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ESSAYS ON INTERNATIONAL TRADE AND FIRM PERFORMANCE

a thesis

by

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Abstract

This thesis comprises an overview (Chapter 1) and five main chapters (Chapters 2 to 6) on international trade and firm performance in developing countries.

Chapter 2 examines whether developing countries could benefit from having a commodity exchange. We consider this question by studying the potential benefits of a commodity exchange for coffee exports in Ethiopia. Using a triple-differencing (DDD) approach, we find that that the introduction of coffee trading through a commodity exchange has led to a significant increase in Ethiopia's coffee export. We also find that having a commodity exchange has helped Ethiopia to export into new foreign markets. Therefore, policy intervention such as the establishment of a commodity exchange can help to reduce market-related barriers of trade faced by developing countries.

Chapter 3 examines the impact of landlockedness on trade by exploiting a novel natural experiment associated with the transition of Ethiopia from a coastal to a landlocked country. Ethiopia became *de facto* landlocked following a conflict with Eritrea in 1998. Using triple-difference and synthetic control approach, we find that landlockedness has a large negative effect on Ethiopia's exports and imports. Specifically, on average, landlocked geography has contributed to a 43-80% and 67-71% reduction in Ethiopia's ocean-borne exports and imports, respectively. The landlockedness "shock" of Ethiopia also has a persistent effect on trade across time, suggesting that the influence of landlockedness in general is long-lasting.

Chapter 4 examines how landlockedness affects firm productivity by reducing the firm's access to imported inputs. We use the same quasi-natural experiment as Chapter 3 to identify the casual effect of landlockedness on productivity and employ a rich census dataset on Ethiopian manufacturing firms over the period 1996-2006. We find that landlockedness leads to a productivity loss of 14% for firms that rely on imported inputs. We also find that the negative effect of landlockedness is especially

strong for small and private-owned firms.

Chapter 5 uses data on over 33,000 firms from 94 countries to study if genetic distance from the world technology frontier, the United States, influences firm productivity in laggard countries. The thesis adopts a novel method on quantile treatment models and find that genetic distance to the global frontier has an economically and statistically significant effect on firm productivity. Firms operating in a country that are genetically far from the technology leader tend to have lower levels of productivity with the largest negative impact observed at the higher quantiles.

Chapter 6 investigates if the presence of foreign-owned firms in sub-Saharan African countries (SSAs) can help to reduce domestic firms' financial constraints. Using firm-level data spanning across 36 SSAs from the World Bank Enterprise Survey, we find that an increase in foreign firm presence can ease the financial constraints of domestic firms in the SSAs. One reason is that foreign-owned firms are not only less financially constrained, they are also less likely to apply for bank loans. Therefore, an increase in foreign firm presence may reduce the competition for loans and ease the financial constraints of domestic firms by improving their borrowing success.

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Declaration

I certify that this work contains no material that has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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HABTAMU TESFAYE EDJIGU

SIGNATURE .... DATE 10-10-2018

Dedication

To My Beloved Brother Abiyot Tesfaye Edjigu

Chapter 1

Introduction

Over the last few decades, trade liberalization and market reforms have become more widespread throughout developing countries. For example, in 2008, Ethiopia introduced a modern commodity exchange market, the Ethiopian Commodity Exchange (ECX), that had later generated much interest from policy makers in Ghana, Nigeria, Mozambique, Rwanda and Kenya. This is despite the fact that there is little empirical evidence of the efficacy of a commodity exchange. The goal of **Chapter 2** is to shed light on the benefits of having a commodity exchange for developing countries by studying how the establishment of the ECX has affected the export of coffee in Ethiopia.

Prior to the establishment of the ECX, commodities including coffee were traded bilaterally between farmers and buyers who traveled to meet them. At that time, farmers usually did not have information about the prevailing retail price in other markets and the price offered by wholesalers or exporters. Consequently, exploitative intermediaries or middlemen', who were well informed about the market price, would buy commodities from smallholder farmers at relatively lower prices and sell them to wholesalers or exporters at higher prices. The lack of reliable price information in other markets therefore limited the ability of farmers to negotiate a better price. Moreover, farmers often faced high risk of default by buyers, as there was very limited legal means that farmers could use to enforce contracts. For example, Gabre-Madhin (2012) showed that 67% of the internal commodity trade faced contractual default. Because of such risk, trade was limited to short distances and confined to networks of family members, friends and ethnic connections, which made the sector unprofitable to invest in (Gabre-Madhin, 2001). According to Gabre-Madhin (2001) and Gabre-Madhin and Goggin (2005), the weak infrastructure combined with poor market institutions had limited the potential scale of coffee production and volume of export in Ethiopia.

In 2008, the Ethiopian government sought to overcome these issues by establishing a commodity exchange market, the Ethiopian Commodity Exchange (ECX), which replaces the countrys traditional coffee auction floor to a modern market exchange system with a market-clearing price determined competitively at the exchange itself. The ECX provides several services to facilitate coffee transactions. For instance, it provides daily market information through electronic display boards (ticker boards) that are established in coffee producing villages, and disseminate information using Interactive Voice Response (IVR), message services (SMS) and through the ECX's website. It also provides warehouses for storage and for facilitating quality testing of coffee produced in the local villages. Finally, the ECX helps in the underwriting and enforcing of standard trading contracts and payments through its partner settlement banks. These services raise the profitability of coffee farming and motivate the farmers to produce larger quantities of higher quality coffee for the export market. Nevertheless, there is still a debate on whether ECX is successful. For example, some had argued that a commodity exchange is an advanced market mechanism that only functions well in industrialized countries (Gabre-Madhin and Goggin, 2006). Sitko and Jayne (2012) also document that the performance of agricultural commodities exchanges in Africa remain poor due to the limited success in attracting financial institutions, conflict of interest among brokers, and the high fixed costs of trading in the commodities exchanges. In addition, exporters in Ethiopia has complained about price-meddling by authorities (Ferreira et al., 2017).

In Chapter 2, we exploit the ECX as a quasi-natural experiment to study the effect of a commodity exchange on coffee exports. To estimate the effect of the ECX on the coffee exports of Ethiopia, we implement a triple difference-in-differences (DDD) approach within a gravity framework. This approach exploits country-commodity-year variation in export.[1] It also has certain advantages over the standard difference-in-differences (DD) approach that is based either on a commodity-level or country-level analysis. For example, a commodity-level DD would consider the exports of coffee (the treatment) and non-ECX commodities (the control) from Ethiopia and compare their trends before and after the establishment of the ECX. However, such a comparison may falsely attribute the effects of macroeconomic shocks on coffee to the ECX, especially if these shocks and the ECX had happened at the same time. Similarly, a country-level DD approach would consider the exports of coffee from Ethiopia (the treatment) and Kenya (the control) and compare the response of their coffee exports before and after the establishment of the ECX. However, such a comparison may also falsely attribute a response in Ethiopian coffee exports, caused by institutional reforms and infrastructural improvements, to the ECX. The triple difference-in-differences approach enables us to avoid these confounding issues. In particular, when we employ this approach, we find that the introduction of the exchange has a strong effect in increasing Ethiopia's coffee exports. In addition, we find that ECX has positive and statistically significant impact on the country's coffee export into new foreign markets.

Despite market reforms and trade liberalization, some countries may still experience low levels of participation in international trade. One reason is due to poor geography, such as landlockedness (Milner and Zgovu, 2006; Clark, 2014), which increases the cost of trade. For the trade in goods, landlocked countries depend on other countries for transit. As such, they face significant barriers of trade such as the barrier of long distances to global markets, huge port fees, and inconvenient transit procedures that contribute to high transport and time costs. Landlocked countries have an import share to GDP of 11 percent compared with 28 percent for coastal countries. Their average per-capita export volume is less than half of that of their coastal neighbors (World Bank, 1998; Faye et al., 2004). While cross-country studies on this area (e.g. Limao and Venables, 2001; Raballand, 2003; Coulibaly and

[1]Country-commodity-year variation refers to the three source of variation exploited to identify the effect of the ECX on export : i) country variation (Ethiopia and Kenya), ii) commodity variation (ECX product versus non-ECX products) and iii) year variation (before and after the introduction of ECX).

Fontagné, 2006; World Bank, 2014) suggest that landlocked countries trade less than coastal countries, there is no evidence that this effect is causal.

In **Chapter 3**, we provide the first natural experimental evidence on the causality and persistence of the effect of landlockedness on trade. Our natural experiment comes from the sudden transition of Ethiopia from a *de-facto* coastal country to a *de facto* landlocked one in 1998. Prior to the separation of Ethiopia and Eritrea, Ethiopia was a coastal country that uses Port of Assab, which is located in the province of Eritrea, as its main seaport. In 1993, however, Eritrea became an independent state and Ethiopia became a *de jure* landlocked. Despite so, there was an agreement between Ethiopia for Ethiopia's free and unrestricted use of the port of Assab located in the independent Eritrean state (IMF, 1997; Faye et al., 2004; Connell and Killion, 2010). This continued until 1998, where a territorial dispute led to the start of Eritrean-Ethiopian war and Port of Assab was immediately closed. From this moment onwards, Ethiopia became both *de jure* and *de facto* landlocked.

To estimate the effect of landlockedness, we employ two approaches: the triple difference-in-differences approach and the synthetic control approach. The triple difference-in-differences approach enables us to use a span of fixed effects to identify the "treatment" effect of landlockedness on trade. The synthetic control approach provides us with a data-driven method to obtain a control group that mirrors Ethiopia's pre-intervention trend as closely as possible. Our empirical results reveal that landlockedness has a large negative impact on Ethiopia's exports and imports: on average, being landlocked reduces Ethiopia's ocean-borne exports and imports by about 43-80% and 67-71%, respectively.[2] We also find that the landlockedness shock has a persistent effect on trade, suggesting that the negative influence of landlockedness is not easily overcome.

The negative effect of landlockedness on trade raises a question whether it could affect the productivity of firms. Following on from **Chapter 4**, we exploit the 1998 Ethiopia-Eritrea war as a natural experiment to examine the effect of landlockedness

[2] Because landlockedness primarily affects land and sea freight than air freight, this "closing in" of Ethiopia should affect the trade of bulky, low-valued goods more strongly than the trade of light, high-valued goods.

on firm-level productivity. We find that landlockedness leads to a productivity loss of 14% for firms depend on imported inputs. To explain the possible channels for why landlockedness has a negative effect on the productivity of firms, we show that landlockedness has a negative effect on both the extensive margin (number of importing and exporting firms) and the intensive margin (volume of imports and exports per firm), which may explain why landlockedness could adversely affect the productivity of firms.

Concerning firm productivity, recent literature has sought to explain why there are large and persistent differences in productivity across countries. For example, Spolaore and Wacziarg (2009) argue that genetic distance, which captures a wide array of cultural traits transmitted intergenerationally over the long run within populations, is a source of prolonged differences in productivity across countries. The central argument of Spolaore and Wacziarg's (2009) hypothesis is that genetic distance hinders the diffusion of technologies from the technological leader to the laggard countries. Thus, large genetic distances can explain large differences in income per capita across countries. Building upon the existing literature (Ashraf and Galor, 2013; Ang and Kumar, 2014; Bove and Gokmen, 2017, see, also,), in **Chapter 5**, we use firm-level data on over 33,000 firms from 94 countries and employ the group quantile IV methodology proposed by Chetverikov et al. (2016, Econometrica) to show that genetic distance to the global frontier has an economically and statistically significant effect on firm productivity. We find that firms operating in a country that are genetically far from the technology leader tend to have lower levels of productivity.

Access to finance is one of the most important concerns for firms in sub-Saharan Africa. In **Chapter 6**, we use firm-level analysis to study if the presence of foreign-owned firm can help to reduce the financial constraints of domestic firms. Using cross-country firm-level data that spans across 36 SSAs, we find that in industries with a larger foreign firm presence, domestic firms tend to be less financially constrained. We also find that foreign-owned firms are not only less financially constrained, they are also less likely to borrow from banks. Moreover, in industries where foreign firm presence is larger, domestic firms tend to have greater success in securing bank loans. Therefore, one explanation for why foreign firm presence can help to reduce the financial constraints of domestic firm is that foreign firms are less in need of credit. As such, the presence of foreign firms reduces the competition for bank credit, which helps to improve financial access for domestic firms.

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Chapter 2

Agricultural Commodity Exchange and Trade in Developing Countries: Evidence from a Quasi-natural Experiment

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i. the candidate's stated contribution to the publication is accurate (as detailed above);

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iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Abstract

Would developing countries benefit from having a commodity exchange? We consider this question by studying its effects on coffee exports in Ethiopia. Coffee farming is the most important agricultural activity in Ethiopia, as it supports the livelihood of 15 million farmers and generates a quarter of the country's export. In April 2008, the government of Ethiopia introduced the Ethiopian Commodity Exchange (ECX) to provide reliable market information and storage facilities to farmers, especially coffee producers, which help them engage in the export industry. Using a triple-differencing (DDD) approach, we find that the introduction of coffee trading through the ECX has led to a significant increase in Ethiopia's coffee export. We also find that the ECX has led to the export of coffee into new foreign markets. Our paper is related to recent initiatives by governments and international organizations to introduce agricultural commodities exchanges in developing countries. We provide quasi-natural experimental evidence to show that such initiatives can help to reduce market-related barriers of trade faced by these countries.

Key Words: Commodities Exchange, Coffee Export, Ethiopia, Triple Differences

JEL Codes: D47, Q13, F14, F6

2.1 Introduction

Many developing countries rely on the exports of agricultural commodities sector as a main source of national income (Reardon and Timmer, 2007; World Bank, 2008; Gollin, 2010).[1] However, in these countries, there are also structural issues that prevent markets for agricultural commodities from functioning well. For example, agricultural producers require reliable price information, sound contractual agreements, and extended marketing chains, which these countries lack (Gabre-Madhin and Goggin, 2005; Mutenyo, 2011; Gabre-Madhin, 2012)(Tiffin and Irz, 2006; Byerlee et al., 2009; Islam, 2016). Moreover, they also require strong institutions to protect themselves from being exploited by intermediaries (Gabre-Madhin, 2001; Gabre-Madhin and Goggin, 2006; Goyal, 2010). Without strong institutions, the profitability of farmers, their incentives to produce, and consequently their export earnings could be curtailed (UNCTAD, 2009; Goyal, 2010).

It has been argued that these structural challenges can be addressed with the help of an agricultural commodity exchange, which is a centralized market place where sellers and buyers meet to transact commodities in an organized fashion (UNCTAD, 2009). Modern commodity exchange platforms, for instance, may eliminate exploitative intermediaries, provide more transparency on the prevailing market price to farmers, and ultimately, promote agricultural production and exports. For this reason, governments and international organizations have worked together to introduce agricultural commodities exchanges in their own countries, which they hope would reduce such market-related barriers.[2] Empirically, while it seems intuitive that commodity exchanges would help the agricultural commodities sectors, we do not have strong evidence that developing countries would benefit from having a commodity exchange, especially when it is an advanced market mechanism.

In this paper, we exploit a quasi-natural experiment to study how having a

[1]Different studies illustrate that agriculture is the primary source of income in developing countries. For example, 65% of the labor force is employed in agriculture (World Bank, 2008). Moreover, for African and South Asian countries, the share of agricultural output to GDP exceeds 40% and agricultural export constitute 15-30% of GDP (World Bank, 2008; Gollin, 2010).

[2]For example, UNCTAD is working with the African Union, with national governments and the private sector to develop agricultural commodity exchanges. Many emerging countries such as India, Brazil, China, Malaysia and the South Africa have also introduced modern commodities exchanges.

commodity exchange affects coffee exports in Ethiopia. In April 2008, the Ethiopian government introduced a commodities exchange market, called the Ethiopian Commodity Exchange (ECX), to replace the countrys traditional coffee auction floor.[3] The ECX provides several services to facilitate coffee transactions. For instance, it provides daily market information through electronic display boards (ticker boards) to coffee producing villages, where information are disseminated using Interactive Voice Response (IVR), message services (SMS) and through the ECX's website. It also provides warehouses across the country that facilitate storage and quality testing. Finally, the ECX facilitates standard trading contracts and payments through its partner settlement banks. These services raise the profitability of coffee farming and motivate the farmers to produce larger quantities of higher quality coffee for the export market.

To estimate the effect of the ECX on the coffee exports of Ethiopia, we implement a triple difference-in-differences (DDD) approach within a gravity framework. For identification, the triple differencing approach has certain advantages over the standard difference-in-differences (DD) approach. If we implement the latter, we could only compare the treatment and control between commodities (for the same country) or between countries (for the same commodity). For example, a commodity-level DD would look at the exports of coffee (the treatment) and non-ECX commodities (the control) from Ethiopia and compare how their trends before and after the establishment of the ECX. However, such a comparison may falsely attribute the effects of macroeconomic shocks on coffee to the ECX, if these shocks and the ECX occurred at the same time. Similarly, a country-level DD approach would consider the exports of coffee from Ethiopia (the treatment) and Kenya (the control) and compare the response of their coffee exports before and after the establishment of the ECX. However, such a comparison may also falsely attribute a response in Ethiopian coffee exports, caused by factors such as institutional reforms and infrastructural improvements, to the ECX.

[3]Ethiopian coffee farmers are now required to sell their coffee at designated primary markets, where only certified buyers are allowed to make purchases. Similarly, coffee processors must receive approval to use designated warehouses, where their products are graded based on whether they are suitable for the export market or are only for sale in the domestic market.

The triple-differencing approach addresses these issues by comparing the difference between the exports of coffee (an ECX product) and a non-coffee product (a non-ECX product) of Ethiopia to the difference between the exports of coffee and a non-coffee product of Kenya.[4] Because the triple difference exploits country-commodity-year variations in exports, we may employ fixed effects with more complex structures to deal with potential confounders that a standard DD approach cannot deal with. Here, we follow Magee (2008) and Cheong et al. (2017) to include the full set of country-pair, exporter-year, exporter-product, product-year, and importer-year fixed effects into our gravity model.[5]

Our estimates show that as a policy, the establishment of the ECX has been an effective means for promoting exports. Specifically, Ethiopia has seen an 84% increase in coffee export on average after the ECX was established. This impact is twice as large as the impact of joining regional trade agreements, trade concessions, and importer tariff reductions.[6] Our estimates also show that the establishment of the ECX does not have spillover effects on non-ECX products, in the sense that while the ECX has led to a significant increase in Ethiopia's coffee export, there is no evidence that it has reduced the export of a non-ECX commodity. Finally, our results show that the ECX not only affects coffee exports along the intensive margin, but it also has a statistically significant impact on coffee exports along the extensive margin.

This paper makes two contributions. Firstly, it speaks to the debate on whether a commodity exchange is effective for promoting exports in developing countries. For Ethiopia, the ECX potentially affects over 4.2 million smallholder farmers and

[4]We consider Kenya as a control country since this country is the largest coffee Arabica exporter in Africa. Kenya has also no functional agricultural commodities exchange.

[5]According to Ghosh and Yamarik (2004) and Magee (2008), the gravity model is sensitive to the choice of different covariates. Magee (2008) demonstrate that controlling a whole set of fixed effects in the gravity model allows to capture the different determinants of trade. For example, importer-exporter fixed effects helps to capture all unobserved time-invariant factors that affect the bilateral trade between two countries. Similarly, importer-year fixed effects capture all time-invariant and time-varying characteristics of the importer country, such as GDP per capital and population.

[6]For example, Frazer and Van Biesebroeck (2010) show that export may increase by as much as 40% due to US trade concession policy for Africa (also known as AGOA), and Cheong et al. (2017) shows that Pakistan export increases by around 45% following a temporary removal of tariff.

more than a quarter of the countrys export earnings,[7] but its effect on export is not empirically investigated. While a commodity exchange seems to be useful for promoting exports, some have argued that an exchange is an advanced market mechanism that only functions well in industrialized countries.[8] The differing views on this issue, however, are based mainly on anecdotal evidence. Therefore, our paper hopes to provide some statistical evidence to shed light on this issue.

Secondly, our paper contributes to the literature methodologically by providing quasi-natural experimental evidence on the impact of the commodity exchange in the developing countries context. The original ECX project was aimed at facilitating the exchange of food grains including wheat, maize and beans. However, the world food crisis adversely affected the domestic grain market, and led to a tripling of prices. The slowdown of trading food grains, which is an external shock, resulted in the introduction of coffee trading into the exchange. Therefore, the introduction of coffee in the ECX platform was not pre-meditated, but was driven by events that affected food supply.[9] It is in this regard that the ECX is the best quasi-natural experiment for studying the impact of a commodity exchange in the developing countries context.

The rest of the paper is structured as follows. Section 2.2 provides background on Ethiopian Commodities Exchange. Section 2.3 describes the empirical strategy. Section 2.4 describes the data. Section 2.5 present results and finally section 2.7 concludes.

[7]See Minten et al. (2014) and Craparo et al. (2017) for more detail.

[8]For example, Sitko and Jayne (2012) have shown that the performance of agricultural commodity exchanges in Africa is poor because of the limited success in attracting financial institutions to the modern market platform, conflict of interest among brokers, and the high fixed costs of trading in the commodity exchanges. In fact, Van der Mheen-Sluijer (2010) has expressed doubts on the ECX's success in achieving the demands of coffee importers. Ethiopian coffee exporters were also complaining about issues of price-meddling by government authorities (Ferreira et al., 2017).

[9]A program is endogenous when the program itself is non-random and/or when the program participants are non randomly selected

2.2 Background

A. Coffee Market in Ethiopia

Ethiopia has a long history in coffee production and is now the largest coffee producer in Africa.[10] Coffee is also the main export commodity of Ethiopia. It contributes to nearly 25 percent of the country's total export and supports the livelihood of more than 15 millions of people (Moat et al., 2017). Therefore, policy makers in Ethiopia look towards coffee production as a means of raising smallholders income, government revenue, and foreign currency (Petit, 2007).

