages only affects firms' operational costs. By leveraging order-level export data and exploiting seasonal power outages in Myanmar, I compare how the export practices of sellers in Myanmar are different between dry seasons and wet seasons.

I find that garment exporters and international buyers decrease their trade value and volume in seasons of frequent power outages. This suggests that the frequent outages disrupt the garment exporters' production processes. Moreover, at an order level, as well as the decreases in the export volume and quantity, sellers decrease their export unit price. This implies that the international buyers have strong bargaining powers and squeeze suppliers' margins in these seasons.

I investigate whether or not buyers' characteristics are important during the wet season. For this purpose, I focus on the international buyers' sourcing strategies and positions. In the buyer's sourcing strategies, there are two completely different models in the garment industry: a spot sourcing strategy and a relational sourcing strategy. First, following Cajal-Grossi et al. (2020), I measure buyers' sourcing strategies. In Myanmar, international buyers of similar market size exhibit significant differences in their approach to sourcing. Next, I examine whether the effect of the outages is different across orders for buyers adopting different sourcing strategies. I find that on average, international buyers that adopt relational sourcing strategies pay significantly higher prices for the garments they purchase. This result implies that the international buyers adopting relational sourcing pay incentives suppliers in Myanmar. However, they change their incentive structures and shift to ordering high-quality products for longer periods in the seasons when the operational costs are high.

In uncompetitive market structures in developing countries, there is a room for abuse of upstream market power to squeeze the downstream suppliers' margins. I investigate whether that exploitative motivation by the large buyers is enhanced in the wet season. I find that the large international buyers place fewer orders with longer lead times by decreasing their trade value and quantity. Moreover, they squeeze the suppliers' margins only by increasing the unit input prices of orders. These results imply that these buyers retrieve their loss by squeezing the suppliers' margins further in the wet season.

I also examine whether the location of sellers induces different trading patterns of sellers by exploiting one interesting event in 2017. Focusing on the creation of a new generator in Thaketa township, I compare the trading practices of sellers in the same district of Thaketa township or in the township directly connected to Thaketa township via 66kV transmission line with the ones in other regions in Yangon. I find that while sellers not in the same regions based on these two criteria decrease their export value and quantity with their smaller margins, the ones in the same region sell more quantities and increase their export value and their output-input price ratio. These results suggest that the distance to an electric power plant is crucial for sellers to avoid the distribution loss caused by aging supply facilities.

These empirical findings suggest an important policy implication regarding how to promote exports, particularly in developing countries. Since infrastructural instability in developing countries is of significant concern for linking domestic firms with foreign buyers, an intervention that stabilizes the infrastructure is an important area to be improved. Moreover, even if the infrastructure is unstable, how to build the relationship with international buyers adopting relational sourcing strategies are potentially helpful for firms to keep their exports. Identifying how the effect of the infrastructural instability through trading practices influences welfare in developing countries could be avenues for future research.

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Tables

Table 3.1: Descriptive Statistics: Sellers

VARIABLES	(1) Observation	(2) Mean	(3) SD	(4) p25	(5) p50	(6) p75
$Count_s^o$	191	8.037	15.16	1	2	7
$Count_s^j$	191	2.236	1.813	1	2	3
$Count_s^b$	191	1.168	0.643	1	1	1
$Share_s^j$	191	0.739	0.325	0.493	0.976	1
$Share_s^b$	191	0.950	0.189	1	1	1
$Count_{sj}^o$	427	4.888	9.238	1	2	4
$Count_{sj}^b$	427	1.080	0.379	1	1	1

Note: Super- and sub-scripts are as follows: o corresponds to orders, s to sellers, b to buyers, j to HS 4-digit product categories. $Count_y^x$ is the number of x per y. For example, $Count_s^o$ is the number of orders per seller. $Share_y^x$ is the share of x in y. For example, $Share_b^s$ the average seller's share in buyer's trade. The column under the heading "Observation" reports the count of cells relevant to the level of aggregation of the variable in the row.

Table 3.2: Descriptive Statistics: Buyers

VARIABLES	(1) Observation	(2) Mean	(3) SD	(4) p25	(5) p50	(6) p75
$Count_b^o$	179	8.575	17.46	1	2	7
$Count_b^j$	179	2.302	1.896	1	2	3
$Count_b^s$	179	1.246	0.567	1	1	1
$Share_b^j$	179	0.732	0.335	0.472	0.976	1
$Share_b^s$	179	0.932	0.175	1	1	1
$Share_b$	179	0.00559	0.0131	0.000513	0.00124	0.00461

Note: Super- and sub-scripts are as follows: o corresponds to orders, s to sellers, b to buyers, j to HS 4-digit product categories. $Count_y^x$ is the number of x per y. For example, $Count_b^o$ is the number of orders per buyer. $Share_y^x$ is the share of x in y. For example, $Share_s^b$ the average buyer's share in seller's trade. The column under the heading "Observation" reports the count of cells relevant to the level of aggregation of the variable in the row.

Table 3.3: Trading Practices of Sellers between Dry and Wet Seasons

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Quantity)	ln(Value)	ln(# of Orders)	ln(# of Buyers)	ln(# of Categories)
Wet Season	-0.430***	-0.515***	-0.327***	-0.0194	-0.0659
	(0.106)	(0.147)	(0.101)	(0.0254)	(0.0581)
Seller FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	475	475	475	475	475
R-squared	0.748	0.661	0.745	0.578	0.666

Note: Value is measured by the US$. # of orders is the number of orders a seller receives at time t. # of buyers is the number of buyers from which a seller receives orders at time t. # of Categories is the number of HS 4-digit product categories a seller makes at time t. Wet Season takes 1 if time t is in the wet season (from May to October).
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 3.4: Trading Practices of International Buyers between Dry and Wet Seasons

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ln(Quantity)	ln(Value)	ln(# of Orders)	ln(# of Sellers)	ln(# of Categories)
Wet Season	-0.373***	-0.441***	-0.209**	0.0582**	-0.0213
	(0.101)	(0.147)	(0.104)	(0.0279)	(0.0543)
Buyer FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	474	474	474	474	474
R-squared	0.750	0.679	0.714	0.579	0.663

Note: Value is measured by the US$. # of orders is the number of orders a buyer places at time t. # of sellers is the number of sellers to which a buyer places orders at time t. # of Categories is the number of HS 4-digit product categories a buyer orders at time t. Wet Season takes 1 if time t is in the wet season (from May to October).
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 3.5: Trading Practices at Order Levels between Dry and Wet Seasons

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln(Quantity)	ln(Value)	ln(Output Price)	ln(Input Price)	ln(Ratio)	ln(Lead Time)
Wet Season	-0.118***	-0.140***	-0.0224	0.0390	-0.0614*	0.0778**
	(0.0321)	(0.0366)	(0.0188)	(0.0327)	(0.0370)	(0.0356)
Seller FE	Yes	Yes	Yes	Yes	Yes	Yes
HS Code FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Order Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,667	4,667	4,667	4,667	4,667	3,833
R-squared	0.678	0.631	0.716	0.714	0.584	0.760

Note: Value is measured by the US$. Output Price is the unit output price and it is derived by Value/Quantity. Input Price is the unit input price and it is the value of the imported goods divided by the quantity exported. Ratio is the output-input price ratio and it is the unit output price divided by the input price. Lead Time is the lead time per quantity. Wet Season takes 1 if time t is in the wet season (from May to October).
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 3.6: Location Choice

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Northern				Western			
$\mathbb{1}\{Year \geq 2005\}$	0.0327				0.00627			
	(0.0657)				(0.0272)			
$\mathbb{1}\{Year \geq 2010\}$		0.0358				0.00856		
		(0.0655)				(0.0273)		
$\mathbb{1}\{Year \geq 2015\}$			0.0676				-0.0105	
			(0.0669)				(0.0274)	
Established Year				0.00225				0.000358
				(0.00303)				(0.00110)
Observations	191	191	191	191	191	191	191	191
R-squared	0.001	0.002	0.005	0.003	0.000	0.001	0.001	0.000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Eastern				Other Districts			
$\mathbb{1}\{Year \geq 2005\}$	-0.0293				-0.00968			
	(0.0539)				(0.0405)			
$\mathbb{1}\{Year \geq 2010\}$		-0.0399				-0.00439		
		(0.0537)				(0.0403)		
$\mathbb{1}\{Year \geq 2015\}$			-0.0661				0.00891	
			(0.0531)				(0.0428)	
Established Year				-0.00222				-0.000391
				(0.00255)				(0.00179)
Observations	191	191	191	191	191	191	191	191
R-squared	0.002	0.003	0.007	0.004	0.000	0.000	0.000	0.000

Note: Northern is a dummy variable which takes 1 if firm i is located in Yangon Northern District. Western is a dummy variable which takes 1 if firm i is located in Yangon Western District. Eastern is a dummy variable which takes 1 if firm i is located in Yangon Eastern District. Other Districts is a dummy variable which takes 1 if firm i is located in other districts outside Yangon. $\mathbb{1}\{Year \geq 2005\}$ is a dummy variable which takes 1 if firm i was established after 2005. $\mathbb{1}\{Year \geq 2010\}$ is a dummy variable which takes 1 if firm i was established after 2010. $\mathbb{1}\{Year \geq 2015\}$ is a dummy variable which takes 1 if firm i was established after 2015. Established Year is the year when firm i was established.
* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 3.7: Buyers' Concentration and Sourcing

Top 100	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Observation	Mean	SD	p25	p50	p75
ln(Market Share)	100	-5.389	1.139	-6.350	-5.574	-4.652
ln(Relational)	100	-1.174	0.932	-1.773	-0.924	-0.558

All Buyers	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Observation	Mean	SD	p25	p50	p75
ln(Market Share)	179	-6.610	1.963	-7.575	-6.695	-5.379
ln(Relational)	179	-0.732	0.888	-1.099	-0.588	0

The two panels of this table report summary statistics of the log of buyer's market share and the baseline metric of buyer's sourcing following Cajal-Grossi et al. (2020).

Table 3.8: Buyers' Sourcing and Trading Practices between Dry and Wet Seasons

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln(Quantity)	ln(Value)	ln(Output Price)	ln(Input Price)	ln(Ratio)	ln(Lead Time)
Wet Season	-0.398***	-0.321***	0.0768*	0.270***	-0.193**	0.407***
	(0.0894)	(0.101)	(0.0392)	(0.0710)	(0.0808)	(0.102)
ln(Relational)	-0.185*	0.540***	0.725***	0.0295	0.696***	0.214
	(0.111)	(0.178)	(0.138)	(0.0788)	(0.175)	(0.138)
Wet Season × ln(Relational)	-0.106***	-0.0646	0.0419***	0.0710**	-0.0291	0.138***
	(0.0388)	(0.0414)	(0.0153)	(0.0315)	(0.0345)	(0.0427)
Seller FE	Yes	Yes	Yes	Yes	Yes	Yes
HS Code FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Order Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,667	4,667	4,667	4,667	4,667	3,833
R-squared	0.679	0.644	0.749	0.698	0.596	0.761