Prior to 1991, the coffee market in Ethiopia was regulated by the government through its agency, Ethiopia Coffee Market Corporation (ECMC). During this time, the government tightly controlled the trade and price of coffee. Farmers in the main coffee growing area were given a certain quota to supply coffee, at a fixed price, to the government (through the ECMC). The Central Bank of Ethiopia also sets the minimum export price while the Ministry of Coffee and Tea determined the domestic price (Petit, 2007; Gemech and Struthers, 2007; Andersson et al., 2017).

Following the dismantling of Ethiopia's socialist regime in 1991, the transitional government undertook market reforms that affected coffee production and marketing. For example, the ECMC was closed, the coffee market was deregulated, and license fees and tariffs for coffee trading were reduced. The export price controls and local coffee price floors were also abolished (Petit, 2007). All these reforms were made to encourage and expand the private sector's participation in the coffee market, and to stimulate production and improve export earnings from coffee (Gemech and Struthers, 2007).

However, while these reforms had led to a larger number of private firms in the coffee trade, little had changed in the marketing and distribution of coffee and other agricultural products (Gabre-Madhin and Goggin, 2006). In fact, prior to the establishment of the ECX, coffee farmers often did not know what the prevailing retail price in different markets and the price offered by wholesalers or exporters were. This

[10] For example, Ethiopia is believed to be the origin of coffee Arabica.

gave rise to exploitative intermediaries or middlemen, who were well informed about the market price, to buy coffee from smallholders farmers at lower prices and sell them to wholesaler or exporters at higher prices. The lack of reliable price information in other markets had also limited the farmers' bargaining power in price negotiation. Moreover, the farmers also faced high risk of default as there were limited legal means of enforcing contracts. For example, Gabre-Madhin (2012) showed that 67% traders faced contractual default. To manage such risk, trade was limited to short distance markets and confined to network of family members, friends and ethnic connection, which made the sector unprofitable to invest in (Gabre-Madhin, 2001).[11] Therefore, weak infrastructure and market institutions, which affected the marketing and distribution of coffee, had limited the potential scale of coffee production and export in Ethiopia (Gabre-Madhin, 2001; Gabre-Madhin and Goggin, 2005).

B. The Ethiopian Commodity Exchange

The establishment of the Ethiopian Commodity Exchange (ECX) was preceded by a series of events unrelated to the coffee industry. In 2000 and 2001, Ethiopia had a bumper crop, mostly grains, which led to a 60 to 80 percent drop in price of these surplus goods (Gabre-Madhin, 2012). Because of weak market systems and transportation costs, the surplus agricultural production were not transported and distributed to regions that had relatively less supply, which curtailed farmers' profits of harvesting grains in those years. As such, many were unable to pay for fertilizers, which led to a cut-back on fertilizer use,[12] and consequently, a significant decline in agriculture production in the following year (Gabre-Madhin, 2012). This series of events culminated into a major food crisis, which subjected 14 million Ethiopians to potential famine, highlighted the need for Ethiopia to adopt a modern agricultural commodities marketing and distribution system (Gabre-Madhin, 2001).

Faced with such risk, the Ethiopian government launched a modern market system – the ECX – in 2008. The ECX started with a spot trading and "open outcry" bidding

[11] Because there was no warehousing and clearance system, coffee had to physically moved to the trading floor. Moreover, since there was no warehousing across coffee producing villages, producers bear most of the transportation costs associated with selling to exporters.

[12] Farmers were unable to pay for fertilizer. Thus, fertilizer use was reduced by 27 percent.

system, which was appropriate for the level of technology and institutional system of the country at that time. The original ECX project was aimed to facilitate the trading of food grains including wheat, maize and beans. However, the world food crisis adversely affected domestic grain price, causing it to rise by 200 percent in June 2008. The slowdown of food grains trade resulted in the introduction of coffee to the exchange and the suspension of Ethiopia's traditional coffee auction floor.[13]

Coffee trade has benefited from three main services provided by the ECX. Firstly, the ECX provides daily market information through electronic display boards (ticker boards) to coffee producing villages. In addition, information is disseminated using Interactive Voice Response (IVR), short message services (SMS) and through the ECX website. Secondly, it provides warehouses for storage and to facilitate quality testing of coffee supplied by coffee producing villages. Thirdly, the ECX facilitates standard trading contracts and payments through its partner settlement fbanks. The main rationale for introducing the ECX is to avoid exploitative intermediaries (i.e. the middlemen), increase farmers' revenue and production, ultimately, to raise export earnings.

The ECX is successful in many aspects. For example, after the ECX was established, coffee farmers were able to receive up to 70% of the final export price than the 38% they had received prior to the ECX (Gabre-Madhin, 2012). In 2011, the total value of the ECX trade reached USD 1.1 billion and the ECX expanded its number of warehouses to 55 with a total capacity of 250,000 tons.

The ECX had also settled USD 20 million or more on T+1 (next day) basis with no single default. They also now disseminate market price information through their outdoor electronic ticker boards located in 32 rural sites, through their website that attracts visitors from over 107 countries, and directly to their 256,000 mobile subscribers, radio, TV and print media (Gabre-Madhin, 2012). The ECX enables farmers to make both production and marketing decision on the basis of information.

[13]With the help of international donors such as Agency for International Development, the Canadian International Development Agency, the World Bank, the International Fund for Agricultural Development, the United Nations Development Programme, World Food Program and the European Union, *Eleni Gabre-Madhin* was the main driving force behind the successful establishment of the Ethiopia Commodity Exchange (Gabre-Madhin, 2012; Andersson et al., 2017).

In particular, they will help farmers know the quality grading of their product and the price premium they will earn from improving the quality of their coffee (Gabre-Madhin, 2012). All of these services may help to promote production and increase export earnings.

2.3 Empirical Strategy

To evaluate the impact of the establishment of the Ethiopian Commodities Exchange (ECX) on coffee export, we estimate the following triple difference-in-difference (DDD) specification within a gravity framework:

$$Export_{ijkt} = exp[\beta_1 Treat_i \times ECX_k \times Post_t + \mu_{it} + \mu_{ik} + \mu_{kt} + \mu_{ij} + \mu_{jt}]\varepsilon_{ijkt} \quad (2.1)$$

where $Export_{ijkt}$ is export value of coffee k from country i to country j during year t. Country i denotes either Ethiopia or Kenya; whereas country j represents the top trading partners of Ethiopia or Kenya.[14] $Treat_i$ is in an indicator variable that takes the value of 1 if the country is Ethiopia (the "treated" country) and 0 for Kenya (the "control" country). ECX_k is an indicator variable that takes a value 1 for coffee (the ECX commodity) and 0 for non-ECX commodities including flower, fruit & vegetable, spices, leather and hide & skin. $Post_t$ is a binary variable that switches from 0 before 2008 to 1 from 2008 onwards for both countries and products.

In our estimations, we take advantage of our disaggregated export data to condition on an extensive set of fixed effects that account for differences over time across countries (i.e., importers and exporters) and products (ECX and non ECX products). The remaining terms of Eq. (2.1) corresponds to fixed effects. Thus, μ_{it} is a set of export-year fixed effects that subsume the typical gravity regressors (such as such as importer and exporter GDP and multilateral resistance terms); μ_{ik} is exporter-product fixed effects that captures, for example, exporters preferential trade

[14] The thirty-three major trading partners of the two country are Austria, Belgium, Brazil, Bulgaria, Canada, China, Egypt Arab Rep., France, Germany, Greece, India, Iran Islamic Rep., Israel, Italy, Japan, Korea Rep., Kuwait, Malaysia, Morocco, Netherlands, Pakistan, Romania, Russian Federation, Saudi Arabia, South Africa, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom, and United States.

policies on products that may affect commodity exports differently; μ_{kt} is a set of product-year fixed effects that controls for potential commodity specific time varying unobserved factors; μ_{ij} represent the exporter-importer fixed effects to account for time invariant unobserved factors such as bilateral distance, language etc. ε_{ijkt} is the error term.

The coefficient of interest (i.e. β_1) captures the average impact of the ECX on coffee export of Ethiopia. To estimate Eq. (2.1), we use Poisson pseudo-maximum likelihood (PPML) estimation proposed by Silva and Tenreyro (2006). The PPML approach has several methodological advantages over the common OLS estimation, which involves the log-linearization of Eq. (2.1) and then estimating the parameters of the log-linearized model. Firstly, log-linearizing the gravity equation will alter the properties of the error term, such that the conditional expectation of the *log of the error term* (i.e $E(ln\varepsilon_{ijct})$) will be a function of the regressors, which could cause the estimates to be inconsistent (Silva and Tenreyro, 2006). Secondly, the log-transformation of the gravity equation requires data with zero bilateral trade to be dropped. For a typical developing country such as Ethiopia, there are many zero bilateral trade values. Thus, we will lose a large amount of data if drop the zeros. Importantly, the zeros are themselves informative. If we parse our bilateral trade data to those with positive values, this could generate a sample section problem that could bias our OLS estimates. For these reasons, it will be more appropriate to estimate the multiplicative form of the gravity equation using the PPML approach (Silva and Tenreyro, 2006, 2010).

Threats to Identification of the ECX: We highlight some concerns related to identifying the impact of the ECX on export of coffee in Ethiopia. While some of this concerns are common to all impact evaluation analysis, some are specific to the ECX program.

Obtaining a Counterfactual: The first challenge in estimating the impact of the ECX on coffee export is to identify the appropriate counterfactual group. We consider a neighboring country, Kenya, as the control since it is the second largest African country that produces and exports Coffee Arabica but does not have a commodity exchange. However, country-level difference-in-differences model may falsely attribute a change in Ethiopia's coffee export, caused by factors such as institutional reforms and infrastructural improvement, to the ECX. To address this concern, we add non-ECX commodities (flowers, fruits and vegetables, hide and skin, leather and spices) as an additional control group. Hence, we estimate the impact of the ECX on coffee export using the triple differences (DDD) approach. The triple difference approach by comparing the difference between export if coffee (and ECX product) and other products (non-ECX products) of Ethiopia to the different between the exports of coffee and other commodity product of Kenya. Because triple difference exploits country-commodity-year variations in exports, we are able to control fixed effects to deal with potential confounding factors (Frazer and Van Biesebroeck, 2010).

Parallel Trends: One of the main assumption for the validity of our identification is that the change in export over time would have been the same across coffee and other commodities, in the absence of the EXC. Using coffee export data between 2003 to 2007, we perform a placebo test that falsely assumes 2006 as the starting period of the ECX. In addition, we test the parallel trend assumption by comparing trends in export of non-ECX commodities in Ethiopia and Kenya using data for the whole sample period (2003-2013). The trends in export of non-ECX commodities of both countries should follow the same trend regardless of the ECX.

Idiosyncratic or Covariate Shocks: The second issue comes from the fact that when estimating β_1, there are potential confounding factors. During the sample period, there could be improvements in infrastructure, irrigation and trade facilitation that could increase production and exports of coffee in Ethiopia. Without addressing this possibility, we may falsely attribute these potential benefits to the ECX itself. To address this issue, we include product-year fixed effects in Eq. (2.1) that partial out all confounding time-varying or invariant factors affecting coffee exports.

In addition, the two coffee exporting countries– Ethiopia and Kenya – may experience other institutional or policy reforms during the treatment period that affects their coffee exports differently. To address this concern, we include exporter-year fixed effects in Eq. (2.1) that capture the effects of aggregate shocks on coffee export. These dummies also capture changes in GDP, income per capita, population and other aggregate variables that affect coffee export in both countries. We have also added exporter-product fixed effect to control for the possibility of exporters preferential trade policies on product types that may affect different products export differently.

Importers of Ethiopian coffee may also experience positive or negative idiosyncratic shocks that affect Ethiopia's coffee export. If these potential shocks coincide with the ECX, the estimated effect of the ECX on exports may not reflect the true impact. To address this issue, we include importer-year fixed effects in Eq. (2.1) that eliminate the confounding effects of shocks to the importing countries. Similarly, we also include the exporter-year fixed effect, as it takes care of all exporter specific factors of exports – observed or unobserved, time-varying or time-invariant – such as the exporter's institution, GDP, per capita income and population. Furthermore, we include importer-exporter fixed effects to partial out all characteristics between the importer and exporter that affect how much they trade.

2.4 Data

We use data on exports of Ethiopia and Kenya to their common major trading partners (Appendix 1A provides the full list of the major trading partners of the two countries) for the period between 2003 and 2013. The export flow data is taken from the UN Comtrade data base. If export flow is not reported in a given year, it is set be zero during that particular year. For the model capturing the extensive margin, we create a dummy dependent variable that is equal to 1 for non-zero exports and 0 if otherwise.

Table 2.1 presents the summary statistics of the data. Columns (1) and (2) report the mean and standard deviation of Ethiopia's export of agricultural commodities including coffee, flower, spice and fruit and vegetable. Furthermore, Columns (3) and (4) present the mean and standard deviation of Kenya's export of the same commodities. The summary statistics shows that the average coffee export of Ethiopia

Table 2.1: Summary Statistics

	Ethiopia		Kenya	
	Mean	Std. Dev.	Mean	Std. Dev.
Product	(1)	(2)	(1)	(2)
Coffee	441503.4	241646.6	96931.5	59316.7
Flower	54109.8	30328.3	367741.9	250960
Fruit and vegetable	95992.1	41469.3	221969.8	104748.9
Hide and skin	9438.3	9211.7	3889.9	3744.1
Leather	48349.8	23024.9	20358.9	9208.5
Spices	82825.5	1152.8	4895.7	3516.8
All agricultural products	169862.6	213051.9	120638.1	160419.5
All manufacturing products	26049.02	22284.46	24199.5	23330.3

Note: All the summary statistics values are in thousands (‘000) of US dollar. All agricultural products include coffee, flower, spices and fruit & vegetable. Similarly all manufactured products include leather and hide & skin.

($441,503,400) is higher than the average coffee export of Kenya ($96,931,500) for the 2003-2013 period. Moreover, Ethiopia average exports of hide & skin, leather and spices are larger than Kenya. The last two rows of Table 2.1 report the average exports of agricultural and manufactured products of the two countries. The average export values indicate that Ethiopia and Kenya generate nearly equal amount of of revenue from the export of agricultural and semi-processed manufactured goods in the sample period.

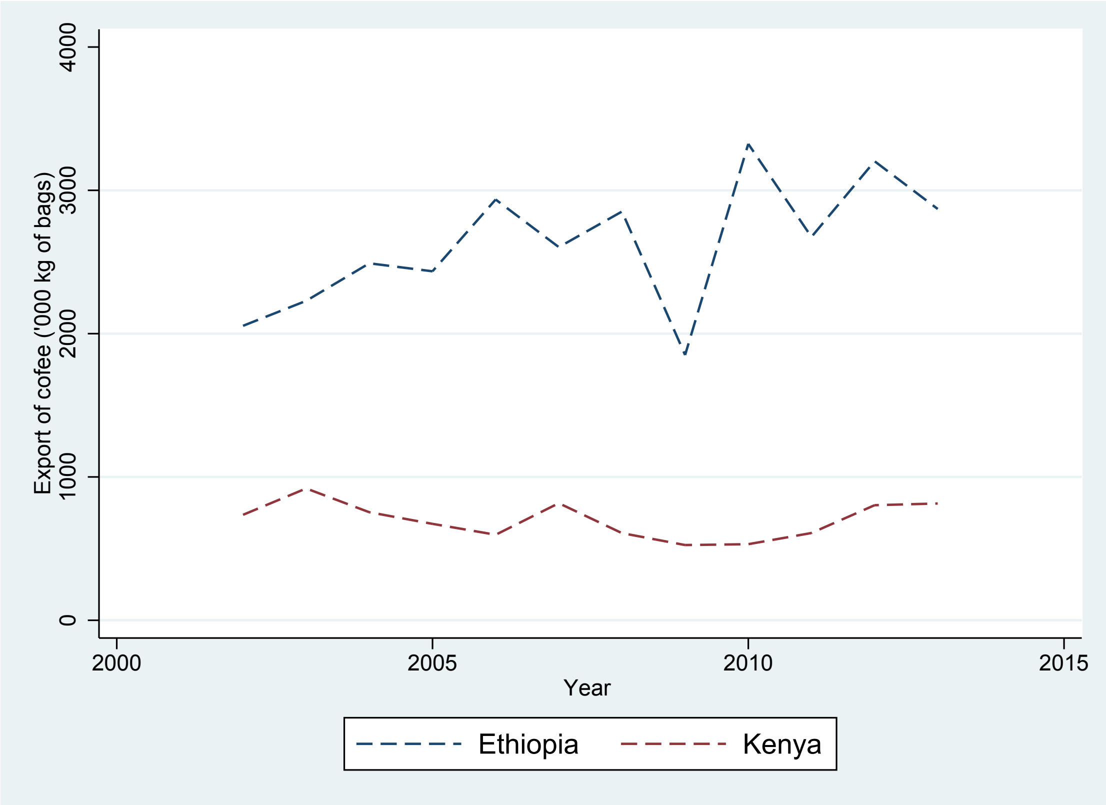
Figure 2.1 presents the time series plots of coffee exports for Ethiopia and Kenya during 2003-2013. The blue dotted line shows the quantity of coffee export for Ethiopia and the red dotted line shows the quantity of coffee export for Kenya. These two plots show that the trends in coffee exports before the introduction of the ECX were quite similar for both countries. However, the trend of Ethiopia's coffee export shows a significant increase following the establishment of the ECX. This suggests that the introduction of the ECX has led to an increase in Ethiopia's coffee export.

2.5 Results

2.5.1 Baseline Results

Table 2.2 presents the triple difference (DDD) estimates of the impact of the ECX on Ethiopia's coffee export, based on Eq. (2.1). In Column (1), we include the

Figure 2.1: Export of Coffee: Ethiopia versus Kenya



Note: This figure shows the overtime aggregate export of coffee for Ethiopia and Kenya in thousands of 60 kg bags.

exporter-year, exporter-product, and product-year fixed effects. In Column (2) we add importer-exporter fixed effects. In Column (3), we include all the above fixed effects. In all specifications, exporter-product clustered robust standard errors are reported in parentheses.

In all specifications, the coefficient of interest (i.e. $Treatment \times ECX \times Post$) is positive and statistically significant at 1%. In particular, the ECX increase Ethiopia's coffee export by 84%.[15] From the policy perspective, this large effect has significant implication for the following reasons. Firstly, coffee export accounts a quarter (i.e. 25%) of Ethiopia's export earning. Hence, the 84% increase in coffee export represents a 21% (i.e. $25\% \times 84\% \approx 21\%$) boost in total export for Ethiopia. Secondly, coffee faming provides a livelihood for 15 million Ethiopians (Moat et al., 2017). We would therefore expect an increase in coffee exports to have a positive social economic impact in Ethiopia. Finally, the magnitude of the coefficient indicates that market

[15] The formula to compute the effect of a dummy variable in a PPML model is $(e^{\beta_i} - 1) \times 100\%$, where β_i is the estimated coefficient of dummy variable i (Silva and Tenreyro, 2006).

Table 2.2: The Impact of the ECX on Coffee Export: Intensive Margin

	(1)	(2)	(3)
Treatment × ECX × Post	0.616***	0.616***	0.616***
	(0.047)	(0.047)	(0.047)
Fixed Effects			
Exporter × Year	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes
Exporter × Importer	No	Yes	Yes
Importer × Year	No	No	Yes
Observations	3564	3564	3564
Pseudo R^2	0.079	0.721	0.771

Note: Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (2.1). ***Treatment*** is an indicator variable that is equal 1 for Ethiopia's export products and 0 for Kenya's export products; ***ECX*** is 1 for coffee export and zero for the other five export products (i.e. flower, fruit & vegetable, spices, leather, and hide & skin); and ***Post*** is 1 after 2008 and zero otherwise. Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

reform in developing country could have higher effect than joining regional trade agreements, trade concessions, and importer tariff reductions. For example, Frazer and Van Biesebroeck (2010) show that US trade concession policy for Africa (also known as AGOA) increases export by about 40% and Cheong et al. (2017) finds that temporary removal of tariff following a natural disaster increases Pakistani export by around 45%. These responses are only about one-half of the increase in coffee exports, which follows from the introduction of coffee to the ECX platform.

2.5.2 Robustness Checks

In this section we examine the robustness of our results by performing five checks consists of placebo test, alternative estimation method, alternative control groups and assessments based on restriction of trading partners in the gravity model.

A. Placebo Test

The main assumption required for the internal validity of our triple differenced approach is the parallel trend assumption. This assumption requires export of coffee for both Kenya and Ethiopia have the same trends if the treatment had not occurred. Hence, we examine whether or not the export of coffee (the treated group) and the other commodities (the control group) had parallel trends before the introduction of the ECX, we falsely assume 2006 to be the treatment year (i.e the introduction of the ECX) and estimate the model using only pre-treatment data ranges from 2003 to 2007 (because there is no treatment during these years).

Table 2.3 presents the results from the placebo test. In Column (1), we control for the exporter-year, exporter-product and product-year fixed effects. In Column (2), we control for importer-exporter fixed effects. In Column (3), we control for all the interactive fixed effects. The estimated coefficients of the placebo tests are all statistically insignificant. This suggests that there are nothing else, besides the ECX, that had caused the ECX and non-ECX products to have divergent trends.

Table 2.3: The Impact of ECX on Coffee Export with False Treatment Year

	(1)	(2)	(3)
Treatment × ECX × Post-2005	0.200	0.200	0.200
	(0.131)	(0.131)	(0.131)
Fixed Effects			
Exporter × Year	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes
Exporter × Importer	No	Yes	Yes
Importer × Year	No	No	Yes
Observations	1584	1584	1584
Pseudo R^2	0.061	0.697	0.704

Note: Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (2.1). Year 2006 is used as false treatment period to check the validity of our identification strategy. Hence, ***Treatment*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***ECX*** is 1 for coffee export and zero for the other five export products (i.e. flower, fruit & vegetable, spices, leather, and hide & skin); and $\boldsymbol{Post-2005}$ is 1 for 2006 and 2007 and zero otherwise. Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B. Alternative estimation method

The question of how to estimate gravity model is not trivial. Our baseline results in Table 2.2 are based on Poisson pseudo maximum likelihood (PPML) estimation. This approach provides consistent estimates in the presence of conditional heteroskedasticity caused by log-linearizing the gravity model. However, its downside is that it is a nonlinear regression approach; thus, it is not suitable for estimating models with a large number of fixed effects (Magee, 2008).[16] To check if our baseline result is an artifact of the estimation approach chosen, we re-estimated the model using ordinary least squares (OLS) regression, which allows us to control for many fixed effects in the model.