Note: Value is measured by the US$. Output Price is the unit output price and it is derived by Value/Quantity. Input Price is the unit input price and it is the value of the imported goods divided by the quantity exported. Ratio is the output-input price ratio and it is the unit output price divided by the input price. Lead Time is the lead time per quantity. Wet Season takes 1 if time t is in the wet season (from May to October). ln(Relational) is the log of the baseline metric of buyer's sourcing following Cajal-Grossi et al. (2020). Controls include three buyer-, relationship- and market-level covariates. Buyer controls include the log of the value imported by the buyer throughout my data and across all products, and the log of the number of months elapsed at the time of the order since the buyer was first observed in the data. Relationship controls include the log of the value traded by the buyer and seller throughout my data and across all products, the log of the number of months elapsed at the time of the order since the pair of the buyer and seller was first observed in the data, share of the seller in all of buyer's trade, and share of the buyer in all of seller's trade. A market control includes Herfindhal index which describes how concentrated the trade in a relationship is at the time of order.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 3.9: Buyers' Market Power and Trading Practices between Dry and Wet Seasons

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln(Quantity)	ln(Value)	ln(Output Price)	ln(Input Price)	ln(Ratio)	ln(Lead Time)
Wet Season	-0.0601	-0.0858*	-0.0258	0.00228	-0.0281	-0.0301
	(0.0486)	(0.0491)	(0.0204)	(0.0517)	(0.0516)	(0.0528)
Wet Season × Best 10	-0.173***	-0.147**	0.0258	0.182***	-0.156**	0.234***
	(0.0619)	(0.0688)	(0.0364)	(0.0587)	(0.0651)	(0.0676)
Seller FE	Yes	Yes	Yes	Yes	Yes	Yes
HS Code FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Order Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,667	4,667	4,667	4,667	4,667	3,833
R-squared	0.679	0.643	0.745	0.698	0.594	0.761

Note: Value is measured by the US$. Output Price is the unit output price and it is derived by Value/Quantity. Input Price is the unit input price and it is the value of the imported goods divided by the quantity exported. Ratio is the output-input price ratio and it is the unit output price divided by the input price. Lead Time is the lead time per quantity. Wet Season takes 1 if time t is in the wet season (from May to October). Best 10 takes 1 if buyer b is in the best 10 international buyers in the sample period. Controls include three buyer-, relationship- and market-level covariates. Buyer controls include the log of the value imported by the buyer throughout my data and across all products, and the log of the number of months elapsed at the time of the order since the buyer was first observed in the data. Relationship controls include the log of the value traded by the buyer and seller throughout my data and across all products, the log of the number of months elapsed at the time of the order since the pair of the buyer and seller was first observed in the data, share of the seller in all of buyer's trade, and share of the buyer in all of seller's trade. A market control includes Herfindhal index which describes how concentrated the trade in a relationship is at the time of order.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 3.10: Location and Trading Practices between Dry and Wet Seasons

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln(Quantity)	ln(Value)	ln(Output Price)	ln(Input Price)	ln(Ratio)	ln(Lead Time)
Wet Season	-0.236***	-0.236***	0.000257	0.164***	-0.163***	0.182***
	(0.0390)	(0.0475)	(0.0274)	(0.0332)	(0.0421)	(0.0432)
Wet Season × Eastern	0.312***	0.258***	-0.0547	-0.219***	0.165**	-0.302***
	(0.0791)	(0.0804)	(0.0385)	(0.0639)	(0.0661)	(0.0851)
Seller FE	Yes	Yes	Yes	Yes	Yes	Yes
HS Code FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Order Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,667	4,667	4,667	4,667	4,667	3,833
R-squared	0.643	0.744	0.698	0.594	0.761	

Note: Value is measured by the US$. Output Price is the unit output price and it is derived by Value/Quantity. Input Price is the unit input price and it is the value of the imported goods divided by the quantity exported. Ratio is the output-input price ratio and it is the unit output price divided by the input price. Lead Time is the lead time per quantity. Wet Season takes 1 if time t is in the wet season (from May to October). Eastern is a dummy variable, which takes 1 if seller s is in the eastern district in Yangon to which Thaketa township belongs. Controls include three buyer-, relationship- and market-level covariates. Buyer controls include the log of the value imported by the buyer throughout my data and across all products, and the log of the number of months elapsed at the time of the order since the buyer was first observed in the data. Relationship controls include the log of the value traded by the buyer and seller throughout my data and across all products, the log of the number of months elapsed at the time of the order since the pair of the buyer and seller was first observed in the data, share of the seller in all of buyer's trade, and share of the buyer in all of seller's trade. A market control includes Herfindhal index which describes how concentrated the trade in a relationship is at the time of order.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Table 3.11: Location and Trading Practices between Dry and Wet Seasons

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln(Quantity)	ln(Value)	ln(Output Price)	ln(Input Price)	ln(Ratio)	ln(Lead Time)
Wet Season	-0.228***	-0.228***	0.000305	0.156***	-0.156***	0.172***
	(0.0388)	(0.0472)	(0.0271)	(0.0332)	(0.0419)	(0.0430)
Wet Season × Connected	0.294***	0.236***	-0.0576	-0.195***	0.138**	-0.280***
	(0.0803)	(0.0810)	(0.0391)	(0.0654)	(0.0671)	(0.0863)
Seller FE	Yes	Yes	Yes	Yes	Yes	Yes
HS Code FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Order Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,667	4,667	4,667	4,667	4,667	3,833
R-squared	0.679	0.643	0.744	0.698	0.594	0.761

Note: Value is measured by the US$. Output Price is the unit output price and it is derived by Value/Quantity. Input Price is the unit input price and it is the value of the imported goods divided by the quantity exported. Ratio is the output-input price ratio and it is the unit output price divided by the input price. Lead Time is the lead time per quantity. Wet Season takes 1 if time t is in the wet season (from May to October). Connected is a dummy variable, which takes 1 if seller s is in the township directly connected to Thaketa township via 66kV transmission line. Controls include three buyer-, relationship- and market-level covariates. Buyer controls include the log of the value imported by the buyer throughout my data and across all products, and the log of the number of months elapsed at the time of the order since the buyer was first observed in the data. Relationship controls include the log of the value traded by the buyer and seller throughout my data and across all products, the log of the number of months elapsed at the time of the order since the pair of the buyer and seller was first observed in the data, share of the seller in all of buyer's trade, and share of the buyer in all of seller's trade. A market control includes Herfindhal index which describes how concentrated the trade in a relationship is at the time of order.