Table 2.4: The Impact of the ECX on Coffee Export: OLS Estimates

	(1)	(2)	(3)
Treatment × ECX × Post	1.170***	1.170***	1.170***
	(0.141)	(0.143)	(0.148)
Fixed Effects			
Exporter × Year	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes
Exporter × Importer	No	Yes	Yes
Importer × Year	No	No	Yes
Observations	3564	3564	3564
R^2	0.25	0.40	0.41

Note: OLS is used to estimate Eq. (2.1) using $\boldsymbol{log(1 + Export_{ijkt})}$ as the dependent variable. $\boldsymbol{Treatment}$ is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; $\boldsymbol{ECX}$ is 1 for coffee export and zero for the other five export products (i.e. flower, fruit & vegetable, spices, leather, and hide & skin); and $\boldsymbol{Post}$ is 1 after 2008 and zero otherwise. Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The OLS results, provided in Table 2.4, show that the coefficients on $Treatment \times ECX \times Post$ are positive and statistically significant at 1% level.[17] Therefore, there is no evidence that the statistical significance of our baseline results is dependent on the estimation method chosen.

C. Restricting the "control" (non-ECX) commodities

In the baseline results, our control group (non-ECX commodities) consists of both agricultural items (flower, spices, fruit and vegetable) and non-agricultural items (leather, hide and skin) that are not traded via the ECX. However, there may be a concern that factors such as agricultural policy may affect export of coffee and agricultural commodities more uniformly than export of non-agricultural

[16] For example, although it is infrequent, the PPML estimator automatically excludes some of our fixed effects (due to collinearity) in our baseline model which might be a bit concerning.

[17] Notably, the OLS estimates are quite large compared to the PPML estimates of Table 2.2. This results are consistent with the evidence documented by Silva and Tenreyro (2006) that OLS overestimates the effect of trade attributes in gravity model due to misspecification issues.

Table 2.5: Using only Agricultural Goods as Control Group

	(1)	(2)	(3)
Treatment × ECX × Post	0.661***	0.661***	0.661***
	(0.044)	(0.044)	(0.044)
Fixed Effects			
Exporter × Year	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes
Exporter × Importer	No	Yes	Yes
Importer × Year	No	No	Yes
Observations	2376	2376	2376
Pseudo R^2	0.067	0.735	0.787

Note: ***Treatment*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***ECX*** is 1 for coffee export and zero for the other three agricultural export products (i.e. flower, fruit & vegetable, and spices); and ***Post*** is 1 after 2008 and zero otherwise. Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (2.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

commodities. Thus, by including of non-agricultural commodities into our regression, this may accentuate the contrast between coffee and non-coffee exports after the ECX was established, and therefore, drive the statistical significance of our results. To reduce such potential contrast, we restrict the control group to agricultural commodities only. Table 2.5, shows that the impact of ECX on coffee export remains positive and statistically significant at 1% significance level, which suggests that our baseline results are not driven by the inclusion of non-agricultural commodities into the control group.

D. Varying the sample of trading partners

In the baseline regressions (Table 2.2), we have used data on bilateral coffee and non-coffee exports of Ethiopia and Kenya to 33 major trading partners. One concern about the gravity model is that its estimates are potentially sensitive to the sample of trading partners included in the analysis (Magee, 2008). For example, Haveman and Hummels (1998) have shown that the effect of Regional Trade Agreements (RTA) on trade is sensitive to the sample of trading partners used in the analysis. When the number of the sample countries is changed, the effects of RTA vary dramatically as well.

Here, we explore if our baseline results are robust to the use of different sample countries. As a robustness check, we have re-estimated our model using the top 20, 15 and 10 trading partners and with all the interactive fixed effects (i.e. exporter-year, exporter-product, product-year, importer-exporter and importer-year fixed effects). In Table 2.6, Columns (1)-(3) present the estimation results associated with the use of the top 20, 15 and 10 trading partners, respectively. Based on these results, we find that the magnitude of the estimated coefficient of the triple interaction term increases when we reduce the number of trading partners. In addition, the estimated coefficients of the triple interaction term are positive and statistically significant at least at 5% significance level. This suggests that the statistical significance of the ECX for exports is not driven artificially by the sample of countries

Table 2.6: The Impact of ECX on Coffee Export: Using Different Top Trading Partners

	(1)	(2)	(3)
	Top 20 partners	Top 15 partners	Top 10 partners
Treatment × ECX × Post	1.046***	1.177***	1.190**
	(0.252)	(0.216)	(0.589)
Fixed Effects			
Exporter × Year	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes
Exporter × Importer	Yes	Yes	Yes
Importer × Year	Yes	Yes	Yes
Observations	2160	1590	1060
Pseudo R^2	0.793	0.800	0.867

Note: ***Treatment*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***ECX*** is 1 for coffee export and zero for the other five export products (i.e. flower, leather, hide & skin, fruit & vegetable, and spices); and ***Post*** is 1 after 2008 and zero otherwise. Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (2.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

E. Alternative definition of the "treatment" year

The Ethiopia Commodities Exchange was established in April 2008 and launched its operation by trading wheat, maize and beans. However, the world food price crisis that affected Ethiopia's grain market has led the ECX to introduce coffee trade into the exchange.[18] Hence, we address this concern by re-defining the treatment year as 2009 instead of 2008 and assess the impact of the ECX. Table 2.7 shows the triple-difference results when we assume 2009 as a beginning of the treatment year. The estimated coefficients in Columns (1)-(3) show that the ECX has a positive and statistically significant effect on coffee export. Compared to the baseline results (when 2008 is defined as the treatment year), the coefficients of the triple interaction term in Table 2.7 only vary slightly. Thus, whether we use 2008 or 2009 as the treatment year will not affect our conclusion about the statistical significance and impact of the ECX.

Table 2.7: The Impact of ECX on Coffee Export: an Alternative Treatment Year

	(1)	(2)	(3)
Treatment × ECX × Post2009	0.543***	0.543***	0.543***
	(0.048)	(0.048)	(0.048)
Fixed Effects			
Exporter × Year	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes
Exporter × Importer	No	Yes	Yes
Importer × Year	No	No	Yes
Observations	3564	3564	3564
Pseudo R^2	0.079	0.720	0.771

Note: ***Treatment*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***ECX*** is 1 for coffee export and zero for the other five export products (i.e. flower, fruit & vegetable, spices, leather, and hide & skin); and ***Post2009*** is 1 after 2009 and zero otherwise. Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (2.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2.6 Further Analysis

2.6.1 Does the ECX Matters for the Export Extensive Margins?

The previous results primarily focus on the effect of the ECX on the intensive margin (i.e. volume) of coffee exports. However, the establishment of the ECX may also

[18] After a serous of intensive discussions with the government and other stake holders, in July 2008 a law was passed to trade and export coffee through ECX.

increase the number of destinations, the extensive margin, to which coffee is exported. In this section, we examine the effect of the ECX on coffee export extensive margin. Following Cheong et al. (2017), we re-estimate Eq. (2.1) using the PPML estimator, where the dependent variable is an indicator variable that equals to 1 if positive trade flows occur to a certain product-destination-year and zero otherwise.

Table 2.8: The Effect of ECX on Coffee Export: Extensive Margin

	(1)	(2)	(3)
Treatment × ECX × Post	0.095**	0.095**	0.095**
	(0.039)	(0.039)	(0.039)
Fixed Effects			
Exporter × Year	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes
Exporter × Importer	No	Yes	Yes
Importer × Year	No	No	Yes
Observations	3564	3564	3564
Pseudo R^2	0.231	0.319	0.345

Note: Our dependent variable is an indicator variable that equals to 1 if positive trade flows occur to a certain product-destination-year and zero otherwise. ***Treatment*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***ECX*** is 1 for coffee export and zero for the other five export products (i.e. flower, fruit & vegetable, spices, leather, and hide & skin); and ***Post*** is 1 after 2008 and zero otherwise. Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (2.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.8 reports the DDD results on how ECX affects the extensive margin of coffee exports. As the coefficients in Columns (1) to (3) show, regardless of the fixed effects used in the gravity model equation, the introduction of coffee in the Ethiopian agricultural exchange system increases the probability of coffee export to new destinations by about 10%. The estimated coefficients are also statistically significant at least at the 5% level. This suggests that besides the intensive margin, a commodity exchange could also increase the extensive margins of the commodity trade.

2.6.2 ECX and the Export of Non-ECX Commodities

In the previous sections, we have find that that the Ethiopian Commodity Exchange–ECX– is associated with increase in coffee export. In this section, we assess whether the ECX affect export of non-ECX commodities.

In carrying out this analysis, we use the following regression specification:

$$Export_{ijkt} = exp[\beta_1 Treat_i \times Product_k \times Post_t + \mu_{it} + \mu_{ik} + \mu_{kt} + \mu_{ij} + \mu_{jt}]\varepsilon_{ijkt} \tag{2.2}$$

where $Export_{ijkt}$ indicates the export of non-ECX product k (i.e. flower, fruit & vegetable, spices and hide & skin) from country i to country j at time t. μ_{ij}, μ_{it}, μ_{ik}, μ_{kt}, and μ_{jt} represent the importer-exporter, exporter-year, exporter-product, product-year and importer-year fixed effects respectively. Our coefficient of interest in this DDD model is β_1. If ECX does not have any spillover effects, β_1 will be statistically insignificant.

Table 2.9: The Effect of the ECX on Export of non-ECX Commodities

	(1)	(2)	(3)	(4)
	Flower export		Fruit & Veg.	
Treatment $\times$Product$\times$ Post	-0.102	-0.102	-0.075	-0.075
	(0.073)	(0.073)	(0.092)	(0.092)
Fixed Effects				
Exporter $\times$ Year	Yes	Yes	Yes	Yes
Exporter $\times$ Product	Yes	Yes	Yes	Yes
Product $\times$ Year	Yes	Yes	Yes	Yes
Exporter $\times$ Importer	No	Yes	No	Yes
Importer $\times$ Year	No	Yes	No	Yes
Observations	2970	2970	2970	2970
Pseudo R^2	0.062	0.836	0.062	0.836

Note: ***Treatment*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***Product*** is 1 for Flower export (Column (1) and (2)) or for fruit and vegetable export (Column (3) and (4)) and zero for the other four non-ecx export products (i.e. spices, leather, and hide & skin, flower or fruit & vegetable); and ***Post*2008** is 1 after 2008 and zero otherwise. Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (2.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table (2.9) presents estimates of Eq. (2.2). The coefficient of interest (*Treatment* $\times$ *Product* $\times$*Post*) is statistically insignificance suggesting that ECX does not have effect on the exports of non-ECX commodities (flower and fruit & vegetables). The absence of spillover effect further evidence in favor of the a causal interpretation of the ECX effect on coffee export.

2.7 Conclusion

The establishment of a agricultural commodities exchange in developing countries are often justified by presuming such exchange markets would help farmers expand their production and increase export revenue. However, while it seems intuitive that commodity exchanges would help the agricultural commodities sectors, we do not have strong evidence that developing countries would benefit from having a commodity exchange, especially when it is an advanced market mechanism.

In this paper, we examine whether developing countries benefit from having a commodity exchange. We consider this question by studying its effects on coffee exports in Ethiopia. Coffee farming is the most important agricultural activity in Ethiopia, as it supports the livelihood of 15 million farmers and generates a quarter of the country's export. In April 2008, the government of Ethiopia introduced the Ethiopian Commodity Exchange (ECX) to provide reliable market information and storage facilities to farmers, especially coffee producers, which help them engage in the export industry.

Using a triple-differencing (DDD) approach, we find that the establishment of the ECX has led to an increase in Ethiopia's coffee export by about 84%. To put things into perspective, the impact of the ECX on exports is twice the impact of joining regional trade agreements (Magee, 2008) or trade concession policies such as AGOA (Frazer and Van Biesebroeck, 2010) and temporary removal of tariff following a natural disaster (Cheong et al., 2017) on trade.

We also find that the ECX has led to the export of coffee into new foreign markets. Our paper is related to recent initiatives by governments and international organizations to introduce agricultural commodities exchanges in developing countries. We provide quasi-natural experimental evidence to show that such initiatives can help to reduce market-related barriers of trade faced by these countries.

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Appendix A.

Table A1: List of Trading Partners of Ethiopia and Kenya

Austria	Belgium	Brazil	Bulgaria
Canada	China	Egypt Arab Rep.	France
Germany	Greece	India	Iran Islamic Rep.
Israel	Italy	Japan	Korea Rep.
Kuwait	Malaysia	Morocco	Netherlands
Pakistan	Romania	Russian Federation	Saudi Arabia
South Africa	Sweden	Switzerland	Thailand
Turkey	Ukraine	United Arab Emirates	United Kingdom
United States			

Note: We consider the exports of Ethiopia and Kenya for their 33 common trading partners. The sample period extends from 2003-2011.

Chapter 3

Landlockedness, Trade Cost and Trade: Evidence from a Natural Experiment in Ethiopia

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Overall percentage (%)	40%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the co- author of this paper.		
Signature		Date	06/09/2018

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Nicholas Sim		
Contribution to the Paper	Contributed to the planning of the article, supervised the development of the work, helped in the interpretation of the results and wrote part of the manuscript.		
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Abstract

It is argued that landlocked countries are usually less developed due to landlockedness being a significant barrier to trade. Empirically, however, there is little evidence on how large the causal effect of landlockedness is, as exogenous variations in landlockedness useful for addressing this question are rare. In this paper, we exploit a novel natural experiment when Ethiopia's became a *de facto* landlocked country following a conflict with Eritrea in 1998. Because landlockedness primarily affects land and sea freight than air freight, this "closing in" of Ethiopia should affect the trade of bulky, low-valued goods more strongly than the trade of light, high-valued goods. To estimate the effect of landlockedness, we employ two approaches: the triple difference-in-differences approach and the synthetic control approach. The triple difference-in-differences approach enables us to use a span of fixed effects to identify the "treatment" effect of landlockedness on trade. The synthetic control approach provides us with a data-driven method to obtain a control group that mirrors Ethiopia's pre-intervention trend as closely as possible. Our empirical results reveal that landlockedness has a large negative impact on Ethiopia's exports and imports: on average, being landlocked reduces Ethiopia's ocean-borne exports and imports by about 43-80% and 67-71%, respectively. We also find that the landlockedness shock has a persistent effect on trade, suggesting that the negative influence of landlockedness is not easily overcome.

Key Words: Landlockedness, Trade cost, Ethiopia, Difference-in-Differences

JEL Codes:C21, F14, F15, O10, P33

3.1 Introduction

It is well-known that landlocked countries tend to be less developed than their coastal neighbors. One explanation is that landlockedness is a significant barrier to trade, which stifles the development of countries with landlocked geography (Raballand, 2003; Faye et al., 2004; Arvis et al., 2010). For example, among developing countries, landlocked developing countries have only a third of the import share of coastal developing countries (World Bank, 1998), and they export less than half of the per-capita volume of their coastal counterparts (Faye et al., 2004). Consequently, they do not trade as much, landlocked developing countries usually have lower levels of socio-economic development as well. Currently, about half the population in these countries live on less than US$2 per day and about 1 in 10 newborns are not expected to live past the age of five.

Given the poverty levels faced by many landlocked developing countries, economists have sought to understand how serious and persistent the problem of landlockedness might be. Unfortunately, this issue is also an extremely difficult one to shed light on. Although landlocked developing countries tend to be poorer, it is unclear if this is due to landlockedness itself, other geographical attributes, unobserved institutions that are somehow correlated with landlocked geography, or other factors. Currently, research on the effects of landlockedness are mostly carried by estimating the coefficient on the landlocked dummy in cross-country regressions with cross-sectional data (e.g. Limao and Venables, 2001; Raballand, 2003; Coulibaly and Fontagné, 2006; World Bank, 2014). This estimated coefficient, as researchers have acknowledged, may not reflect the causal effect of landlockedness, since it could be confounded by the effects of other time-invariant country characteristics (Carrere and Grigoriou, 2008; Paudel et al., 2014). Although these confounding effects could be eliminated by employing panel regressions with country fixed effects, the trouble is that landlockedness is itself time-invariant. Thus, its effect will be purged by country fixed effects along with other time-invariant confounders.[1] Consequently, even though it is intuitive that landlockedness adversely affects trade, there are no causal estimates to show how serious (or not) this problem actually is.

In this paper, we will provide the first natural experimental evidence on the causality and persistence of the effect of landlockedness on trade. Our natural experiment comes from the sudden transition of Ethiopia from a *de-facto* coastal country to a *de facto* landlocked one in 1998. Eritrea had been a province of Ethiopia.[2] In 1991, however, pro-independence rebel forces initiated combat and defeated the Ethiopian forces, and Eritrea's independence was secured following a referendum two years later. Despite the *de jure* separation, there was a protocol of understanding between the government of Ethiopia and the newly-formed state of Eritrea for Ethiopia's free and unrestricted use of the Eritrean port of Assab (IMF, 1997; Faye et al., 2004; Briggs and Blatt, 2009; Connell and Killion, 2010). As stated under the intergovernmental transit and port service agreement and customs arrangement of the protocol of understanding, both governments had agreed that Ethiopia would be granted continued free access to the port of Assab with its own customs branch office. Under this agreement, Ethiopia's imports and exports through the port of Assab, which accounted for 95 percent of the country's trade throughput (Briggs and Blatt, 2009; Connell and Killion, 2010), were exempted from Eritrean customs duties and related charges (IMF, 1997). As such, even though Ethiopia was *de jure* landlocked, the port of Assab was practically a *de facto* Ethiopian port within Eritrea.[3]

This arrangement, however, fell apart in 1998 when war broke out between Eritrea and Ethiopia due to border related issues.[4] The escalation of this border-dispute had

[1]To quantify the impact of landlockedness, existing studies typically use a time invariant dummy variable – an indicator of landlockedness - that takes a value of one if a country is landlocked. However, the country fixed effect will partial out the time invariant landlocked indicator, causing the effect of landlockedness to be unidentified.

[2]Eritrea was a colony of Italy from 1998-1941. Following the independence from Italy, British took over the administration from 1941-1952. Eritrea become an autonomous region of Ethiopian and become again province of Ethiopia in 1952 and 1961 respectively.

[3]Ethiopia was a *de jure* landlocked country with coastal access since 1993, but a *de facto* coastal country until 1998.

[4]Both countries disputed over the control of the border town of Badme.

"taken everybody by surprise, including Ethiopian Prime Minister Meles Zenawi" (Abbink, 1998, p. 551). Due to this conflict, the port of Assab, which is Ethiopia's main commercial outlet to the world, was immediately closed. From that moment on, Ethiopia became truly landlocked. Besides Ethiopia, no other sovereign states in modern times had gone from being a coastal to a landlocked country.

Empirically, we employ two estimation methods to study the treatment effect of landlockedness on trade for Ethiopia. First, we employ a triple difference-in-differences (DDD) approach to estimate the impact of landlockedness on the *bilateral* trade of Ethiopia within a gravity model. Our triple-differencing approach exploits three sources of variation: country variation (landlocked country–Ethiopia– and coastal country–Kenya), product variation (bulky oceanborne freight and light airborne freight) and time variation (before and after "*de facto*" landlockedness).[5] To estimate our gravity model, we used 13 years disaggregated bilateral trade data of the treated and the control countries along with more than 30 common major trading partners of the two countries. The data ranges from 1993 to 2005. In addition, to address the sensitivity of gravity model to the number of variables included in the regression,[6] we control a large set of exporter-year, exporter-product and product-year fixed effects (Magee, 2008; Cheong et al., 2017).

Second, we employ the synthetic control approach to study the impact of landlockedness on the *aggregate* exports and imports of Ethiopia. This method enables us to obtain a data-driven counterfactual, known as a synthetic control, as a weighted average of all the coastal countries in Africa for which data is available.[7] Unlike the conventional approach of choosing a single comparison group, the weighting of the potential control groups (i.e. other coastal African

[5]We define the export of four major ocean-borne products including coffee, leather, vegetable and hide & skin as 'treated' and airborne–gold–as 'control' commodity. Similarly, we define twelve major ocean-borne imports as 'treated' and airborne – medicine and pharmaceutical—as 'control' products

[6]According to Ghosh and Yamarik (2004) and Magee (2008), gravity model is sensitive to the number of variables included in the regression.

[7]We use 34 coastal countries altogether to construct the synthetic control. The list of coastal African countries are Algeria, Angola, Benin, Cameroon, Cape Verde, Congo Dem. Rep., Congo Rep., Cote d'Ivoire, Djibouti, Arab Republic of Egypt, Equatorial Guinea, Eritrea, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Libya, Madagascar, Mauritius, Morocco, Mozambique, Nigeria, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Tanzania, Togo and Tunisia.

countries) enables the weighted average, which is the synthetic control, to achieve a pre-intervention trend that mirrors Ethiopia's even more closely (See, for example, Abadie et al., 2010; Cheong et al., 2017). More importantly, the synthetic control is data-driven, in the sense that the weights used to construct it are not arbitrarily imposed, but are chosen (based on some loss criteria) so that its characteristics and those of Ethiopia are as similar to each others' as possible.

Our empirical results show that Ethiopia's export and import products are strongly affected by landlockedness. Specifically, landlockedness on average reduces Ethiopian's exports of coffee, leather, crude vegetable and hide & skin by about 43%, 49%, 80% and 72%, respectively. In addition, it reduces Ethiopian's ocean-borne imported goods, such as petroleum, fuel and fertilizer, by 71%, 68.6% and 66.9%, respectively. These large reported effects are robust to various robustness checks, such as placebo test and sub-sample analysis.