* Significant at the 10%. ** Significant at the 5%. *** Significant at the 1%.

Figures

Figure 3.1: Electric Power Consumption in Myanmar

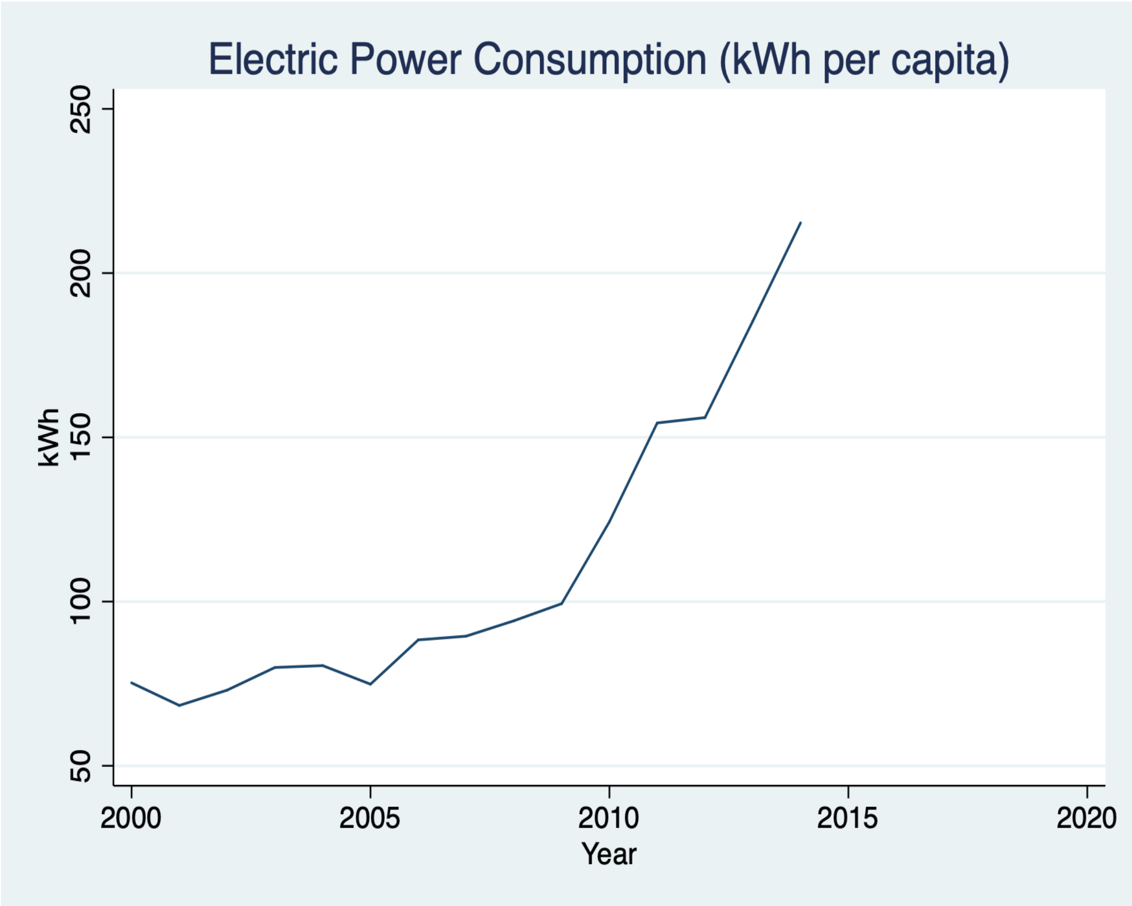

Figure 3.1 reports electric power consumption in Myanmar between 2000 and 2014. Its unit is kilowatt-hour per capita. Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants.
Source: World Bank Open Data

Figure 3.2: The Percentage of Population with Access to Electricity in Myanmar

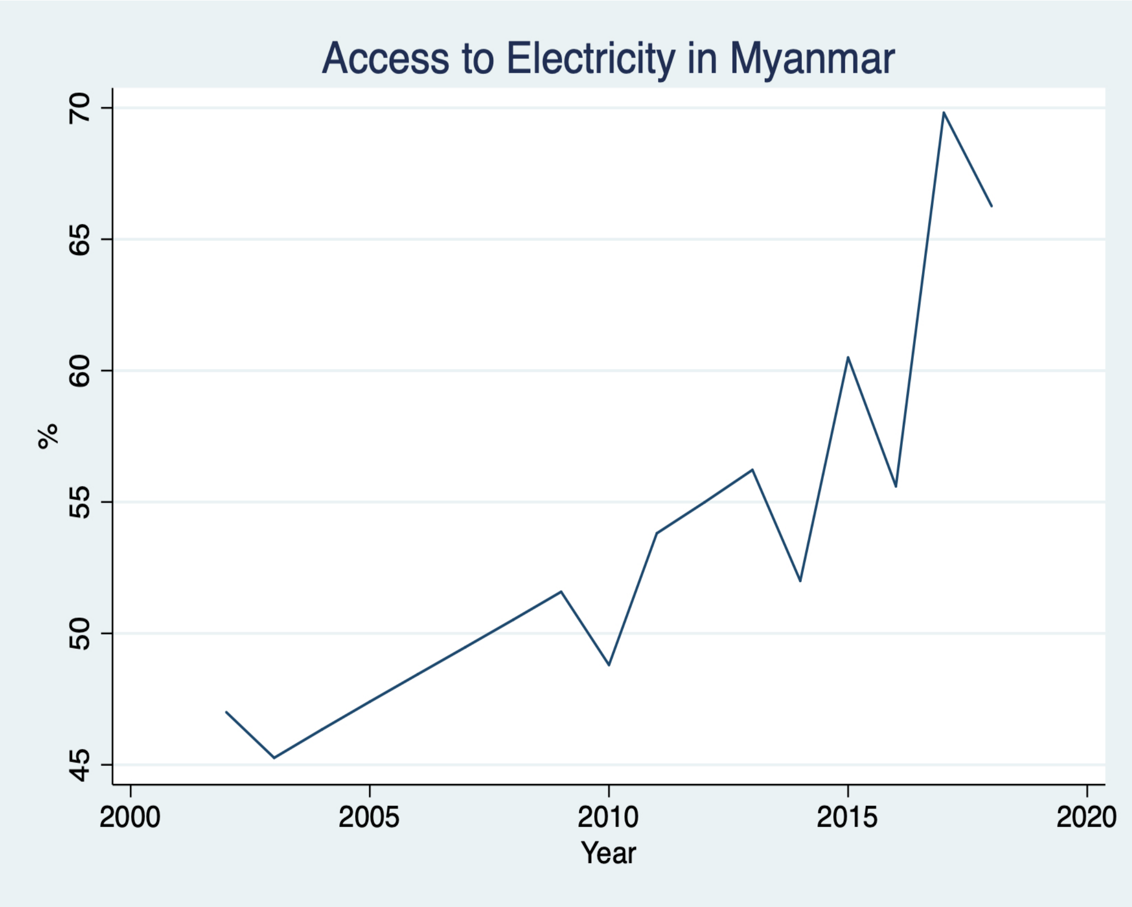

Figure 3.2 reports access to electricity in Myanmar between 2002 and 2018. Access to electricity is measured by the percentage of population with access to electricity.
Source: World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.

Figure 3.3: Number of Blackouts and Average Blackout Duration in Yangon

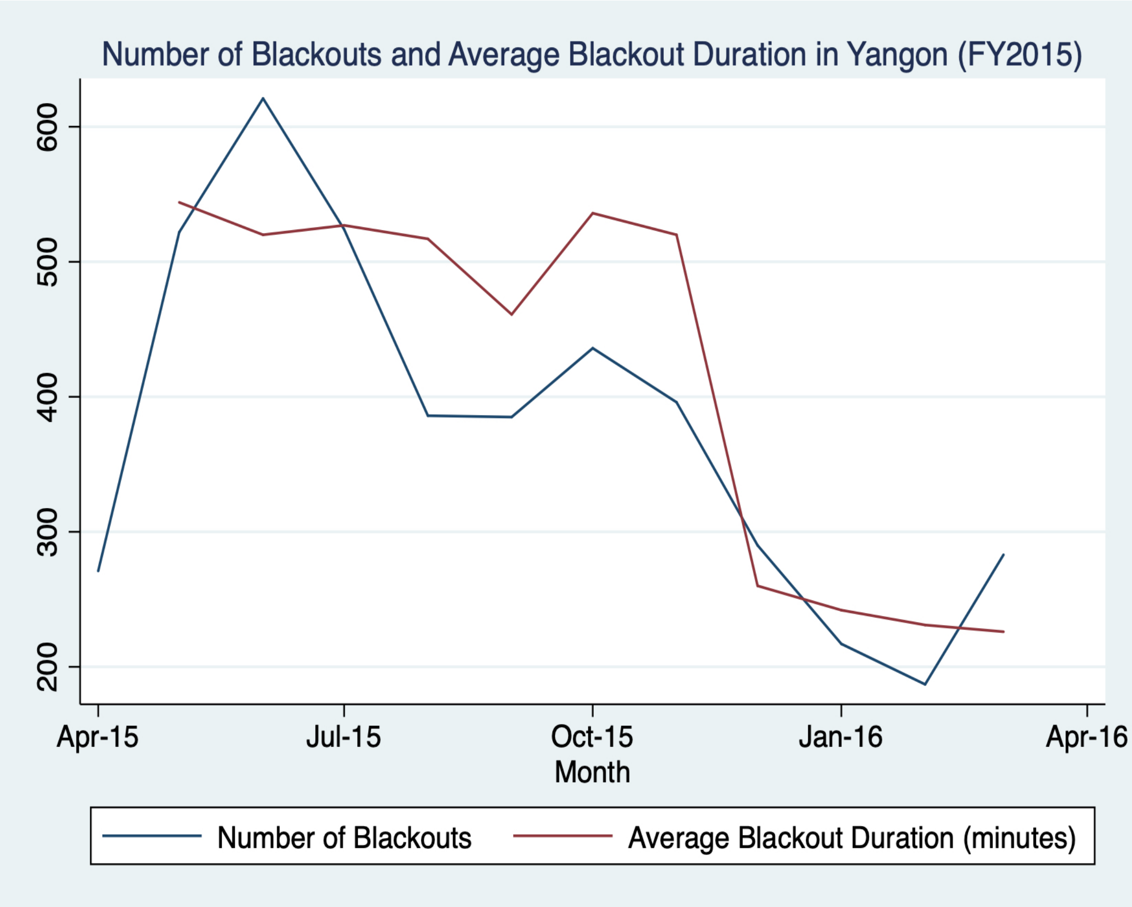

Figure 3.3 reports the number of blackouts and the average blackout duration in Yangon between April in 2015 and March in 2016. The unit of duration is the minute. The number of blackouts is measured by how many times the blackouts occur in Yangon. The average blackout duration is measured by how long on average it takes until recovery.
Source: Japan International Cooperation Agency (2018). Republic of the Union of Myanmar, Data Collection Survey on Urban Area Distribution Network Development: Final Report.