To further investigate how persistent the negative effect of landlockedness is, we estimate the size of the treatment effects across years. We find that the effect of landlockedness on Ethiopia's export and import products is not short-lived, but is persistent, to the extent this effect is stronger further down the years for certain goods. The synthetic control method also provides evidence that after the landlockedness shock, there is an increasing divergence between the aggregate exports and imports of Ethiopia and those of the synthetic control. As such, the negative effect of landlockedness on trade is not merely a level effect, but also has an effect on slowing down trade relative to the counterfactual.

Our work is most closely related to the literature that looks at the effect of geographical barriers on trade, especially landlockedness, on the export and import. For example, Radelet and Sachs (1998) studied the effect of geographical isolation and shipping cost on manufactured export and found that the manufacturing exports of landlocked countries are significantly lower than that of coastal countries. Similarly, Limao and Venables (2001), Raballand (2003), Coulibaly and Fontagné (2006), Carrere and Grigoriou (2008), Paudel et al. (2014) and World Bank (2014) argued that landlockedness had a negative impact on trade. To estimate the effect of landlockedness, they estimated the coefficient on a time-invariant landlocked country dummy contained in a cross-sectional cross-country regression. The problem with these results is that they lack a causal interpretation, since it is not possible to disentangle the effects of landlockedness from the effects of other time-invariant country factors, as country fixed effects will partial all of them out. Our work overcomes these issues by providing the first quasi-natural experimental evidence on the effects of landlockedness that are estimated from a panel model with a rich fixed effects structure.

Our work is also broadly related to the literature that studies the relationship between trade cost and international trade. Trade economists have long been concerned about the source of trade costs and how they affect trade. A vast literature has attempted to estimate the causal effects of policy barriers (tariffs and non-tariff barriers), transportation (freight costs, time costs), and the effects of the costs associated with the use of different currencies on exports and imports (see Anderson and Van Wincoop, 2004; Disdier and Head, 2008; Christ and Ferrantino, 2011; Djankov et al., 2010; Hummels and Schaur, 2013; Silva and Tenreyro, 2010). In this regard, our paper speaks to this literature by establishing results on the effect of landlockedness, which is a geographical barrier of trade.

The reminder part of the paper is structured as follows. Section 3.2 provides the background information about how Ethiopia becomes landlocked in 1998. Section 3.3 discusses the model specification and the estimation method of the study. Section 3.4 discusses our data sources and the descriptive statistics of the key variables. Section 3.5 presents our main findings as well as several robustness checks. Section 3.7 concludes.

3.2 Background

3.2.1 Ethiopia's Access to the Port of Assab

The port of Assab had been Ethiopia's main gateway to the global market. Since the early 1980s, infrastructure additions and reconstructions had been made to improve

Table 3.1: Time-line for the Independence of Eritrea and the Border War with Ethiopia.

1991	Ethiopian rebels and Eritrea defeat the central government of Ethiopia.
1993	Eritrea becomes independent state.
1998	Eritrean-Ethiopian border war and Ethiopia become *de facto* landlocked.
2000	End of Eritrean – Ethiopian war.

the port. These included the widening of its harbor, the addition of warehouses and container berth, the construction of shipyards with ship building capabilities, and the expansion of road transportation infrastructure with the assistance of World Bank, African Development Bank, Norway and China (Fair, 1988). The port had a well-functioning transportation infrastructure, and was connected by 624 km highway to Addis Ababa, the capital city of Ethiopia. At some point in time, it had even accounted for 95 percent of the country's main ocean-borne export and import cargo throughput (Connell and Killion, 2010; Murphy et al., 2013).[8]

Up to the early 1990s, Ethiopia had sovereignty over Assab. However, this changed when the Eritrean People Liberation Front (*EPLF*) and Ethiopian rebel forces from secessionist and dissident groups initiated combat against Ethiopia to establish their full independence and shared government power. After three decades of war against successive governments of Ethiopia, the *EPLF* and Ethiopian rebel forces defeated the Ethiopian central government forces in 1991 (see the time-line in Table 3.1). The defeat of the then government of Ethiopia was followed by a successful referendum for independence among the people of Eritrea, which led to Eritrea's independence in

[8]Until the federation of Eritrea in 1952, Ethiopia was landlocked country. Its routes to external world was the 780 km railway from Djibouti constructed in 1917. Following federation and then annexation of Eritrea, Ethiopia became a coastal country until 1998.

27 April,1993 (Pool, 1993). Because all of Ethiopia's coastline are located in Eritrea, Ethiopia became *de jure* landlocked and thus lost sovereignty over Assab when Eritrea declared independence.

However, notwithstanding the loss of its coastline, Ethiopia did not become *de facto* landlocked. This is because there was an agreement (a protocol of understanding) between the Transitional Government of Ethiopia (TGE) and the state of Eritrea for Ethiopia's free and unrestricted use of the port of Assab. As stated under an intergovernmental transit and port service agreement and customs arrangement, both governments agreed that Ethiopia would be granted continued free access to the port of Assab with its own Ethiopian customs branch office, and the imports and exports of Ethiopia would remain exempt from Eritrean customs duties and related charges (IMF, 1997; Faye et al., 2004; Connell and Killion, 2010). Thus, the port of Assab was used almost exclusively for export-import trade to Ethiopia's capital city Addis Ababa, the population of Assab was predominantly Ethiopian, the telecommunication system was connected with Ethiopia, and the economy of Assab was entirely built on businesses from Ethiopia (Connell and Killion, 2010).[9] As such, Assab essentially remained an Ethiopian town within Eritrea.

3.2.2 Eritrean-Ethiopian War and the Landlockedness of Ethiopia

This arrangement over the use of port of Assab fell apart on May 6, 1998 when Ethiopia and Eritrea went into war over a border dispute. From then on, the port of Assab was immediately closed to Ethiopia and the country became *de facto* landlocked. With the "closing in" of Ethiopia, it is now the most populous landlocked country in the world, with a population size fast approaching 100 million. Since becoming *de facto* landlocked in 1998, Ethiopia's has redirected its trading routes to a neighboring country, Djibouti, which now handles the great majority of Ethiopia's trade. Unlike trading through the port of Assab, Ethiopia's trade flow is subjected

[9]Morvover, Port of Assab was purchased by Rubattinio shopping company, Italian company, in 1869 from two Ethiopian sultans prior to the establishment of Eritrea as a region. Hence, Port of Assab can be considered as historical property of Ethiopia.

to fees for using the sea ports of other countries and to other related costs associated with the crossing of another sovereign country (Lorton, 2000; Begashaw, 2008).[10]

As discussed, we are primarily interested in the impact that landlockedness might have on development, with trade as the key focus here. Why, then, do we look towards Ethiopia to address this question? Firstly, Ethiopia is the only sovereign country in modern times that had been both coastal and landlocked. Secondly, the availability of trade data before and after the landlockedness for Ethiopia (without Eritrea) enables us to study the causal effect of landlockedness on trade with Ethiopia as an example. Finally, the timing of Ethiopia's *de facto* landlockedness was unanticipated: not only did Ethiopia become *de facto* landlocked, the circumstance that led to its landlockedness caught "everybody by surprise" (Abbink, 1998) .[11] Thus, from an econometric perspective, the landlockedness of Ethiopia was a plausibly exogenous shock, which we could use to identify the causal effect of landlockedness.

3.3 Empirical Strategy

Our empirical framework estimates the impact of landlockedness on trade using the gravity model. In its simplest form, the traditional gravity model assumes that trade flows between country i and country j are positively related with the economic size of the two countries and negatively related with their distance.[12] The most widely used standard gravity equation comes from Anderson and Van Wincoop (2003). They show that besides economic size and distance, multilateral resistance terms could also determine trade flows between countries, and these can be controlled for by exporter and importer fixed effects. In this study, we augment the Anderson and Van Wincoop (2003) gravity model by adding an indicator variable that measures the effect of *landlockedness* on trade, and then apply a triple difference-in-differences

[10] Begashaw (2008), report the estimated annual fees that Ethiopia pay for using Djibouti Port. According to the author, Ethiopia pays more than USD 850 million to DP World Djibouti annually before the 2008 increase in port fees.

[11] Abbink (1998) wrote that The violent Eritrean-Ethiopian border dispute which erupted on May 6 1998 has taken everybody by surprise, including Ethiopian prime minister Meles Zenawi.

[12] Theoretical explanation for the gravity model are provided by (Anderson, 1979; Deardorff, 1998)

estimation approach.[13] Thus, we estimate the following equation:

$$T_{ijkt} = exp(\beta_1 Treat_i * Bulky_k * Post_t + \mu_{it} + \mu_{ik} + \mu_{kt})\varepsilon_{ijkt} \quad (3.1)$$

where T_{ijkt} is either the 3-digit Standard International Trade Classification (SITC) level of import or export flow from country i to country j at time t; $Treat$ is a dummy variable that is equal to 1 for Ethiopia and 0 for Kenya; $Bulky$ is a dummy variable that is equal to 1 for bulky (ocean freight goods) and 0 for light goods that are transported by air freight; $Post$ is a dummy variable that is equal to 1 after 1998 and 0 otherwise. Following the recent literature on gravity models (see, for example, Magee, 2008; Frazer and Van Biesebroeck, 2010; Cheong et al., 2017), we also include a large set of interacted fixed effects, where μ_{it} denotes the export-year fixed effects that subsume the typical gravity regressors (such as changes in exporter's income), and μ_{ik} and μ_{kt} represent the exporter-product and the product-year fixed effects, respectively. Finally, ε_{ijkt} is the idiosyncratic error term of product j traded between countries i and j at time t. We estimate Eq. (3.1) for different sets of import and export sectors. The coefficient on the triple interaction term (β_1) measures the net impact of landlockedness on trade.

Estimation Issues We discuss two key empirical issues and how we take care of them. The first issue comes from that fact that if there are many zeros in the bilateral trade data (which there are), our estimated gravity equation could be biased and inconsistent. This stems from the practice of transforming the gravity equation (e.g. Eq. (3.1) into its log-linear version first, and then estimate the log-linearized gravity equation by OLS. However, to accommodate the modeling of bilateral trade in its log form, we need to drop all country-pair observations with zero trade, since the log of zero is undefined. Consequently, this could cause severe sample attrition.

One stop-gap approach of handling the zero trade problem is to add one dollar to the value of trade ($T_{ijkt} + 1$) before taking the log transformation. However, this procedure is ad-hoc and may still yield inconsistent estimates (Silva and Tenreyro,

[13] Silva and Tenreyro (2010) employs the difference-in-differences approach to estimate the effect of currency union on trade through a gravity model framework.

2006). Moreover, trade data are usually heteroskedastic (Silva and Tenreyro, 2006). The expected value of the log-linearized error term in the gravity equation is likely to be a function of economic size, distance and other multilateral resistance variables, which makes OLS regression inappropriate. To address this issue, we follow Silva and Tenreyro (2006) to estimate Eq. (3.1) using the Poisson Pseudo Maximum Likelihood (PPML) estimator. The PPML estimator estimates Eq. (3.1) in its multiplicative form. Thus, it has the advantage of retaining zero trade values and provides consistent estimates in the presence of heteroskedasticity.[14]

The second issue comes from the fact that the effect of landlockedness of Ethiopia could be confounded by the potential effect of the Eritrean-Ethiopian war. Recall that Ethiopia became (both *de jure* and *de facto*) landlocked after it went into war with Eritrea in 1998. Since both the border war and the landlockedness of Ethiopia occur at the same time, it may be challenging to identify the net effect of landlockedness on trade flows using a pure difference-in-differences analysis.

To address this problem, we take advantage of the variation in the traded products that landlockeness can affect. The idea is the following. The war with Eritrea should affect both ocean-borne and airborne trade of Ethiopia, but landlockedness should affect only ocean-borne trade but not airborne trade. Thus, the change in the trend of ocean-borne trade before and after 1998 should capture the effects of both landlockedness and the war, but the change in the trend of airborne trade before and after 1998 should only capture the effects of the war (i.e. not landlockedness). As such, we could use the latter to partial out the effects of war in the trends of ocean-borne trade. For this reason, we include airborne commodities (light and expensive products) as an additional 'control' group. In doing so, we will have contrast between commodities, countries and time, and therefore, we will estimate the effect of landlockedness on trade by implementing the triple difference-in-differences approach that compares the difference between the export or import of bulky versus light goods of Ethiopia, to the difference in the export or import of bulky versus light

[14]The dependent variables (that include disaggregated import and export) are used without log transformation but the coefficient estimates can be interpreted as elasticities (Silva and Tenreyro, 2006; Paudel and Burke, 2015).

goods of Kenya, before and after 1998.

Besides dealing with the confounding effects of war, the triple-differencing approach also has the advantage of enabling us to partial out differences in trends that have nothing to do with landlockedness. For example, our estimates could be capturing the effects of systematic shocks to ocean-borne and airborne goods that are not associated with the landlockedness. If we include the ocean-borne trade of Kenya as an additional control group, we could partial out the potential divergence of trends in ocean-borne and airborne trade caused by systematic shocks.

More generally, by exploiting variations at the country, year and product levels as our triple-differencing approach does, we could include a rich set of fixed effects, such as exporter-year, exporter-product and product-year, to better identify β. These fixed effects ensure that we are not attributing the influence of year-specific commodity or country traits (shocks) to landlockedness. For example, following Ethiopia's landlockeness, exporter of bulky commodities may enjoy new infrastructure such as roads that may affect bulky and light commodities differently. Such potential confounder, however, could be controlled for by product-year fixed effect. Similarly, the two exporting countries-Ethiopia and Kenya may experience country-specific institutional or policy changes during the treatment period. To partial out the effects of country-specific policies or shocks, as well as the effects of all country-specific factors for trade, we could control for exporter-year fixed effects.[15] Finally, the possibility of referential trade policies on products may affect exports differently. Such confounding effects could also be dealt with by exporter-product fixed effects.

3.4 Data

The data for this analysis is taken from the UN Comtrade database. We use bilateral export and import data of bulky (ocean-borne) and light (airborne) commodities of Ethiopia and Kenya between 1993 and 2007.[16] The import and export data are

[15]The country-year fixed effects also capture the effect of exporters' change in GDP, income per capital, population and other gravity variables.

[16]We use 33 major trading partners of Ethiopia and Kenya to construct the bilateral panel data set. We also use the data from 1993-2010 for the synthetic control regression.

constructed using mirror data as these are likely to be more accurate in a developing country context (Paudel and Burke, 2015).[17] The data used in the analysis is at the one-digit (aggregated) and three-digit (disaggregated) Standard International Trade Classification (SITC).

For ocean-borne exports, We consider four major ocean-borne export products including coffee, leather, vegetable and hide & skin, which will be our "treated" goods. For the airborne exports, we consider gold, which will be our "control" good.

For ocean-borne imports, we consider fertilizer, fuel, petroleum, chemicals, iron and steel, metal, industrial machines, special machines, rubbers, transportation, textile, dyeing, perfume, and miscellaneous manufacturing materials. Like before, these ocean-borne imports will be our '"treated' goods. For airborne imports, we consider light commodities such as medicine and pharmaceutical products, which will be our "control" goods. Data on the exports and imports of these goods for Ethiopia (without Eritrea) prior to the closure of Assab port are available for 1993-1997.

3.5 Triple Difference-in-Differences Analysis

3.5.1 Landlockedness and Export

A. Baseline

Table 3.2 presents the triple difference-in-differences estimation results for the different major export products. Columns (1)-(4) report the effect of landlockedness on coffee, leather, crude vegetable (that includes natural gums, resins, cut flowers, gum resins and other similar export products), and hide and skin export, respectively. For these results, we have included exporter-year, exporter-product and product-year fixed effects into the model. For inference, we report robust standard errors that are adjusted for two-way clustering by exporter and product.

Column (1) reveals that landlockedness has a large negative and statistically significant effect on Ethiopia's coffee export. Specifically, the estimated coefficient

[17] Export from Ethiopia and Kenya is constructed from the import by largest trading countries. Similarly, the import from Ethiopia and Kenya are constructed form Export reported by major trading partners

Table 3.2: The Effect of Landlockedness on Disaggregated Export

	Types of export item			
	Coffee	Leather	Crude Vegetable	Hide & skin
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-0.561***	-0.681***	-1.589***	-1.271***
	(0.014)	(0.091)	(0.050)	(0.130)
Fixed Effects				
Exporter × Year	Yes	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes
Observations	1560	1560	1560	1560
Pseudo R^2	0.085	0.022	0.069	0.041

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***Bulky*** is 1 for ocean-borne exports and zero for light (air-borne) export product (i.e. export of gold); and ***Post*** is 1 after 1998 and zero otherwise. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

on the triple interaction term shows that coffee exports are reduced by about 43% following the landlockedness of Ethiopia, on average.[18] This 43% reduction in coffee exports is significant: coffee faming provides the livelihood income of 15 million Ethiopians (Moat et al., 2017) and coffee exports account for a quarter (i.e. 25%) of Ethiopia's export earnings. Hence, through a back-of-the-envelop calculation, a 43% reduction in coffee exports translates into a 11% (i.e. 25% × 43% ≈ 11%) decline in total export earnings. This is just coffee alone: the total negative effects of landlockedness are likely to be much larger.

Columns (2), (3) and (4) also show that lack of access to the Assab port reduces Ethiopia's export of leather, crude vegetable, and hide and skin by 49%, 80% and 72%, respectively. All these estimates are statistically significant at 1%. Overall, the negative effects of landlockedness observed here appears to be larger than the negative effects reported in the previous studies. These studies usually estimate the effect of landlockedness by estimating the coefficient on the landlocked dummy. As such, they cannot deal with confounding factors like country fixed effects. For example, Limao and Venables (2001) finds that a median landlocked country trades 28% less than a maritime country. In addition, Paudel et al. (2014) shows that landlocked developing

[18] The formula to compute the effect of a dummy variable in a PPML model is $(e^{\theta_i} - 1) \times 100\%$, where θ_i is the estimated coefficient of dummy variable i (Silva and Tenreyro, 2006).

countries (LLDCs) export about 25% less than other least developing countries. By contrast, our study shows that for the ocean-borne goods considered, landlockedness has caused exports to decline by about 50% or more.

B. Placebo test

Next, we conduct a placebo test for our baseline results in Table 3.2. The placebo test evaluates the effect of landlockedness on export before Ethiopia actually became a *de facto* landlocked country in 1998. If our identification strategy in Table 3.2 is valid, then landlockedness should not have any statistically significant effects before 1998. As such, we employ 1996 as a false treatment year (i.e. placebo), and present the triple-differenced estimate of its effect on the four major export items of Ethiopia in Table 3.3.[19] Across all columns, we find that the placebo is statistically insignificant. Thus, there is good evidence that our baseline estimate is capturing the effect of landlockedness and not other coincidental events.

Table 3.3: Placebo: the Effect of Landlockedness on Disaggregated Export

	Types of export item			
	Coffee	Leather	Crude Vegetable	Hide & skin
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-0.110	-0.380	0.169	-0.648
	(0.322)	(0.328)	(0.326)	(0.490)
Fixed Effects				
Exporter × Year	Yes	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes
Observations	600	600	600	600
Pseudo R^2	0.070	0.083	0.024	0.058

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***Bulky*** is 1 for ocean-borne exports and zero for light (air-borne) export product (i.e. export of gold); and ***Post*** is 1 for 1996 and 1997; and 0 for 1993 to 1995. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Importer country level clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[19] Therefore, the pre-treatment period is from 1993-1995 and the false treatment period is from 1996-1997.

C. The dynamic effect of landlockedness on export

Previously in Section A., we estimate the average effect of landlockedness on exports during the treatment period. However, such an estimate does not tell us if the negative effects of landlocked is short-lived or persistent.[20] In this section, we investigate how persistent the negative effect landlockedness is. To do so, we interact the triple-difference term with year dummies (Frazer and Van Biesebroeck, 2010), and compare the exports in each treatment year with the exports in the pre-treatment years to track the evolution of the effect of landlockedness on exports overtime.

In Table 3.4, we report the year-by-year effects of landlockedness on Ethiopia's coffee exports (Column (1)), leather exports (Column (2)), crude vegetable exports (Column (3)), and hide & skin exports (Column (4)). All the coefficients of the quadruple interaction term show that the average effect of landlockedness is persistent. Thus, the effect of landlockedness does not appear to be short-lived. That being said, there is also no evidence that the negative effect of landlockedness is becoming stronger over time.

D. Restricting the sample of countries

To obtain the results reported earlier, we have used data on thirty three major trading partners of both the treated country (i.e. Ethiopia) and the control country (Kenya) to investigate the effect of landlockedness on export. It is well known that estimates from the gravity model are potentially sensitive to the sample of countries included in the analysis (Haveman and Hummels, 1998; Magee, 2008).[21] As a robustness check, we re-estimate the model using data on exports with Ethiopia's and Kenya's top 20, 15 and 10 trading partners.

In Table 3.5, we only include the top 20 most important trading partners of the two countries. As before, we find that landlockedness has a negative and statistically significant effect on the exports of Ethiopia. These results continue to hold when

[20] There is a presumption that landlockedness has long-lasting negative impacts on trade and economic development (Arvis et al., 2010; World Bank, 2014).

[21] Haveman and Hummels (1998) shows the effect of Regional Trade Agreements (RTA) on trade is sensitive to change in sample of countries used in the analysis: the impact of of RTA varies when the sample of countries in the regressions is changed.