Figure 3.4: Myanmar Textiles and Clothing Exports to Five Major Countries between 2010 and 2018

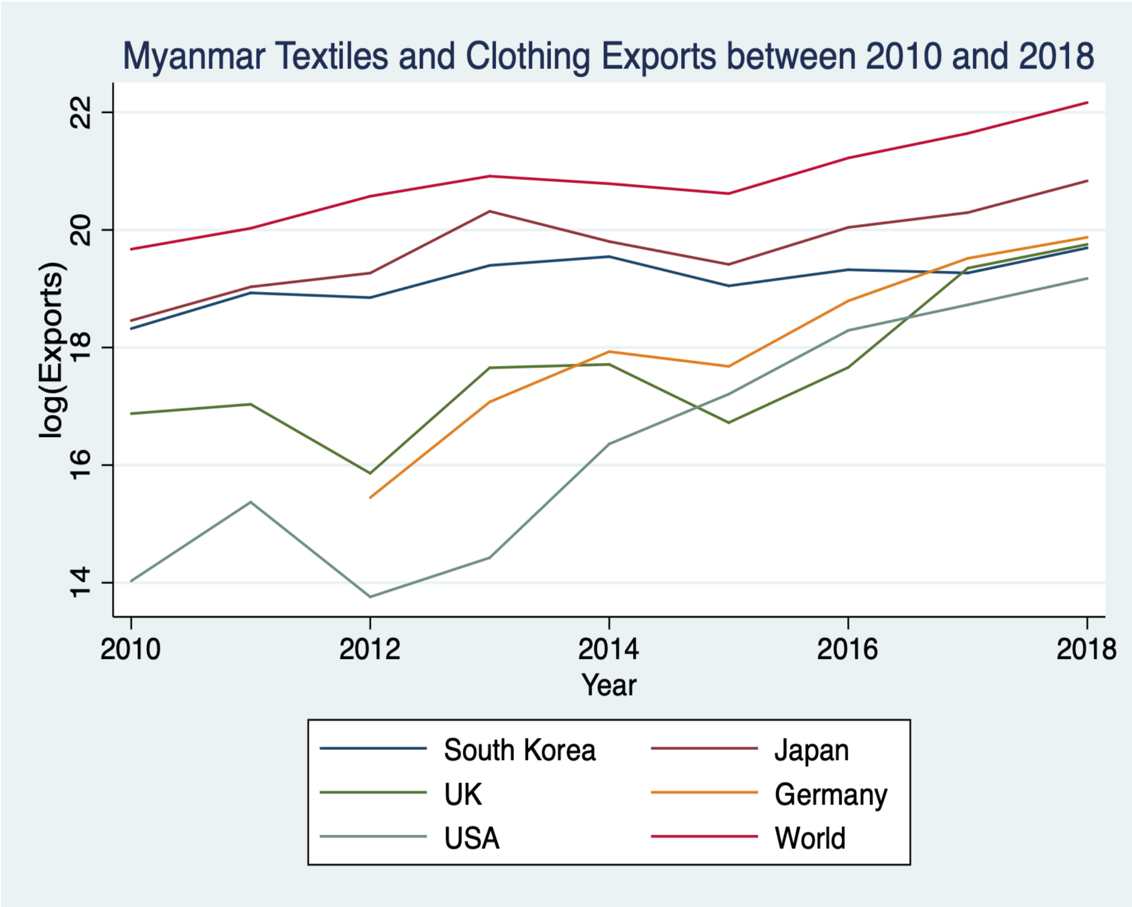

Figure 3.4 shows the total textiles and clothing exports of Myanmar and the exports of Myanmar to five major countries between 2010 and 2018. The five major countries are Germany, Japan, South Korea, the UK and the USA.
Source: The World Integrated Trade Solution