Table 3.4: The Dynamic Effect of Landlockedness on Export

	Types of export item			
	Coffee	Leather	Crude Vegetable	Hide & skin
	(1)	(2)	(3)	(4)
DDD × D_1998	0.318***	-0.651***	-0.524***	-0.138***
	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_1999	0.534***	0.787***	-0.624***	-0.007***
	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2000	-0.767***	-0.904***	-1.321***	-1.191***
	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2001	-2.236***	-1.792***	-1.692***	-1.638***
	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2002	-3.129***	-2.951***	-2.836***	-2.589***
	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2003	-1.959***	-1.406***	-1.916***	-1.625***
	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2004	-2.044***	-1.263***	-2.098***	-2.032***
	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2005	-1.716***	-0.546***	-1.748***	-2.021***
	(0.000)	(0.000)	(0.000)	(0.000)
Fixed Effects				
Exporter × Year	Yes	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes	Yes
Observations	1560	1560	1560	1560
Pseudo R^2	0.085	0.069	0.019	0.040

Note: ***DDD*** $\equiv$ ***Treat*** × ***Bulky*** × ***Post***. ***Treat*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***Bulky*** is 1 for ocean-borne exports and zero for light (air-borne) export product (i.e. export of gold); and ***Post*** is 1 after 1998 and zero otherwise. ***D_year*** is a dummy variable that equals 1 for that specific ***year*** and zero otherwise. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Importer country level clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

restrict our sample to the top 15 or 10 trading partners (see Table B1 and Table B2 in Appendix B). Hence, the impact of landlockedness on export is similar to the baseline in terms of sign and statistical significance, and is not sensitive to the number of trading partners considered in the analysis.

Table 3.5: The Effect of Landlockedness on Disaggregated Export: Top 20 Partner Countries

	Types of export item			
	Coffee	Leather	Crude Vegetable	Hide & skin
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-0.650***	-0.722***	-1.653***	-1.222***
	(0.017)	(0.089)	(0.051)	(0.130)
Fixed Effects				
Exporter × Year	Yes	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes
Observations	1430	1430	1430	1430
Pseudo R^2	0.079	0.026	0.067	0.047

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's export products and zero for Kenya's export products; ***Bulky*** is 1 for ocean-borne export and zero for light (air-borne) export product (i.e. export of gold); and ***Post*** is 1 after 1998 and zero otherwise. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.5.2 Landlockedness and Import

A. Baseline

In this section, we look at the effect of landlockedness on Ethiopia's ocean-borne imports. For each of the major imports, we re-estimate Eq. (3.1) by replacing the dependent variable, which was exports, with the imports from the major trading partners. The key variable of interest is once again "$Treat \times Bulky \times Post$" and the coefficient on the triple-interaction term measures the the effect of landlockedness on Ethiopia's ocean-borne imports.

In Columns (1)-(16) of Table 3.6, we find that all the coefficients of "$Treat \times Bulky \times Post$" are negative and statistically significant, suggesting that landlockedness reduces the major imports. The difference in the magnitude of the estimates across the product types indicates the presence of heterogeneity in how landlockedness affects imports. For example, landlockedness severely affects the import of petroleum, mineral fuel and fertilizer,[22] but has a smaller impact on the import of general industrial machinery, machinery specialized for particular industries and inorganic chemicals.[23]

[22] According to the point estimates, landlockedeness reduces the import of petroleum, fuel and fertilizer by 71%, 68.6% and 66.9%, respectively.

[23] One plausible explanation why some heavy items has a relatively smaller coefficient for import is that Ethiopia as a developing country has price (cost) inelastic demand for import, especially for products that are not easily produced within the country. The infant industries in Ethiopia would not able to import substitute products such as industrial and special machinery relative to other import items such as perfume imports. Thus, though landlockedness reduce the import of these goods to some extent, it was not affected strongly as other goods. Hence, the coefficients for the import of these products are smaller. .

Table 3.6: The Effect of Landlockedness on Different Import Goods

	Types of import item							
	Fertilizer	Fuel	Petroleum	Chem_material	Chem_related	Dyeing	Perfume	Inorganic_chem
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treat × Bulky × Post	-1.106***	-1.161***	-1.264***	-0.389***	-0.256***	-0.370***	-0.135***	-0.085***
	(0.028)	(0.081)	(0.086)	(0.018)	(0.007)	(0.018)	(0.016)	(0.028)
Importer × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer × Product	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1456	1456	1456	1456	1456	1456	1456	1456
Pseudo R^2	0.196	0.078	0.079	0.125	0.272	0.165	0.152	0.171

	Types of import item							
	Rubber	Textile_yarn	Metal	Iron_steel	Mis_manu	Special_machinery	Indus_machinery	Road_vehicle
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Treat × Bulky × Post	-0.674***	-0.399***	-0.329***	-0.239***	-0.257***	-0.062***	-0.063***	-0.085***
	(0.027)	(0.016)	(0.019)	(0.013)	(0.013)	(0.011)	(0.016)	(0.020)
Importer × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer × Product	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1456	1456	1456	1456	1456	1456	1456	1456
Pseudo R^2	0.116	0.048	0.080	0.040	0.101	0.064	0.084	0.051

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's import products and zero for Kenya's import products; ***Bulky*** is 1 for ocean-borne imports and zero for light (air-borne) import products (i.e. import of medicine and pharmaceutical products); and ***Post*** is 1 after 1998 and zero otherwise. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Similarly, landlockedness has also a detrimental effect on the import of foreign raw materials and intermediate inputs in manufacturing sector. In our regression, we find that landlocked status reduces import of rubber, steel, textile yarn and dyeing by 49%, 21%, 32.9% and 30.9%, respectively. This reduction may have a large implication for firms in the manufacturing sector as technology may diffuse through the used of imported intermediate inputs. Kasahara and Rodrigue (2008), for example, show that foreign inputs improves productivity through learning, variety and quality effects. **?** also argue that importing foreign intermediaries raise firm's productivity.

Overall, the strong adverse effects on almost all major imports support the argument that landlockedness is indeed a serious impediment to access global markets (see, for example, Limao and Venables, 2001; Faye et al., 2004; Djankov et al., 2010; Christ and Ferrantino, 2011).

B. Placebo test

The key identification assumption in our estimation is that in the absence of landlockedness, there should be no difference in the trends between the imports of ocean-borne and airborne cargo. Using import data from 1993 to 1997, we perform a falsification test, in which we assume that Ethiopia was landlocked in 1996 (i.e. a placebo) instead of 1998. Table 3.7 presents the estimation results, where the coefficients on the triple-interaction term are statistically insignificant. This suggests that the effect on imports post-1998 is not a placebo effect.

Table 3.7: Placebo: the Effect of Landlockedness on Different Import Goods

	Types of import item			
	Fertilizer	Fuel	Petroleum	Chem_material
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	0.316	0.347	0.312	0.119
	(0.364)	(0.274)	(0.300)	(0.195)
Exporter × Year	Yes	Yes	Yes	Yes
Exporter × Product	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes
Observations	560	560	560	560
Pseudo R^2	0.156	0.056	0.062	0.074

	Types of import item			
	Chem_related	Metal	Road_vehicle	indust_machinery
	(5)	(6)	(7)	(8)
Treat × Bulky × Post	0.286*	0.200	0.143	0.400
	(0.168)	(0.277)	(0.241)	(0.256)
Importer × Year	Yes	Yes	Yes	Yes
Importer × Product	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes
Observations	560	560	560	560
Pseudo R^2	0.212	0.043	0.068	0.072

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's import products and zero for Kenya's import products; ***Bulky*** is 1 for ocean-borne imports and zero for light (air-borne) import products (i.e. import of medicine and pharmaceutical products); and ***Post*** is 1 after 1996 and zero before 1996. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Importer-product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C. The dynamic effect of landlockedness on import

Table 3.8 presents the year-by-year effects of landlockedness on imports. The strong negative effect of landlocked status on import does not disappear; instead the impact of landlockedness increases significantly over time for certain goods. For example, landlockedness has reduced the import of fertilizer from 14% to 88.6%; mineral fuel from 41.7% to 71.7% and petroleum from 41.6% to 71.6%. For fertilizer, petroleum and mineral fuel, the impact of landlockedness during the last year of our sample (88.6%, 71.7% and 71.6%) is larger than the average effect of landlockedness measured over the previous eight years period (68.6%, 71% and 66.7%, from Table 3.6). This is consistent with the presumption that landlockedness has persistent negative effect on trade.

Table 3.8: The Dynamic Effect of Landlockedness on Import

	Types of import item							
	Fertilizer	Fuel import	Petroleum	Chem_material	Chem_related	Textile_yarn	Road_vehicle	Mis_manu
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DDD × D_1998	-0.151***	-0.541***	-0.538***	-0.374***	-0.243***	-0.135***	-0.343***	-0.227***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_1999	-1.070***	-0.241***	-0.236***	-0.061***	-0.167***	-0.133***	0.397***	0.193***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2000	-1.010***	-0.584***	-0.581***	-0.121***	-0.272***	-0.288***	-0.038***	-0.050***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2001	-2.110***	-1.211***	-1.210***	-0.559***	-0.352***	-0.513***	-0.683***	-0.309***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2002	-1.372***	-1.447***	-1.478***	-0.825***	-0.549***	-0.448***	-0.905***	-0.391***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2003	-1.320***	-1.251***	-1.589***	-0.474***	-0.413***	-0.153***	-0.522***	-0.337***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2004	-1.848***	-1.433***	-1.434***	-0.941***	-0.496***	-0.602***	-0.867***	-0.356***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DDD × D_2005	-2.173***	-1.263***	-1.259***	-1.329***	-0.618***	-0.818***	-1.507***	-0.797***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Importer × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer × Product	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1456	1456	1456	1456	1456	1456	1456	1456
Pseudo R^2	0.196	0.065	0.066	0.124	0.272	0.048	0.050	0.101

Note: $\boldsymbol{DDD \equiv Treat * bulky * Post}$. ***Treat*** is an indicator variable that equals 1 for Ethiopia's imports and zero for Kenya's imports; ***Bulky*** is 1 for ocean-borne import and zero for light (air-borne) import product; and ***Post*** is 1 after 1998 and zero otherwise. ***D_year*** is a dummy variable that equals 1 for that specific ***year*** and zero otherwise. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Importer country level clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

D. Restricting the sample of countries

We re-estimate our model by restricting the number of trading partners. Table 3.9 reports the triple-difference analysis using only 20 main trading partners and shows that the sign and statistical significance of the triple interaction term are unchanged from the baseline. In Table B3 and B4 of Appendix B, we conducted further robustness checks by restricting the sample to 15 and 10 main trading partners and find that our results are not sensitive to the selection of major trading partners for the analysis.

Table 3.9: The Effect of Landlockedness on Different Import Goods: with Top 20 Partners

		Types of import item		
	Fertilizer	Fuel	Petroleum	Chem_material
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-1.306***	-1.416***	-1.537***	-0.447***
	(0.036)	(0.121)	(0.128)	(0.021)
Importer × Year	Yes	Yes	Yes	Yes
Importer × Product	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes
Observations	1040	1040	1040	1040
Pseudo R^2	0.242	0.096	0.097	0.151
		Types of import item		
	Chem_related	Textile_yarn	Road_vehicle	Mis_manu
	(5)	(6)	(7)	(8)
Treat × Bulky × Post	-0.341***	-0.556***	-0.272***	-0.387***
	(0.011)	(0.025)	(0.016)	(0.017)
Importer × Year	Yes	Yes	Yes	Yes
Importer × Product	Yes	Yes	Yes	Yes
Product × Year	Yes	Yes	Yes	Yes
Observations	1040	1040	1040	1040
Pseudo R^2	0.329	0.057	0.072	0.124

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's import products and zero for Kenya's import products; ***Bulky*** is 1 for ocean-borne imports and zero for light (air-borne) import products (i.e. import of medicine and pharmaceutical products); and ***Post*** is 1 after 1996 and zero otherwise. Poison Pseudo-Maximum Likelihood (PPML) estimator is employed to estimate Eq. (3.1). Exporter-product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.6 Synthetic Control Analysis

For the previous results, we have used Kenya, a neighboring coastal country, as a comparison. In this section, we implement the synthetic control approach, a data-driven approach that enables us to construct comparison group from the set of possible comparisons that mirrors Ethiopia's pre-intervention trend as closely as possible. To construct the comparison group, we take weighted sum of the export (import) of the 34 coastal African countries as follows:

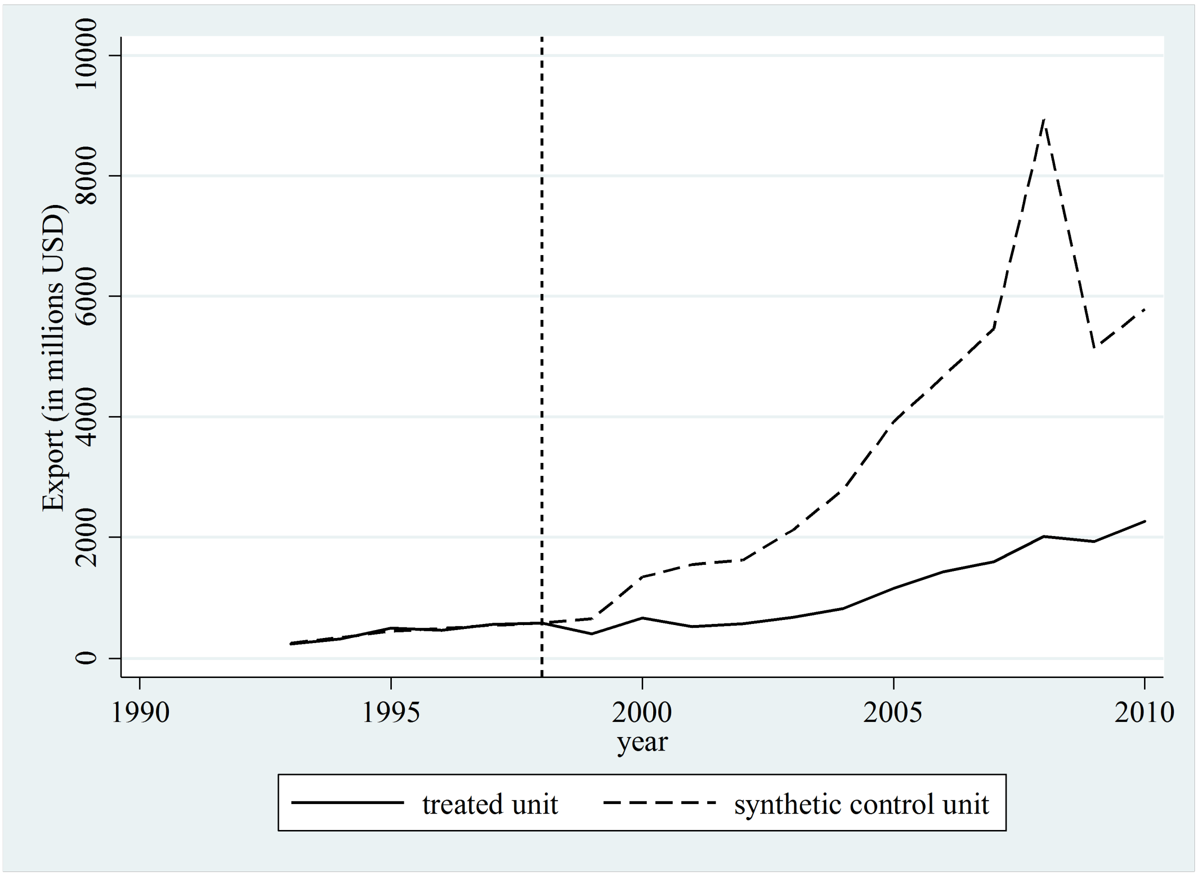
$$\widehat{T}_t = \sum_{j \epsilon c} \omega_j T_{jt} \tag{3.2}$$

where $\widehat{T}_t$ is the synthetic control for annual aggregate Ethiopia's export (import) in year t. T_{jt} is the period t aggregate annual export (import) of the 34 coastal African countries; and ω_j is the weight to coastal country c (note that: $\sum \omega_j = 1$ and $\omega_j \geq 0$). The weights are calculated by minimizing the mean squared errors of the export (import) of the landlocked country (T_{it}) with the coastal country (T_{jt}) in the pre-landlocked period (*i.e.* from 1993-1997) as follows:

$$\omega_j = arg \ min \sum_{t=1993}^{1997} (T_{it} - \omega_j T_{jt})^2 \tag{3.3}$$

Figure 3.1 plots the aggregate annual exports of Ethiopia and the synthetic control. The export of the synthetic control nearly perfectly matches the export of Ethiopia before 1998 (the start of the treatment period). However, after Ethiopia becomes both *de facto* and *de jure* landlocked, the total exports of the synthetic control increase dramatically and reaches at its highest level in 2007 (during the start of the great financial crisis period), while for Ethiopia, total exports decline immediately after being landlocked and remain low for a long-period of time. A benefit of using the synthetic control approach is that it provides a visual examination of the progress of the effect of the treatment (i.e. landlockedness). As shown in Figure 3.1, the difference in the exports of Ethiopia and the synthetic control has widen over time since 1998. This, again, suggests that landlockedness has a long-lasting effect.

Figure 3.1: The Effect of Landlockedness on Aggregate Export



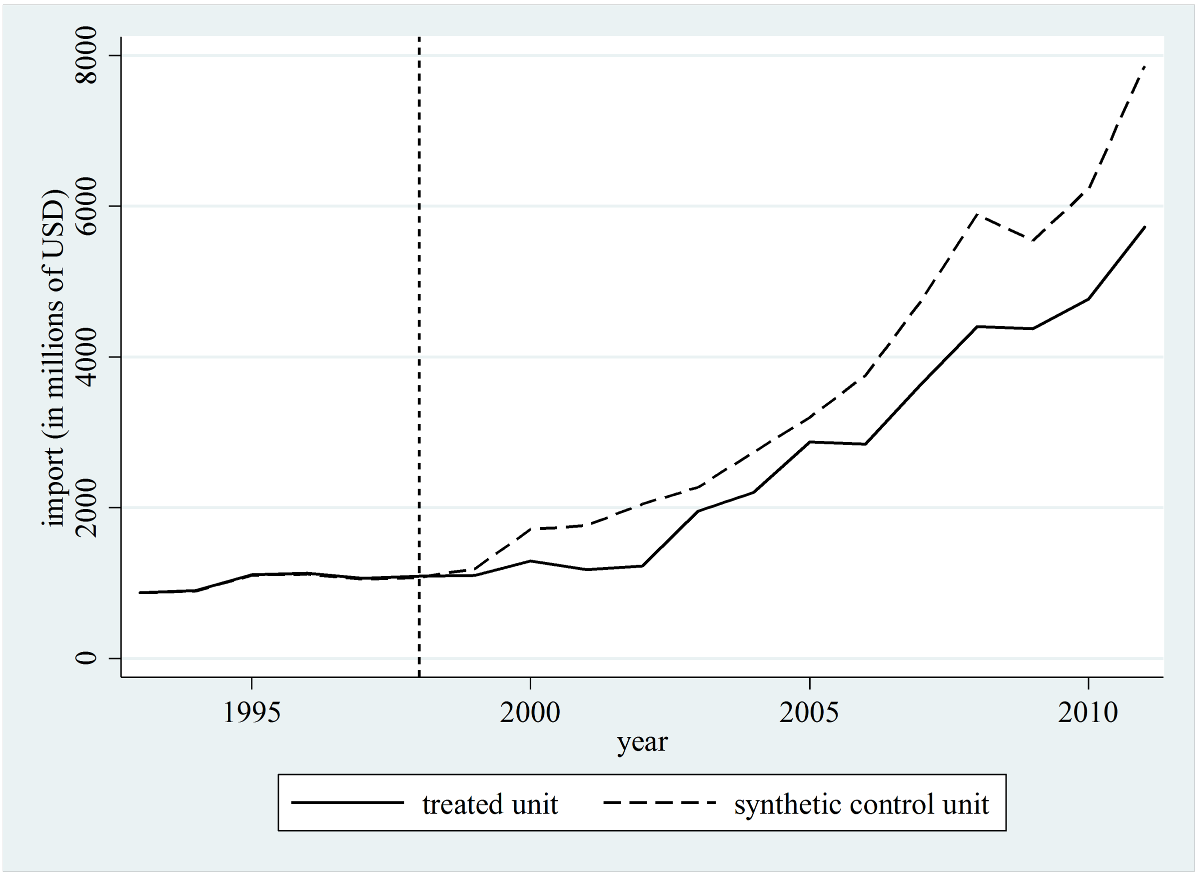
Note: This figure shows the synthetic control plot of the effect landlockedness on Ethiopia's total export. Ethiopia's export is the treated unit and the exports of 34 African coastal countries are the potential controls. The treatment period starts in 1998 as shown by the vertical dotted line.

Similarly, Figure 3.2 shows the impact of landlockedness on Ethiopia's imports. The dotted line plots the total imports for the synthetic control and the unbroken line plots the total imports of Ethiopia. Just as before, the imports of the synthetic control and Ethiopia are nearly identical before the treatment. However, from 1998 onwards, Ethiopia's imports have lagged far behind the synthetic control's. This suggests that landlockedness has a negative effect on the volumes of Ethiopia's imports. Although the divergence is not as large as that for exports, the effect of landlockedness on import is nonetheless persistent across time.

Our main identification strategy is based on the idea that the war with Eritrea should affect both ocean-borne and airborne trade of Ethiopia, but landlockedness should affect only ocean-borne trade but not airborne trade. Thus, the change in the trend of ocean-borne trade before and after 1998 should capture the effects of both landlockedness and the war, but the change in the trend of airborne trade before and after 1998 should only capture the effects of the war not landlockedness. One might be concerned the spillover effect of landlockedness on light goods.

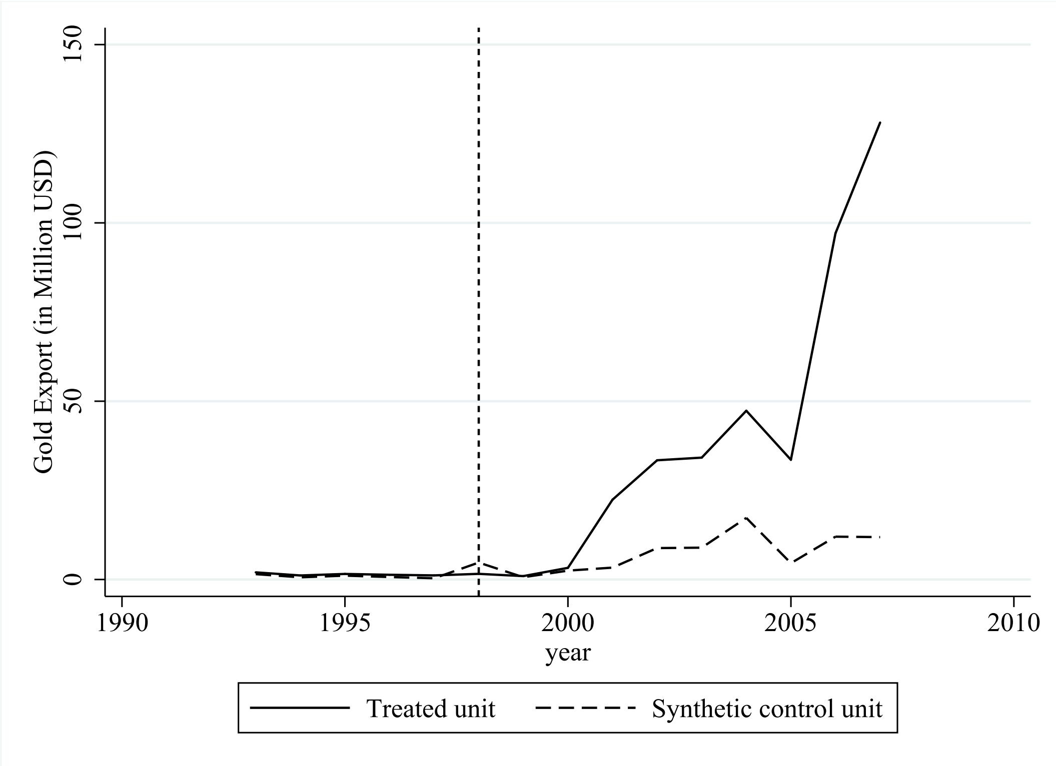
To address your concern about spillover effect of landlockeness on airborne goods, we examine the effect of landlockedness on gold export using synthetic control approach. As show in Figure 3.3, Ethiopia's gold export has not decreased following landlockedness. Rather it stays equal for four year (1998-2001) and increased after 2001. If landlockenss had a negative effect on Gold export, the result would have been the reverse, meaning that Ethiopia gold export would decline after 1998.

Figure 3.2: The Effect of Landlockedness on Aggregate Import



Note: This figure shows the synthetic control plot of the effect of landlockedness on Ethiopia's total import. Ethiopia's import is the treated unit and the imports of 34 African coastal countries are the potential controls. The treatment period starts in 1998 as shown by the vertical dotted line.

Figure 3.3: The Effect of Landlockedness on Light good export



Note: This figure shows the synthetic control plot of the effect landlockedness on Ethiopia's gold export. Ethiopia's export is the treated unit and the exports of 34 African coastal countries are the potential controls. The treatment period starts in 1998 as shown by the vertical dotted line.

3.7 Conclusion

Landlocked developing countries are among the poorest of developing countries. The limited participation in the international markets, due to typical high cost of trade, is often presumed as one of the main contributor of poverty in this countries. Existing studies on this area use a time invariant dummy variable, landlockedness indicator, that takes one if a country is landlocked and zero otherwise to quantify the impact of landlockedness on trade and development outcomes. However, the country fixed effect will partial out the time invariant landlocked indicator causing the effect of landlockedness to be unidentified. Moreover, there is no empirical evidence that examine whether the impact of landlockedness on trade in developing countries is temporal or permanent.

We have evaluated the impact of landlockedness on trade and how it evolves over time using the *de facto* landlockedness of Ethiopia in 1998 as a natural experiment. After Eritrea's independence in 1993, there was a protocol of understanding between the government of Ethiopia and the state of Eritrea for Ethiopia's free and unrestricted use of the port of Assab which is located in Eritrea (IMF, 1997; Faye et al., 2004; Briggs and Blatt, 2009; Connell and Killion, 2010). Therefore, the port of Assab was Ethiopia's main gateway to access global markets until 1998. In 1998, war broke out between the two countries (Eritrea and Ethiopia) due to border related issues. Port of Assab, Ethiopians main commercial outlet to the world, was immediately closed and Ethiopia become a *de jure* and *de facto* landlocked country. We exploit this natural experiment to isolate the causal effect of trade cost due to landlockedness on trade. We use triple-difference and synthetic control approach to investigate the impact of landlockedness on Ethiopia's major export and import products.

We find that landlockedness has a large negative and statistically significant effect on export and import of ocean-borne products. Specifically, we find that landlockedness on average reduces export of coffee, leather, crude vegetable and hide & skin by about 43%, 49%, 80% and 72%, respectively. In addition, landlockedness has a strong negative effect on different ocean-borne import goods of Ethiopia. For example, landlockedness reduces the import of petroleum, fuel and fertilizer by 71%, 68.6% and 66.9%, respectively. For a developing economy that highly depends on agriculture, 68.6% reduction in fertilizer import, for instance, has an important implication on the productivity of the sector.

Moreover, we examine whether the negative effect of landlockedness is short-term or long-lasting. The international community including the World Bank and IMF are supporting landlocked developing countries presuming that being landlocked has a long-lasting negative impact on trade and economic development. Our quadruple-difference results show that the effect of landlockedness on Ethiopia's export and import products is not short-lived. Rather its effect is persistent as the estimated coefficient increases every year after the landlockedness shock.

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Appendix B

Table B1: Landlockedness and Export: Top 15 Partner Countries

	Types of export item			
	Coffee	Leather	Crude Vegetable	Hide & skin
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-0.658***	-0.745***	-1.676***	-1.243***
	(0.016)	(0.093)	(0.051)	(0.142)
Exporter × Year	Y	Y	Y	Y
Exporter × Product	Y	Y	Y	Y
Product × Year	Y	Y	Y	Y
Observations	1430	1430	1430	1430
Pseudo R^2	0.079	0.026	0.067	0.047

Note: ***Treat*** is a dummy that equals 1 for Ethiopia's exports and zero for Kenya's exports; ***Bulky*** is 1 for ocean-borne and zero for light export; and ***Post*** is 1 after 1998 and 0 otherwise. Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B2: Landlockedness and Export: Top 10 Partner Countries

	Types of export item			
	Coffee	Leather	Crude Vegetable	Hide & skin
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-0.341***	-0.909***	-2.165***	-1.241***
	(0.021)	(0.088)	(0.078)	(0.142)
Exporter × Year	Y	Y	Y	Y
Exporter × Product	Y	Y	Y	Y
Product × Year	Y	Y	Y	Y
Observations	1300	1300	1300	1300
Pseudo R^2	0.086	0.026	0.065	0.060

Note: ***Treat*** is a dummy that equals 1 for Ethiopia and zero for Kenya's exports; ***Bulky*** is 1 for ocean-borne exports and zero for light export; and ***Post*** is 1 after 1998 and 0 otherwise. Exporter-Product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B3: Landlockedness and Import: Top 15 Partners Countries

	Types of import item			
	Fertilizer	Fuel	Petroleum	Chem_material
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-0.726***	-1.792***	-1.804***	-0.452***
	(0.047)	(0.168)	(0.167)	(0.023)
Importer × Year	Y	Y	Y	Y
Importer × Product	Y	Y	Y	Y
Product × Year	Y	Y	Y	Y
Observations	780	780	780	780
Pseudo R^2	0.294	0.111	0.110	0.184

	Types of import item			
	Chem_related	Textile_yarn	Road_vehicle	Mis_manu
	(5)	(6)	(7)	(8)
Treat × Bulky × Post	-0.265***	-0.512***	-0.294***	-0.414***
	(0.012)	(0.025)	(0.017)	(0.020)
Importer × Year	Y	Y	Y	Y
Importer × Product	Y	Y	Y	Y
Product × Year	Y	Y	Y	Y
Observations	780	780	780	780
Pseudo R^2	0.329	0.068	0.089	0.140

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's import products and zero for Kenya's import products; ***Bulky*** is 1 for ocean-borne import and zero for light (air-borne) import products (i.e. import of medicine and pharmaceutical products); and ***Post*** is 1 after 1996 and zero otherwise. Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (3.1). Exporter-product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B4: Landlockedness and Import: Top 10 Partners Countries

	Types of import item			
	Fertilizer	Fuel	Petroleum	Chem_material
	(1)	(2)	(3)	(4)
Treat × Bulky × Post	-0.852***	-0.783***	-0.783***	-0.399***
	(0.132)	(0.082)	(0.080)	(0.047)
Importer × Year	Y	Y	Y	Y
Importer × Product	Y	Y	Y	Y
Product × Year	Y	Y	Y	Y
Observations	520	520	520	520
Pseudo R^2	0.393	0.255	0.255	0.244

	Types of import item			
	Chem_related	Textile_yarn	Road_vehicle	Mis_manu
	(5)	(6)	(7)	(8)
Treat × Bulky × Post	-0.201***	0.026	-0.292***	-0.451***
	(0.030)	(0.041)	(0.024)	(0.040)
Importer × Year	Y	Y	Y	Y
Importer × Product	Y	Y	Y	Y
Product × Year	Y	Y	Y	Y
Observations	520	520	520	520
Pseudo R^2	0.434	0.072	0.127	0.171

Note: ***Treat*** is an indicator variable that equals 1 for Ethiopia's import products and zero for Kenya's import products; ***Bulky*** is 1 for ocean-borne import goods and zero for light (air-borne) import products (i.e. import of medicine and pharmaceutical products); and ***Post*** is 1 after 1996 and zero otherwise. Poison pseudo-maximum likelihood (PPML) estimator is employed to estimate Eq. (3.1). Exporter-product clustered robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 4

Landlockedness, Imported Inputs and Productivity: Evidence from Natural Experiment

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Principal Author

Name of Principal Author (Candidate)	Habtamu Tesfaye Edjigu		
Contribution to the Paper	This paper is written a sole author (the Candidate)		
Overall percentage (%)	100%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the sole author of this paper.		
Signature		Date	06/09/2018

Abstract

It is well-known that landlocked geography stifles trade by raising the cost of trade. Trade is important for development. Firms, for instance, tend to become more productive as they engage in international trade, especially if they have access to imported inputs. This paper exploits a novel natural experiment to show that landlockedess has non-trivial negative effects on firm productivity. The experiment is based on Ethiopia, which became *de facto* landlocked after its free access to the Eritrean port of Assab was cut-off following a war between them. Using a rich census dataset from Ethiopian manufacturing firms over the period 1996-2005, we find that landlockedness leads to a 14% productivity loss for firms that use imported inputs versus the counterfactual. We also find that the negative effect of landlockedness on productivity is stronger for small size firms and private-owned firms.

Key Words: Landlockedness, Trade cost, Ethiopia, Difference-in-Differences

JEL Codes:C21, F14, F15, O10, P33

4.1 Introduction

A well-known but little understood trade cost is the cost of landlocked geography to a country. For the trade in goods, landlocked countries depend heavily on other countries for transit. As such, they face significant barriers of trade such as long distance to global markets, huge port fee and inconvenient transit procedures that contribute to high transport and time costs. In 2014, the average cost to import a standardized container of cargo was \$4,343 in landlocked developing countries, while only \$1,559 in coastal developing countries (UN-OHRLLS, 2014). Landlocked countries have an import share to GDP of 11 percent compared with 28 percent for coastal countries. Their average exports are less than half of the per-capita volume of their coastal neighbors (World Bank, 1998; Faye et al., 2004).

Although the literature has attempted to study the effects of landlockedness, we have two observations about how the existing studies are carried out. Firstly, there are several cross-country studies that have shown how landlockedness (e.g. Limao and Venables, 2001; Raballand, 2003; Coulibaly and Fontagné, 2006; UN-OHRLLS, 2014) are associated with lower trade volumes. However, these results may not represent the causal effect of landlockedness, as it can be confounded by other time invariant country characteristics (Head and Mayer, 2014). The reason is that the existing studies usually estimate the effect of landlockedness by estimating the coefficient on a landlocked indicator variable (i.e. dummy variable that indicates if a country is landlocked). However, because the landlocked indicator is time invariant, country fixed effects will partial its effect out along with all the other invariant factors. Secondly, the existing studies have focused primarily on the effect of landlockedness on trade. By reducing firms' access to foreign inputs, landlockedness could also decrease the productivity of firms, as the foreign inputs expand the choice of intermediates goods for producers and may facilitate technological diffusion by embodying technological advances.[1]

[1]Recent studies also draw attention to the extent to which lower trade costs leads to higher productivity through access to foreign intermediate inputs (Amiti and Konings, 2007; Nataraj, 2011; Topalova and Khandelwal, 2011). However, landlockedness, by increasing international trade cost, may act as a barrier to import and reduce technology diffusion.

This paper estimates the effect of landlockedness on firm productivity using the sudden transition of Ethiopia from a *de facto* coastal country to a *de facto* landlocked one in 1998. Ethiopia was a coastal country until 1993. Its main seaport – Port of Assab – was located in the province of Eritrea.[2] In 1993, Eritrea separated from Ethiopia , and thus Ethiopia became *de jure* landlocked but remained *de facto* coastal as the two countries agreed for Ethiopia's free and unrestricted use of port of Assab located in Eritrea (IMF, 1997; Faye et al., 2004; Connell and Killion, 2010). However, in 1998, a territorial dispute led to the start of Eritrean-Ethiopian war and Port of Assab was immediately closed. As a result, Ethiopia became both *de jure* and *de facto* landlocked. Consequently, Ethiopia redirected its international trade through the seaport of a neighboring country, Djibouti, which now handles the great majority of its import and export. Hence, Ethiopian trade flow is subjected to huge fee and cumbersome transit procedures for using other countrys sea port and other related costs associated with crossing a sovereign country (Lorton, 2000; Begashaw, 2008).

To estimate the effect of landlockedness on firm-level productivity, we follow the standard approach in the literature (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Topalova and Khandelwal, 2011). First, we estimate production function at two digit industries level and construct firm-level productivity measures using the Levinsohn and Petrin (2003) methodology. Next, we examine the relationship between landlockedness and the estimated firm-level productivity. We then goes to investigate whether landlockedness has affected firms that import their inputs relative to non-importing firms. We hypothesize that if the productivity loss are due to reduction of importing foreign inputs then forms that import their inputs should be disadvantaged more than non-importers.

We find that landlockedness has a large negative impact on firm-level productivity. The results show that landlockedness lead to a 14 percent productivity loss for firms that import their inputs. Our result is robust to a variety of approaches to deal with time varying fixed effects and the confounding effect of concurrent events, including

[2]Eritrea was one of the 14 provinces of Ethiopia until 1991.

Ethiopian-Eritrean war.

To explain the possible channels for why landlockedness has a negative effect on the productivity of firms, we show that landlockedness has a negative effect on both the extensive margin (number of importing and exporting firms) and the intensive margin (volume of imports and exports per firm), which may explain why landlockedness could adversely affect the productivity of firms

We also document heterogeneity in the impact of the landlockedness across firms. We find that the effect of landlockedness varied across ownership type with private-owned firms showing a much higher negative effect than state-owned firms. Firms in different size categories also affected differently. Small and medium size firms significantly and negatively affected. However, there is no evidence that landlockedness led to loss in productivity for large firms.

The main contribution of this paper is to uncover new findings about the impact of landlockedness on firm-level productivity by exploiting a novel natural experiment. Using the 1998 Ethiopia-Eritrea war a natural experiment, we provide a microlevel evidence and address the potential concern in identifying the effect of landlockedness in the literature. Previous studies on the cost of landlockedness has mainly focused on aggregate trade and they estimate the effect of landlockedness by estimating the coefficient on the landlockedness indicator (time invariant variable) in cross-country regressions (e.g. Limao and Venables, 2001; Raballand, 2003; Coulibaly and Fontagné, 2006; UN-OHRLLS, 2014). However, their results can be driven by other time invariant country characteristics.

This paper also adds to the literature that looks at the effect of importing raw material on firm productivity while using a different natural experiment as an identification strategy (see, for example, Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Topalova and Khandelwal, 2011; Abreha, 2014). Our methodology is similar to the approach by Amiti and Konings (2007). Amiti and Konings investigate the effect of reducing input and output tariff on productivity of firms using Indonesia's trade reform of in 1995 as identification strategy. Similarly, Topalova and Khandelwal (2011) analyze the impact of India's trade liberalization in 1991 on the productivity of manufacturing firms. Unlike these papers, we examine the effect of trade cost driven by landlockedness on productivity of manufacturing firms using Ethiopia's 1998 *de facto* landlockedness as a natural experiment. In addition, this paper explore the mechanisms by which landlockedness may affect the firm productivity, including extensive margin (number of importing and exporting firms) and intensive margin (volume of imports and exports per firm).

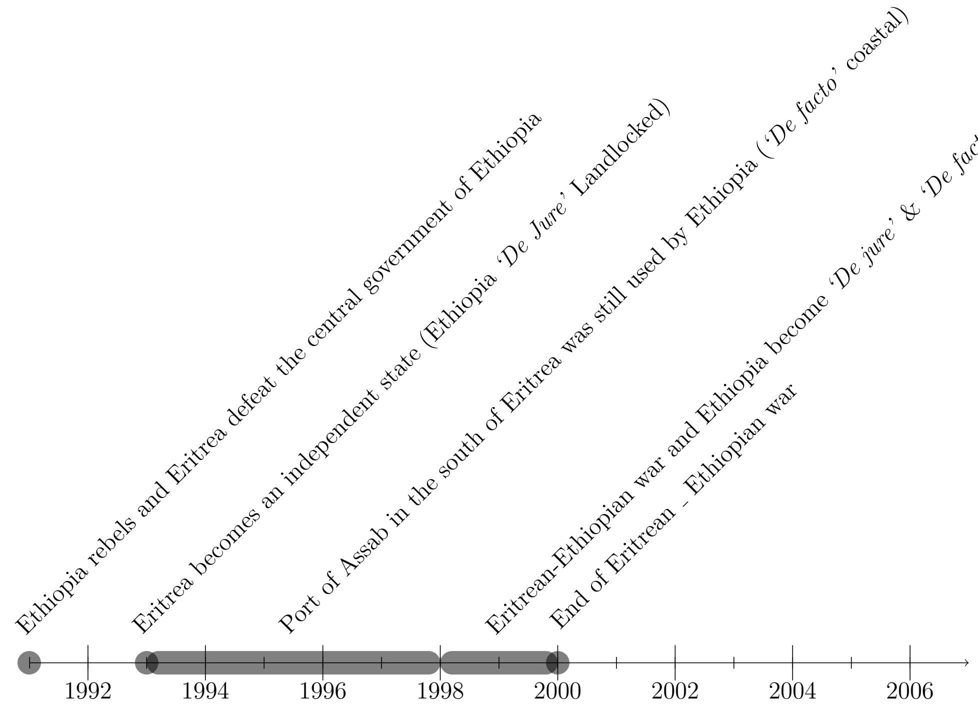
The reminder of this paper is structured as follows. Section (4.2) provides the historical background on how Ethiopia became *de jure* landlocked in 1993 and *de facto* in 1998. Section (4.3) reports the model specification, the estimation method of the study and data sources. Section (4.4) presents the main findings and the various robustness checks of the paper; and finally section (4.7) concludes.

4.2 Eritrean-Ethiopian War and Landlockedness of Ethiopia

Until 1998, Ethiopia was a coastal country using Port of Assab which is located in the province of Eritrea (currently state of Eritrea) as a main seaport of the country to access global markets (Connell and Killion, 2010; Murphy et al., 2013). About 95 percent of the country's international trade were shipped through this port (Faye et al., 2004).

For more than three decades, the Eritrean People Liberation Front (*EPLF*) initiated combat to establish their full independence. After a long years of war against the successive government of Ethiopia, *EPLF* and other Ethiopian rebel forces defeated Ethiopian central government forces in 1991 (as shown in the time line: Figure 1). Following the defeat of the then government of Ethiopia, Eritrea conducted a referendum for independence which leads to the formation of a state of Eritrea in 1993 (Pool, 1993).

Figure 1. Time-line for Ethiopia's landlockedness



After the establishment of Eritrea state in 1993, there was protocol of understanding between the Transitional Government of Ethiopia (TGE) and the state of Eritrea for Ethiopia's free and unrestricted use of the Port of Assab.[3] As stated under an intergovernmental transit and port service agreement and customs arrangement, both governments agreed that Ethiopia would be granted continued free access to the Port of Assab with its own Ethiopian customs office. In addition, Ethiopia's import and export remains exempt from Eritrean customs duties and related charges (IMF, 1997; Faye et al., 2004; Connell and Killion, 2010). Thus, Port of Assab remained practically an Ethiopian port in the state of Eritrea that makes the country a *de jure* landlocked but *de facto* coastal one.

In 1998, a border dispute leads to the starting of Eritrean-Ethiopian war and Port of Assab was immediately closed. As a result Ethiopia became both a *de jure* and *de facto* landlocked country. Currently, Ethiopia is the most populous landlocked country, among the 46 landlocked countries, in the world with population size fast approaching 100 million. Since becoming a *de facto* landlocked country in 1998 ,

[3]There has also been a claim that Port of Assab is a historical, legal and geographical property of Ethiopia (Abbay, 2006; Abreha, 2014). The main argument is that port of Assab was purchased by Rubattinio shopping company, Italian company, in 1869 from two Ethiopian sultans (sultan of Rahita- locates in the current Afar region of Ethiopia) prior to the establishment of Eritrea as a region. Hence, Port of Assab can be considered as historical property of Ethiopia

Ethiopia has shifted its international trading routes to a neighboring country's port , Djibouti port, which now handles the great majority of its import and export. Hence, Ethiopian trade flow is subjected to huge fee and cumbersome transit procedures for using other countrys sea port and other related costs associated with crossing a sovereign country (Lorton, 2000; Begashaw, 2008).