Figure 3.5: The Relationship between Market Share and Sourcing Strategy

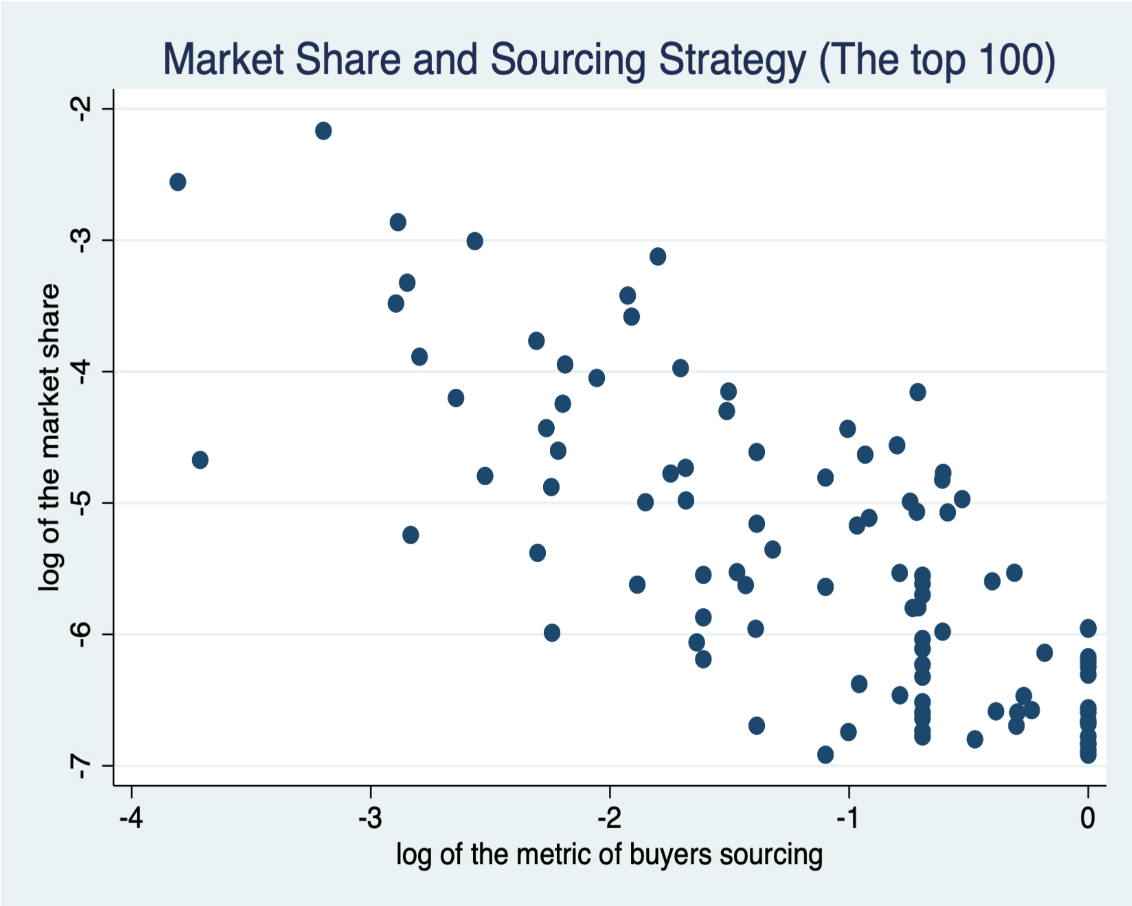

Figure 3.5 shows the correlation between the market share and the sourcing strategy across the top 100 international buyers in Myanmar. I measure the buyer's sourcing strategy following Cajal-Grossi et al. (2020). For the measure, I normalize the number of sellers the buyer trades with, by the number of shipments the buyer receives in each product, to construct a weighted average for each buyer across all products. This measure suggests that buyers reliant on spot sourcing tend to spread out their shipments across multiple suppliers, while relational buyers concentrate them on a set of core suppliers.