This episode on how Ethiopia became landlocked is a good natural experiment for estimating the impact of landlockedness on firm productivity for the following reasons. Firstly, the timing of Ethiopia becoming landlocked was unanticipated to the firms (Abbink, 1998). Therefore, th sudden transition of Ethiopia's *de facto* coastal to *de facto* landlockedness facilitate the causal interpretation of the results. Secondly, the availability of firm-level census data before and after Ethiopia's landlockedness enables us to study the impact of landlockedness on firm productivity. The census includes the universe of all importing and exporting manufacturing firms with more than 10 workers that use electric power driven machines in Ethiopia. Finally, Ethiopia is the most populous landlocked country in the world. Therefore, even though this natural experiment is local to Ethiopia in nature, we may draw useful lessons about how landlockedness affects firm productivity from Ethiopia itself given that it is the largest landlocked country.

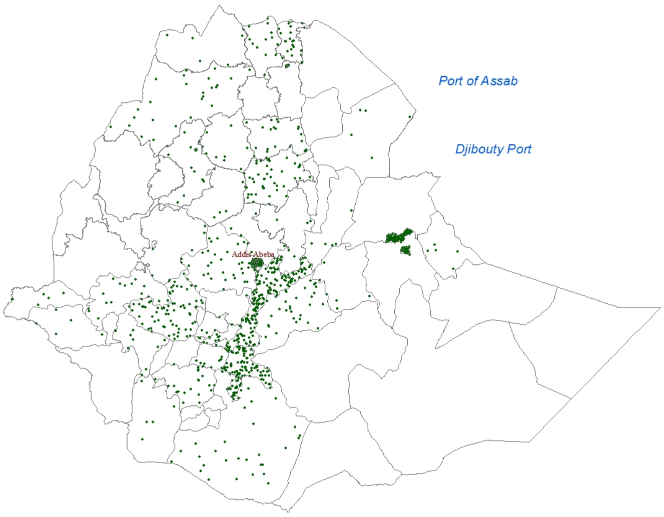


Figure 4.1: Distribution of firms across zones in 1996

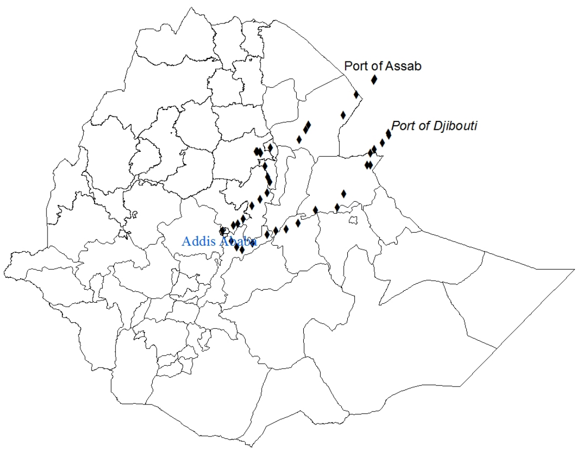


Figure 4.2: Port of Assab and Port of Djibouti

4.3 Empirical Strategy and Data

Productivity To compute firm productivity, we consider a firm with a Cobb-Douglas production:

$$Y_{it} = A_{it}K_{it}^{\beta_1}L_{it}^{\beta_2}M_{it}^{\beta_3} \tag{4.1}$$

where L_{it}, K_{it} and M_{it} are respectively labor, capital and other raw materials that firm i uses in producing Y level of output in period t. The total factor productivity of the firm –the portion of output that is not explained by the amount of inputs used–is measured by A_{it}. Our objective is to estimate the impact of landlockedness on firm-level productivity (TFP). In the first step we estimate firm-level total fator productivity and second, we specify how landlockedness affect productivity.

Taking the natural logs of equation 4.1, we estimate

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it} + \beta_3 m_{it} + \omega_{it} + \varepsilon_{it} \tag{4.2}$$

where small letters refer to natural logarithms, ϵ_{it} is firm specific time varying unobservable productivity shock ($lnA_{it} = \beta_0 + \omega_{it} + \epsilon_{it}$), and β_0 is the average productivity level across firms and overtime; ω_{it} is firm specific time varying productivity shock observable to the profit maximizing decision maker in the firm but not for the econometricians, and thus can affect the variable input choices that causes simultaneity problem. Therefore, we correct it using a variable input, intermediate inputs, as a proxy. Levinsohn and Petrin (2003) show that demand for raw materials depend on observed capital and unobserved productivity: $\omega_{it} = \omega_t(k_{it}, m_{it})$. Assuming $\omega_t = (.)$ is monotonic function, the unobserved productivity can be expressed in terms of observed capital and raw material. Thus, $\omega_{it} = \omega_t(k_{it}, m_{it})$ can be substituted in equation 4.2 and the coefficients in the production function can be consistently estimated.

After we obtain the input coefficients, we construct the firm's total factor productivity for each period, tfp_{it}. This is achieve by subtracting firm i's predicted output from its actual output at time t. However, since data on physical output, capital, labor and raw materials are not available, we estimate the firm's TFP by following the literature to use deflated revenue and value of all inputs as a proxies for the physical quantities. It would be ideal, of course, if we could use the actual physical output; but unfortunately, like most firm-level productivity research, we do not have such information, and thus, must rely on revenue TFP measure. Although a concern about revenue TFP estimates is that they may reflect firm-level differences in mark-ups, these estimates will capture the true technical efficiency as long as price-mark ups are correlated with true efficiency (Topalova and Khandelwal, 2011). Moreover, truly highly productive firms will tend to appear efficient in the productivity estimates regardless of the specific way that their productivity is measured (Syverson, 2011).

Landlockedness The empirical strategy employed in this paper uses the timing of landlockedness (i.e before and after 1998) as well as the share of firm's imported raw materials to identify the effects of imported input on TFP. In a regression framework, the baseline specification takes the following form:

$$\begin{aligned} tfp_{it} = {} & \alpha_0 + \alpha_i + \alpha_j + \alpha_t + \gamma_1(landlockedness_t) \\ & + \gamma_2(Imported\, inputs_{it}) + \gamma_3(landlockedness_t)FM_{it} + X'\gamma + \varepsilon_{it} \end{aligned} \tag{4.3}$$

where tfp_{it} the productivity estimate of firm i at time t, $landlcokedness$ is an indicator variable that equals to 1 after 1998 and 0 otherwise; $imported\ inputs_{it}$ is a measure of value of imported input by firm i at time t; FM_{it} is an indicator variable that equals to 1 if a firm i import its inputs at time t and 0 otherwise; X_{it} is a vector of firm characteristics including age, size, export and firm ownership types. We also include firm fixed effect (α_i) to control for unobserved firm-level heterogeneity. In some specification, we include full sets of fixed effect, which includes (α_t), to control for unobserved macroeconomic factors and trends that affect productivity across all firms and industry fixed effect (α_j), to control unobserved industry-specific heterogeneity. [4]

We are particularly interested in estimating γ_1 & γ_3 using firm fixed effects estimation technique. γ_1 capture the effect of landlockedness on firm productivity and γ_3 measures the impact of landlockedness on firms that import their inputs. We hypothesize that by increasing trade cost and stifle firms trade in the global market, landlockedness will reduce productivity ($\gamma_1 < 0$).

Recent studies also draw attention to the extent to which lower trade costs leads to higher productivity through access to cheaper and high quality foreign intermediate inputs (Amiti and Konings, 2007; Nataraj, 2011; Topalova and Khandelwal, 2011). Firms may benefit from imported inputs through access to more variety inputs and higher quality inputs. However, landlockedness, by increasing international trade cost, may act as a barrier to import and reduce technology diffusion. We hypothesize that if the loss in productivity is due to the reduction of imported intermediary inputs, the importing firms should bear the largest loss from this direct effect. As such, we interact landlockedness with a firm-level dummy variable that indicates whether the firm import any of intermediate inputs or not. A negative and significant (γ_3), therefore, imply that firms that import raw materials bear a higher loss than non-importing firms.

One of the main econometric issues in estimating the the effect of landlockedness is the time invariant nature of landlockedness. As a result, it is confounded by other time-invariant country characteristics (Head and Mayer, 2014). Although these confounding factors could be eliminated by employing panel data methods, the effect of landlockedness is unidentified since it will be partialled out after a within transformation. A time varying Ethiopia's landlockedness used in this paper gives rise to an excellent natural experiment to isolate the effect of landlockedness on trade and firm productivity.

[4]Moreover, when we do not control for time dummy, we include linear time trend to control the overall direction of the productivity movement across time and war period dummy that takes 1 between 1998 and 2000 that absorb the effect of the war on productivity of firms.

Data Our main data source is the Manufacturing Survey of Large and Medium-sized firms from 1996 to 2005. This survey, provided by Central Statistic Authority (CSA), is an annual census of all manufacturing firms in Ethiopia with 10 or more employees. The CSA data capture the formal manufacturing sector with firm-level data on sale, output, local intermediate inputs, imported intermediate inputs, labor, capital, exports, ownership types etc. We use data on sale and inputs to obtain productivity estimates.

The CSA questionnaire provides the value of intermediate inputs used in the production. It also indicate whether these inputs are local or imported. Thus, we have total expenditure on domestic inputs and imported inputs, but not by individual type of input. We aggregate the data within two-digit industry categories to create a 13 manufacturing sectors. The source of input data are of particular importance for this study as they enable us to construct an imported input share that is directly affected by landlockedness.

Table 4.1: International Trade participation of Ethiopia's Manufacturing Firms

Year	#Importers	#Exporters	%Importers	%Exporters	Total firms
1996	348	23	67.70	4.47	514
1997	376	25	69.76	4.64	539
1998	419	28	74.29	4.96	564
1999	405	36	70.93	6.30	571
2000	438	39	74.49	6.63	588
2001	382	36	68.71	6.47	556
2002	445	32	68.04	4.89	654
2003	565	41	79.35	5.76	712
2004	574	46	75.53	6.05	760
2005	486	50	72.54	7.46	670
2006	651	55	69.77	5.89	933

4.4 Results

4.4.1 Main Results

The results from estimating equation (4.3) using firm fixed effects for the period 1996 to 2005 are presented in Table 4.2. All specification includes firm fixed effects and standard error are clustered at industry level. Column (1) shows that without controlling for micro-level covariates and some fixed effects, there is a highly significant, negative relationship between landlockedness and firm productivity. In Column (2), we control for age, import and export and find the effect of landlockedness remains high and statistically significant at the 1% level.

In Columns (3)-(6), we include $Landlockedness_t \times FM_{it}$ to examine the effect of landlockedness on productivity of firms that use imported raw materials. In Column (4), we include firm fixed effect only. In Column (4), we additionally, control for regional fixed effects and linear time trend. In Column (5), we add war period and war regions dummies. In Column (6), we control for year fixed effects. However, we do not include landlockedness dummy as year fixed effect partial out the landlocked indicator, causing landlockedness to be unidentified. For the main specification, reported in Column (5) , we find that landlockedness reduces firm TFP by 28 percent, on average.[5]

If productivity losses from landlockedness are due to the reduction in imported inputs, we would expect firms that import raw materials suffer the most from this direct effect. To check this, we interact landlockedness with a dummy variable that indicates firm's import participation, FM. We classify firms as importing if they import any of their inputs. In Column (5), we find that the coefficients on this interactive term is negative and statistically significant, equal to -0.14. This suggest that landlockedness leads to a 14% productivity loss for firms that use imported inputs versus the counterfactual. This evidence is consistent with our hypothesis that landlockedness affect importing firms more than non-importing firms if they were enjoying from higher quality imported inputs prior to Ethiopia's landlockedness.

[5]The formula to compute the effect of the landlockedness is $(e^{\gamma_2} - 1) \times 100\%$ plus $(e^{\gamma_3} - 1) \times 100\%$.

There may be a concern that the key result is affected by time varying fixed effects that confound Ethiopia's landlockedness. One way to rule this out is to include year fixed effects into the regression. This is what we have done in Column (6), which shows that that the coefficient of $Landlockedness_t \times FM_{it}$ is negative and statistically significant, which is very close to the estimate for importing firms in Column (5).

In addition, Columns (5) and (6) show that exporting firms have higher productivity than non exporting firms. The coefficient on export is positive and statistically significant showing that a 1% increase in export results a 1.6% increase in firm productivity.

Table 4.2: Effect of Landlockedness on Productivity

Dependent variable: $\ln(TFP_{it})$	(1)	(2)	(3)	(4)	(5)	(6)
$Landlockedness_t$ *(=1 if year > 1997)*	-0.329***	-0.329***	-0.190***	-0.190***	-0.145**	
	(0.033)	(0.032)	(0.040)	(0.046)	(0.073)	
$\log(Imported\ raw\ material_{it})$		0.013***	0.020***	0.020***	0.020***	0.020***
		(0.003)	(0.004)	(0.004)	(0.004)	(0.003)
$\log(Export_{it})$		0.012*	0.012*	0.013*	0.016**	0.012*
		(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
Age_{it}		-0.000	-0.000	-0.000	-0.000	-0.001
		(0.000)	(0.000)	(0.000)	(0.000)	(.000)
$Landlockedness_t \times FM_{it}$			-0.148***	-0.149***	-0.139***	-0.145 ***
			(0.041)	(0.041)	(0.041)	(0.040)
Firm fixed effect	yes	yes	yes	yes	yes	yes
Region fixed effect	no	no	no	yes	yes	yes
Time trend	no	no	no	yes	yes	no
War year dummy	no	no	no	no	yes	no
War region dummy	no	no	no	no	yes	yes
Year fixed effect	no	no	no	no	no	yes
Observations	6823	6778	6778	6778	6778	6778

Note: Table reports regression of firm productivity on landlockedness. The dependent variable is TFP of firm i at time t between 1996-2005. TFP is calculated using Levinsohn and Petrin (2003). Our interest variable in the interaction term FM denotes importing firm dummy. Robust standard errors corrected for clustering at industry level in parentheses. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$

4.4.2 Landlockeness, Firm Characteristics and TFP

In this section, we investigate the impact of landlockedness across firms of different ownership type and firm sizes-categories. Firms ownership are classified either private or state-owned (public) and their size is placed in to either large, medium or small size categories. We first examine if privately-owned firms affected by landlockedness than public-owned firms. Table 4.3 presents the results of the impact of landlockedess across ownership type. The results in the preferred specification (see Columns (3) and (6)) show that while landlockedness reduces productivity of private-owned firms, government owned-firm did not experience the same impact. One possible explanation is evidence that public firms likely to get various forms of governments favoritism and enjoy the benefit of participating in the international trade.

We also examine whether the effect of landlockedness on productivity varies across firm categories. Columns (1)-(3) in Table 4.4 indicate that the effect of landlockedness in firm productivity is not similar across firms of different size. Using definition of World Bank, we classify firms with 19 and less workers as small, 20-99 workers as medium and above 99 workers as large firms. One observes that the negative impact of landlockedness on productivity is different across firm size categories. The point estimate in the sample of small firm categories are bigger in magnitude and statistically significant while the estimate is not significant for large firms. This finding perhaps can be explained by the fact that large firms have high capital such that they keep importing even after landlockedness.

Table 4.3: Effect of Landlockedness on Productivity: Public versus Private

Dependent variable: $\ln(TFP_{it})$	Private			Public		
	(1)	(2)	(3)	(4)	(5)	(6)
$Landlockedness_t$	-0.330***	-0.338***	-0.168**	-0.330***	-0.317***	0.003
	(0.041)	(0.040)	(0.079)	(0.053)	(0.057)	(0.131)
$\log(Imported\ raw\ material_{it})$		0.015***	0.025***		0.006	0.011
		(0.004)	(0.005)		(0.006)	(0.007)
$\log(Export_{it})$		0.029**	0.030***		-0.000	0.002
		(0.012)	(0.011)		(0.009)	(0.009)
Age		-0.000	-0.000		-0.001	-0.000
		(0.000)	(0.000)		(0.002)	(0.002)
$Landlockedness_t \times FM_{it}$			-0.170***			-0.142**
			(0.051)			(0.068)
Firm fixed effect	yes	yes	yes	yes	yes	yes
Region fixed effect	no	no	yes	no	no	yes
Time trend	no	no	yes	no	no	yes
War year dummy	no	no	yes	no	no	yes
War region dummy	no	no	yes	no	no	yes
Observations	5407	5379	5379	1416	1399	1399

Note: Table reports regression of firm productivity on landlockedness by firm ownership. The dependent variable is TFP of firm i at time t between 1996-2005. TFP is calculated using Levinsohn and Petrin (2003). The column heading indicates whether the sample includes only private or public. Our interest variable in the interaction term FM denotes importing firm dummy. Robust standard errors corrected for clustering at industry level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.4: Effect of Landlockedness on Productivity: Small, Medium and Large Size Firms

Dependent variable: $\ln(TFP_{it})$	Small	Medium	Large
	(1)	(2)	(3)
$Landlockedness_t$	-0.305**	-0.236**	0.184
	(0.131)	(0.106)	(0.113)
$\log(Imported\ raw\ material_{it})$	0.033***	0.025***	0.006
	(0.008)	(0.006)	(0.006)
$\log(Export_{it})$	0.085	0.050***	0.002
	(0.076)	(0.016)	(0.005)
Age_{it}	-0.004	-0.000	-0.001
	(0.007)	(0.000)	(0.003)
$Landlockedness_t \times FM_{it}$	-0.224***	-0.162***	-0.124*
	(0.086)	(0.062)	(0.065)
Firm fixed effect	yes	yes	yes
Region fixed effect	yes	yes	yes
Time trend	yes	yes	yes
War year dummy	yes	yes	yes
War region dummy	yes	yes	yes
Observations	2041	3073	1764

Note: Table reports regression of firm productivity on landlockedness by firm size categories. The dependent variable is TFP of firm i at time t between 1996-2005. TFP is calculated using Levinsohn and Petrin (2003). The column heading indicates whether the sample includes only small, medium or large. Our interest variable in the interaction term FM denotes importing firm dummy. Robust standard errors corrected for clustering at industry level in parentheses are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.5 Robustness Checks

In this section, we investigate the robustness of our results controlling exporters effect, exclusion of war period (1998-2000), exclusion of war region and adding industry fixed effect. We also present a falsification test.

4.5.1 Controlling Exporters Effect

Our primary focus in this paper is to examine the effect of landlockedness on those firms that import their inputs. However, there may be a concern that the key results are affected by exporters effect assocaited with landlockedness. One way to examine this is to re-estimate the equations using an interaction term of landlockedness and exporter dummy in the regression. We see from Table 4.5 that the coefficients on landlockedness intracted with export dummy ($Landlockedness_t \times export\, dumm_{it}$) is insignificant. Hence, the negative effect of landlockedness on productivity is due to decreased in imported raw material.

4.5.2 Excluding Ethiopia-Eritrea War Period

There may be a concern that the main results are affected by the Ethiopia-Eritrea war, which happed between 1998-2000 that confound the landlockedness timing. One way to test this is to re-estimate TFP and then estimate equation 4.3 using data that exclude this war period (1998-2000). Table 4.6 presents regression result that are estimated excluding data of 1998, 1999 and 2000, to ensure that the estimates are not capturing the effect of the war. We see that in Columns (3)-(6), the coefficient on landlockedness interacted with importing dummy ($Landlockedness_t \times FM_{it}$) is negative and statistically significant. Column (5) is our preferred specification and the magnitude of the coefficient of $Landlockedness_t \times FM_{it}$ (-0.132) is very close to the point estimate of the baseline results shown in Table 4.2. This may not be surprising , given that we include war-period dummy that could pick up the effect of the war on the baseline regression.

Table 4.5: Controlling Exporters Effect

Dependent variable: $\ln(TFP_{it})$	(1)	(2)	(3)	(4)
$Landlockedness_t$ (=1 if year > 1997)	-0.238***	-0.182***	-0.124*	
	(0.041)	(0.046)	(0.069)	
$\log(Imported\ raw\ material_{it})$	0.020***	0.020***	0.020***	0.020***
	(0.004)	(0.004)	(0.004)	(0.004)
$\log(Export_{it})$	0.022**	0.022**	0.022**	0.022**
	(0.010)	(0.010)	(0.010)	(0.010)
Age_{it}	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
$Landlockedness_t \times import\ dummy_{it}$	-0.146***	-0.147***	-0.146***	-0.144***
	(0.041)	(0.041)	(0.041)	(0.041)
$Landlockedness_t \times export\ dummy_{it}$	-0.159	-0.154	-0.153	-0.151
	(0.104)	(0.105)	(0.105)	(0.104)
Firm fixed effect	yes	yes	yes	yes
Region fixed effect	no	yes	yes	yes
Time trend	no	yes	yes	no
War year dummy	no	no	yes	no
War region dummy	no	no	yes	yes
Year fixed effect	no	no	no	yes
Observations	5915	5915	5915	5915

Table reports regression of firm productivity on landlockedness.
The dependent variable is TFP of firm i at time t between 1996-2005.
TFP is calculated using (Levinsohn and Petrin, 2003)
All regression includes industry fixed effects.
Robust standard errors corrected for clustering at industry level in parentheses are reported.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.6: Excluding Eritrea-Ethiopia War Period (1998-2000)

Dependent variable: $\ln(TFP_{it})$	(1)	(2)	(3)	(4)	(5)
$Landlockedness_t$	-0.357***	-0.351***	-0.275***	-0.203**	-0.271***
	(0.042)	(0.044)	(0.053)	(0.081)	(0.092)
$\log(Import_{it})$		0.009**	0.016***	0.016***	0.015***
		(0.004)	(0.005)	(0.005)	(0.005)
$\log(Export_{it})$		0.016*	0.016*	0.016*	0.021**
		(0.009)	(0.008)	(0.008)	(0.010)
Age_{it}		-0.001	-0.001	-0.001	-0.000
		(0.001)	(0.001)	(0.001)	(0.001)
$Landlockedness_t \times FM_{it}$			-0.135**	-0.133**	-0.132**
			(0.053)	(0.053)	(0.056)
Firm fixed effect	yes	yes	yes	yes	yes
Region fixed effect	no	no	no	yes	yes
Time trend	no	no	no	yes	yes
War region dummy	no	no	no	no	yes
Observations	5165	5123	5123	5123	4260

Note: Table reports regression of firm productivity on landlockedness excluding data of 1998, 1999 and 2000.The dependent variable is TFP of firm i at time t between 1996-2005. TFP is calculated using Levinsohn and Petrin (2003). Our interest variable in the interaction term FM denotes importing firm dummy. Robust standard errors corrected for clustering at industry level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.5.3 Excluding War Region

We may still be concerned that the statistical significant effect of landlockedness on firm productivity is driven by the location of firms, specifically stemming from firms located in the war region. In this robustness check, we re-estimate Eq. (4.3) excluding firms located in the Ethiopia-war region.