Figure 3.6: Map of Administrative Districts in Yangon

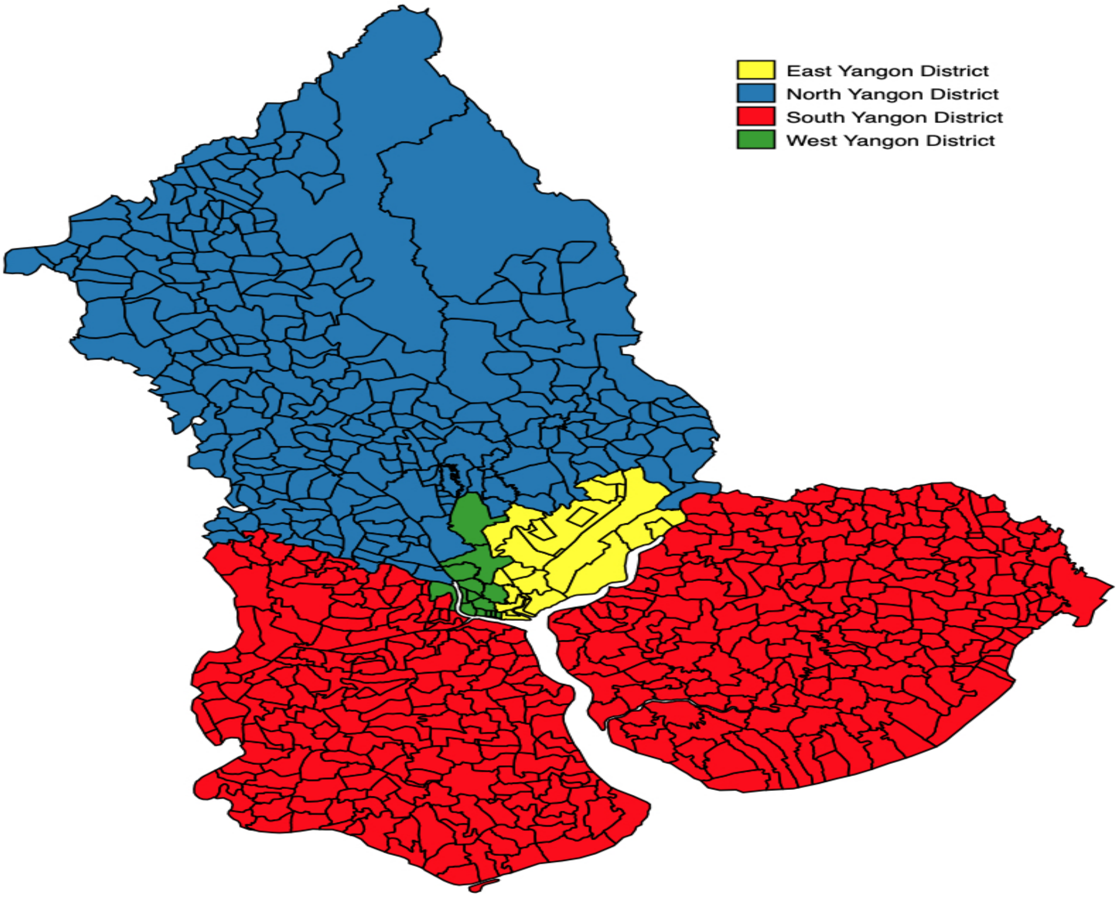

Figure 3.6 shows the map of administrative districts in Yangon by the Yangon City Development Committee (YCDC). Yangon Region is divided into four districts. The western district includes Ahlon, Bahan, Dagon, Hlaing, Kamayut, Kyauktada, Kyimyindaing, Lanmadaw, Latha, Mayangon, Pabedan, Seikkan and Sanchaung. The eastern district includes Thingangyun, Yankin,Dagon Seikkan, East Dagon East, Noth Dagon, South Dagon, South Okkalapa, North Okkalapa, Thakayta, Dawbon, Tamway, Pazuntaung, Botahtaung and Mingala Taungnyunt. The southern district includes Thanlyin, Kyauktan, Thongwa, Khayan, Twantay, Kawhmu, Kungyangon, Dala, Seikkyi/ Khanaungto, Cocogyun and Tada. The northern district includes Insein, Mingaladon, Hmawby, Hlegu, Taikkyi, Htantabin, Shwepyitha and Hlinethaya.

Figure 3.7: Map of Substations and Transmission Lines in Yangon in 2017

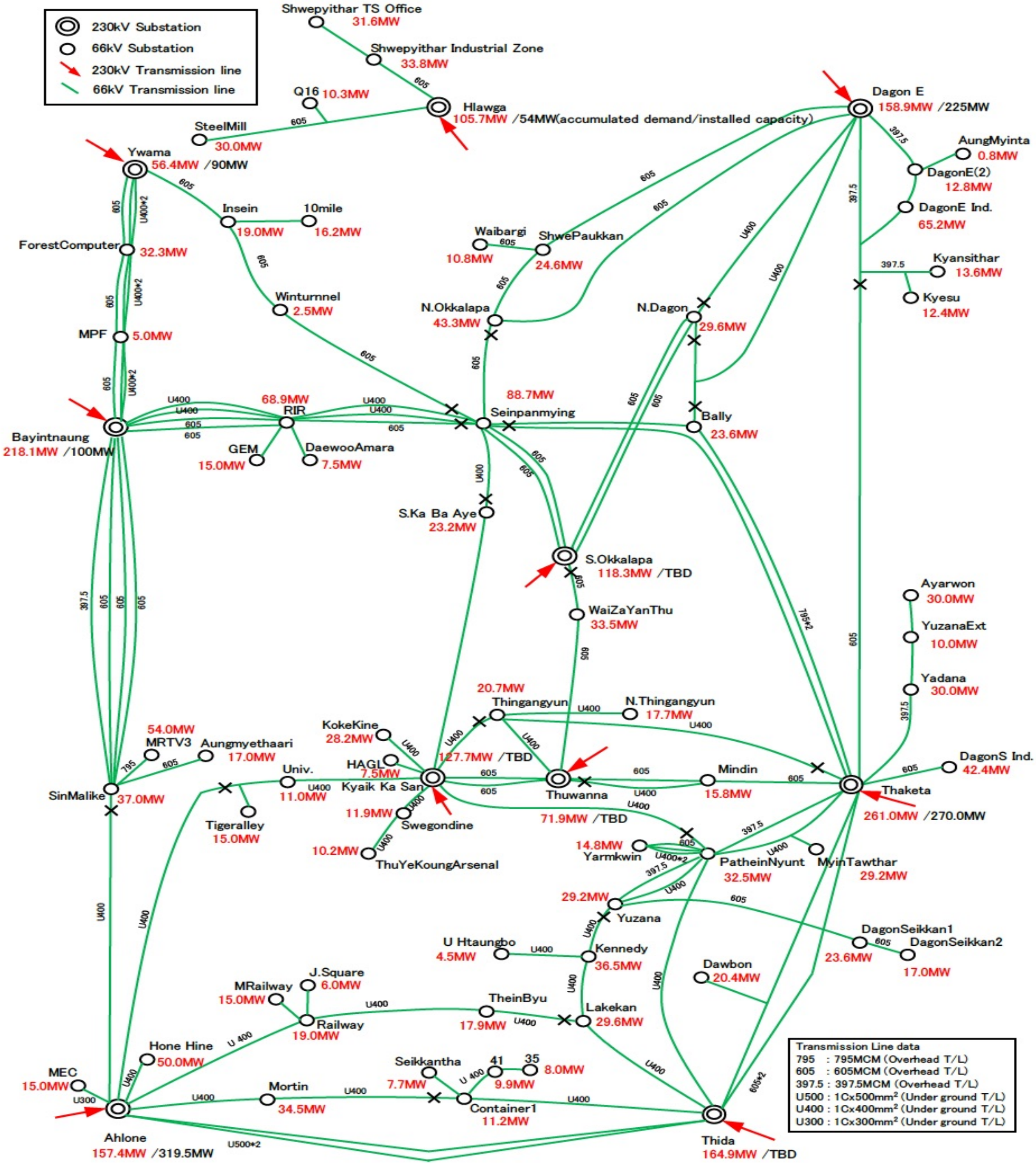

Figure 3.7 the map of 230kV and 66kV substations and 230kV and 66kV transmission lines in Yangon in 2017.
Source: Japan International Cooperation Agency (2018). Republic of the Union of Myanmar, Data Collection Survey on Urban Area Distribution Network Development: Final Report.