As documented by Negash and Tronvoll (2000) , the EritreanEthiopian War began as a territorial dispute, at border of Tigray region (one of Ethiopia's region) and most of the battles took place in the Tigray region. Hence, due to geographic exposure, firms operating in this region might be affected more than those in regions farther away from the war. As such, one may suspect that results are stemming from the inclusion of firms operating in the war-region in the regression. To check the robustness of our result, we re-estimate equation 4.3 excluding sample of firms operating in war region (Tigray). The results in Table 4.7 show that the interactive term ($Landlockedness_t \times FM_{it}$) is still negative and statistically significant at the 1%

level. Therefore, there is no evidence that the statistical significance of landlockedness is driven by the inclusion of firms operating in war region.

Table 4.7: Excluding Eritrea-Ethiopia War Region (Tigray)

Dependent variable: $\ln(TFP_{it})$	(1)	(2)	(3)	(4)	(5)
Landlockedness	-0.326***	-0.194	-0.245***	-0.201***	-0.162**
	(0.033)	(0.210)	(0.041)	(0.046)	(0.074)
log (Imported inputs)		0.025	0.020***	0.020***	0.019***
		(0.019)	(0.004)	(0.004)	(0.004)
log (exported inputs)		-0.010	0.014*	0.015**	0.018**
		(0.016)	(0.007)	(0.007)	(0.008)
Age		-0.036***	-0.000	-0.000	-0.000
		(0.013)	(0.000)	(0.000)	(0.000)
$Landlockedness_t \times FM_{it}$			-0.146***	-0.146***	-0.140***
			(0.041)	(0.041)	(0.042)
Firm fixed effect	yes	yes	yes	yes	yes
Region fixed effect	no	no	no	yes	yes
Time trend	no	no	no	yes	yes
War period dummy	no	no	no	no	yes
Observations	6506	6465	6465	6465	5665

Note: Table reports regression of firm productivity on landlockedness excluding data of Tigray region (war-region). The dependent variable is TFP of firm i at time t between 1996-2005. TFP is calculated using Levinsohn and Petrin (2003). Our interest variable in the interaction term FM denotes importing firm dummy. Our interest variable in the interaction term FM denotes importing firm dummy. Robust standard errors corrected for clustering at industry level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.5.4 Controlling for Industry Fixed Effects

So far, all estimation have been using firm fixed effects. In this section, we examine whether the main results are robust to alternative econometric specifications that includes industry fixed effect instead of firm fixed effects. In Table 4.8, we use industry (two-digit ISIC) fixed effects and control for firm characteristics such as size categories and ownership type. The sign and statistical significance of our estimates are generally consistent with the firm fixed effect model reported in Table 4.3.

Table 4.8: Controlling Industry Fixed Effect

Dependent variable: $\ln(TFP_{it})$	(1)	(2)	(3)	(4)
$Landlockedness_t$	-0.398***	-0.196***	-0.100*	-0.163**
	(0.037)	(0.051)	(0.056)	(0.079)
$\log(Imported\ raw\ material_{it})$	0.019***	0.052***	0.053***	0.050***
	(0.004)	(0.006)	(0.006)	(0.005)
$\log(Export_{it})$	0.023**	0.031***	0.031***	0.027***
	(0.009)	(0.009)	(0.009)	(0.008)
$Landlockedness_t \times FM_{it}$		-0.450***	-0.452***	-0.435***
		(0.061)	(0.061)	(0.059)
Age_{it}		0.000	0.000	0.000
		(0.001)	(0.001)	(0.001)
$Small_{it}$		0.270***	0.266***	0.253***
		(0.087)	(0.087)	(0.087)
$Medium_{it}$		0.391***	0.390***	0.390***
		(0.078)	(0.078)	(0.077)
$Private_{it}$		0.300***	0.310***	0.303***
		(0.090)	(0.091)	(0.092)
Industry Fixed Effect	yes	yes	yes	yes
Region fixed effect	no	no	no	yes
Time trend	no	no	no	yes
War region dummy	no	no	no	yes
War period dummy	no	no	no	yes
Observations	6823	6778	6778	6778

Table reports regression of firm productivity on landlockedness.
The dependent variable is TFP of firm i at time t between 1996-2005.
TFP is calculated using (Levinsohn and Petrin, 2003)
All regression includes industry fixed effects.
Robust standard errors corrected for clustering at industry level in parentheses are reported.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.5.5 Placebo Test

In this section, we conduct a falsification test to study the validity of our identification strategy. The main assumption in our estimation is that by increasing trade cost, landlockedness has a direct negative affect on productivity of importers and exporters. It hinders trade participating firms from accessing higher quality foreign inputs, more varieties of inputs and lower competition. Thus, if the loss in productivity is related with the reduction in foreign inputs and competition, landlockedness should not affect firms that are not participating in the international market during the sample period.

Table 4.9 presents the estimation results using sample of firms that do not import or export during the sample period. In Column (4), the coefficient on landlockedness is insignificant. This supports our observation that landlockedness has a negative effect on the productivity of firms by affecting exports or imports.

Table 4.9: Placebo test: Using Sample of Firms Neither Import nor Export

Dependent variable: $\ln(TFP_{it})$	(1)	(2)	(3)	(4)
$Landlockedness_t$	-0.371***	-0.220	0.172	0.176
	(0.131)	(0.153)	(0.248)	(0.248)
Age_{it}		-0.014	-0.015	-0.015
		(0.021)	(0.021)	(0.021)
Firm Fixed Effect	yes	yes	yes	yes
Time trend	no	yes	no	yes
Region fixed effect	no	no	no	yes
War region dummy	no	no	no	yes
War period dummy	no	no	no	yes
Observations	617	615	615	615

Table reports regression of firm productivity on landlockedness excluding data of nonimporter .
The dependent variable is TFP of firm i at time t between 1996-2005 .
TFP is calculated using Levinsohn and Petrin (2003). .
or exporting firms. Our interest variable in the interaction term *Landlockedness*
Robust standard errors corrected for clustering at industry level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.6 Possible Channels

In this section, we attempt to explore the channels through which landlockedness affect productivity of firms. We ask why firms productivity reduce following Ethiopia's landlockedness?[6]

We attempt to answer the above question by examining whether landlockedness reduce the extensive margin (number of firms that use imported inputs and exporting firms) and the intensive margin (average imports and exports per firm). We hypothesize that if the reduction in productivity is due to a reduction in intensive and extensive import and export following Ethiopia's landlockedness, we should see a negative relationship between landlockedness and extensive and intensive margin of import and export.

In Column (1) (Table 4.10), we estimate the relationship of landlockedness and intensive margin of import (volume of imported inputs) using fixed effect estimation. We find that the coefficient of landlockedness is negative and statistically significant, suggesting that landlockedness reduce the volume of imported inputs. Similarly, the result in Column (2) shows that landlockedness has a significant negative effect at the intensive margin (volume of firm's export). Hence, one channel through which landlockedness reduce productivity of firms is by reducing their export and imported inputs at the intensive margin.

In Table 4.11, we examine the effect of landlockedness on extensive margin of firm's import and export. As the estimated coefficients in Columns (1)-(6) show, regardless of the fixed effect controlled, landlockedness reduces the probability of importing inputs. The estimated coefficients are also statistically significant at least at 5%. However, we find no significant effect of landlockedness on firms' export at the extensive margin.

Overall, the results from Table 4.10 and 4.11 suggest that landlockedness reduce productivity of Ethiopian manufacturing firms: through reducing extensive margin

[6] Amiti and Konings (2007) document that trade liberalization increase importing input that leads to an increase in productivity. They point that the possible channels that trade liberalization improve firm's productivity is through increasing access to more varieties of imported inputs and access to higher quality inputs. Similarly, Bai et al. (2017) show that by increasing competition, exporting helps firms to achieve higher productivity levels.

(i.e number of firms that use imported inputs) and the intensive margin (i.e volume of imported inputs and exports per firm)

Table 4.10: Landlockedness on Import and Export

Dependent variable:	$Import\ inputs_{it}$	$Export_{it}$
$Landlockedness_t$	-0.640**	-0.280**
	(0.325)	(0.142)
Age_{it}	0.002	0.000
	(0.002)	(0.001)
Firm fixed effect	yes	yes
Region fixed effect	yes	yes
Time trend	yes	yes
War year dummy	yes	yes
War region dummy	yes	yes
Observations	7016	7016

Note: The dependent variable is import and export. Robust standard errors corrected for clustering at industry level in parentheses are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.11: Extensive Margin

Dependent variable:	$Import\ inputs_{it}$			$Export_{it}$		
	LPM	Probit	Logit	LPM	Probit	Logit
$Landlockedness_t$	-0.082***	-0.077**	-0.079**	-0.025**	-0.016	-0.015
	(0.031)	(0.030)	(0.030)	(0.011)	(0.010)	(0.020)
Age_{it}	0.000	0.001	0.002	-0.000	0.003*	0.005
	(0.000)	(0.001)	(0.002)	(0.000)	(0.002)	(0.006)
Firm fixed effect	yes	no	yes	yes	no	yes
Region fixed effect	yes	yes	yes	yes	yes	yes
Time trend	yes	yes	yes	yes	yes	yes
War year dummy	yes	yes	yes	yes	yes	yes
War region dummy	yes	yes	yes	yes	yes	yes
Observations	6101	6101	6101	6101	6069	6069

Note: Robust standard errors are reported in the parentheses.Our dependent variable is an indicator variable that equals to 1 if positive import or export occur to destination-year and zero otherwise * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.7 Conclusions

It is well-known that landlocked geography stifles trade by raising the cost of trade. Trade is important for development. Among its benefits, firms tend to become more productive as they engage in international trade, especially when they have access to imported inputs. This paper examine the effect of landlockedness on productivity of manufacturing firms using Ethiopia's landlockedness in 1998 as a natural experiment.

This study is the first to estimate the effect of landlockedness on firm-level productivity. We followed the standard way of estimating total factor productivity, using Levinsohn and Petrin (2003) methodology, which correct for simultaneity in the firm's production function. We find that landlockedness significantly decrease productivity among Ethiopian firms. We also show that the evidence is robust to exclusion of Ethiopia-Eritrea war period, war region, alternative econometric specification.

We hypothesize that if productivity losses from landlockedness are due to reduction in imported inputs, We would expect that importing firms would suffer the largest loss from this direct effect. Consistent with our expectation, we find th importing firm suffer a higher productivity loss compared to nonimporting firms. We also find that the negative effect of landlockedness on productivity is stronger for small sized firms and private-owned firms.

We show that among the possible channels, landlockedness may reduce productivity of firms through reducing extensive margin (number of importing and exporting firms) and the intensive margin (volume of imports and exports per firm). A further disentangling of the channels that can help to reveal why landlockedness reduces firm productivity is an interesting area for future research.

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Chapter 5

Barriers to the Diffusion of Technology across Countries: Assessing the Impact of Genetic Distance on Firm Productivity

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Overall percentage (%)	35%		
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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
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Abstract

Recent studies show that genealogically distant populations tend to differ more in a variety of characteristics transmitted intergenerationally, such as language, appearance, norms, values, customs, beliefs, and habits. Differences in these traits between countries and the world technology frontier, the US, can deter the exchange of ideas and reduce opportunities for learning, adoption of technologies, and innovations. Most of these studies, however, have often focused on country-level data and little is known at a micro-level analysis. In particular, whether genetic distance from the world technology frontier influences firm productivity in laggard countries or not is yet to be established. Building on earlier study by Comin and Hobijn (2010), we proposes a theoretical framework highlighting the mechanism through which genetic distance from the world leader acts as a barrier to technology adoption in laggard countries, thus influencing negatively firms' productivity in those countries. There are some challenges in testing this theory empirically. First, the treatment variable (genetic distance) is measured at country-level while the outcome variable (firm productivity) is available at firm-level, which renders the standard panel data method useless in identifying the causal effect since the treatment is dropped out after a within-type transformation. Second, there is a substantial heterogeneity across the distribution of firms' productivity so that a mean-type regression analysis such as the two-stage least squares method is not appropriate. Using a novel method on quantile treatment models with group-level unobservables recently proposed by Chetverikov et al. (2016), we show that the impact of genetic distance on firm productivity is consistently negative and *near inverted U-shaped* across the distribution of firms' productivity. Clearly, firms operating in a country genealogically far from the technology leader tend on average to have lower level of productivity but it is often the case that two countries, one with a very low technology adoption and the other with a moderate or relatively high technology adoption can be impacted identically by the same shock on current genetic distance. This may justify why some countries that appear closer to the US have not benefited from technology adoption compared with their peers that are genealogically far from the US, or vis-versa.

Key Words: Genetic distance; Barriers; Technology diffusion; Firm productivity; Quantile treatment models; Near inverted U-shape.

JEL Codes: C21; C26; O12; O14

5.1 Introduction

Many empirical studies document substantial and persistent measured productivity differences across countries— e.g., see Hsieh and Klenow (2010) and the review by Syverson (2011). Such differences are also observed across firms within a country, even at a narrowly defined industry code (e.g., four-digit SIC); Syverson (2004). Studies aiming to explain these differences often focus on the aggregate productivity growth— the source of almost all per capita income differences across countries into various micro-components, with the intent of better understanding the sources of such growth (Hall and Jones, 1999; Foster et al., 2001; Hsieh and Klenow, 2009, 2010). It is well known that various factors— such as geography, climate, luck, institutions, culture, policies, rule of law, and corruption— can explain income differences across countries through their direct influence on human/physical capital and total factor productivity (TFP); see Hsieh and Klenow (2010). Most of these theories have been assessed empirically with some for successes (Spolaore and Wacziarg, 2009; Bove and Gokmen, 2017; Spolaore and Wacziarg, 2016; Jäggi et al., 2018) with country-level data. However, we know little on why do firms differ so much in productivity across countries.

Earlier studies that addressed differences in productivity across countries includes Hsieh and Klenow (2010), Bartelsman et al. (2013), Restuccia and Rogerson (2008), Hsieh and Klenow (2009) and Midrigan and Xu (2014). For example, Hsieh and Klenow (2010) discuss why total factor productivity (TFP) varies across countries, highlighting misallocation of inputs across firms and industries as a key determinant. In this paper, we look at a different chain of causality that may explain differences in firms' productivity across countries. Spolaore and Wacziarg (2009) shows that genetic distance can capture cultural traits transmitted intergenerationally over the long run within populations, thus acting as a prominent source of large and persistent variations in income across countries. Following this idea and earlier study by Comin and Hobijn (2010), we proposes a theoretical framework highlighting the mechanism through which genetic distance from the world leader, the United States, acts as a barrier to technology adoption in laggard countries, thus influencing negatively the TFP of firms in those countries.

There are some challenges in testing this theory empirically. First, the treatment variable (genetic distance) is measured at country-level while the outcome variable (firm productivity) is available at firm-level, which makes the standard panel data method useless in identifying the causal effect since the treatment variable will be dropped out after a within-type transformation. Second, there is a substantial heterogeneity across the distribution of firm productivity, hence a mean-type regression analysis is not appropriate, i.e., a distributional method, such as a quantile regression analysis, is warranted. Third, due to the presence of group-level unobservables (country fixed effects) in the model, a standard quantile regression such as in Koenker and Bassett (1978) will yield inconsistent estimates, thus is also not appropriate in dealing with this type of problems.

Using a novel method on quantile treatment models with group-level unobservables recently proposed by Chetverikov et al. (2016) that accommodates the above problems, along with more than 32,000 firms from 94 countries, we show that the impact of genetic distance on firm productivity is consistently negative and *near inverted U-shaped* across the distribution of firms' total factor productivity (TFP). This means that the relationship between genetic distance and TFP is not monotonically decreasing. Indeed, although firms operating in a country genealogically far from the technology leader (the US) tend to have lower level of productivity, it is also the case that a country with a very low technology adoption (i.e., a very low TFP) and that with a moderate or relatively high technology adoption can be impacted identically by the same shock on current genetic distance. This may justify why some countries that appear genealogically closer to the US have not benefited from technology adoption compared with their peers that are far from the US, or vis-versa. We provide several robustness checks that show that the near inverted U-shape property of the relationship between genetic distance and the distribution of firms' TFP is: (i) robust to alternative measures of productivity and genetic distance; (ii) robust to inclusion of institutional quality and trade openness in the model; (iii) the exclusion of European countries whose genetic data are likely less measured with errors than non-European countries.

Moreover, we discuss a plausible chain of causality that my explain differences in firms' TFP across countries. Indeed, we document that current genetic distance is negatively correlated with technology adoption in the in the 1500AD, which in turns is strongly positively associated with current median firms' TFP across countries. As such, we expect current genetic distance to have a negative impact on the distribution (at least the median) of firms' TFP, thus corroborating the main findings of our study. It is nonetheless important to note that the latter analysis is only based on correlations, so more investigations are required to clarify if genetic distance influences firms' productivity through its impact on the technology adoption in the 1500AD. We leave these investigations for future research.

Our study contributes to the emerging empirical literature on the impact of genetic distance on technology diffusion.[1] For example, Spolaore and Wacziarg (2009) show that genetic distance is a key determinant of differences in income across countries, and their result is robust to the inclusion of covariates such as geographical distance, climatic differences, transportation costs, and measures of historical, linguistic, and religious distance. Bove and Gokmen (2017) show that the negative impact of genetic distance on income across countries is stable over time, while Proto and Oswald (2017) establish that some nations may have a genetic advantage in well-being– e.g., the closer is a nation to the genetic makeup of Denmark the happier this nation is. Similarly, Ang and Kumar (2014) investigate the impact of genetic distance from the world technology frontier on financial development. They find that genetic distance negatively affects financial development through its influence on countries ability to adopt innovations from the frontier technology. Although all these

[1]See Giuliano et al. (2006), Spolaore and Wacziarg (2009), Guiso et al. (2009),Ang and Kumar (2014), Bove and Gokmen (2017), Ashraf and Galor (2013b) and Ashraf and Galor (2013a).

studies have some similarity with ours, there are two fundamental differences. First, our study examines the impact of a group-level treatment (genetic distance, that is measures at country-level) on a micro-level outcome (firms' TFP, that measures at firm-level), while theirs focus on a group-level analysis as both their treatment (genetic distance) and the outcome (income/financial development) variables are measured at country-level. Second, while their studies focus on a mean-type regression analysis, we show that a distributional approach is warranted to capture heterogeneity across the distribution of the outcome variable. As such, applying a mean-type regression approach, such as the 2SLS method, often yields an inconsistent estimate of the treatment impact on the outcome variable.

The rest of the paper is organized as follows. Section 5.2 presents the theoretical framework that leads to a testable empirical econometric specification. Section 5.3 presents the empirical specification and describes the estimation strategy. Section 5.4 provides a brief description of the data, including the data sources and the main variables used in the paper. Sections 5.5 presents the baseline results, while Section 5.6 provides some robustness checks. Section 5.7 introduce a brief mechanism that may justify the main results of the paper, while Section 5.8 contains the concluding remarks. The description of the variables and basic summary statistics are included in the appendix.

5.2 Theoretical Framework

A theoretical model describing the mechanism through which *genetic distance* from the frontier country can endogenously affects *technology adoption* in laggard countries (thus impacting on firms' productivity) was first developed Comin and Hobijn (2010). In this section, we show how this theoretical framework can be adapted to a micro level analysis. In particular, we demonstrate how *genetic distance* can influence firms' total factor productivity (TFP), and we test the theory with an econometric specification.

Following Comin and Hobijn (2010), we consider a three sectors model: the households, the world technology frontier, and the firms. We assume there are identical **households** in the economy with unit mass. Each household supplies inelastically a unit of labor, receives wage (w), and saves in bonds that are available in the domestic market with zero net supply. The representatives household maximizes his life time utility subject to the budget constraint and the no-Ponzi scheme condition on bonds. **The technology frontier country** is characterized by a set of technologies and vintages specific to each technology at time t. At each instant t a new technology (τ) exogenously appears. Denoting a technology by the time it was invented, the range of technologies invented by the frontier country are given by $(-\infty, t]$. For each existing technology, a new and more productive vintage appears in the world frontier at every t. We denote the vintage of technology τ by V_τ. Vintages are indexed by the time in which they appear. Hence, the set of existing vintages of technology τ available at time t is $[\tau,\ t]$. The productivity of a technology has two components: $Z(\tau, V_\tau)$ and a_τ. The component $Z(\tau, V_\tau)$ is common across countries and is purely determined by technological attributes, i.e.

$$Z(\tau, V_\tau) = e^{(\chi+\gamma)\tau+\gamma(V_\tau-\tau)} = e^{(\chi\tau+\gamma V_\tau)} \tag{5.1}$$

where $(\chi+\gamma)\tau$ is the productivity level associated with the first vintage of technology τ and $\gamma(V_\tau-\tau)$ represents the productivity level associated with the introduction of new vintages. The second component, a_τ, is the country specific productivity term that is described in (5.2) below.

Identical **firms** operate competitively in each country. They adopt a new technology τ from the frontier countries, combine it with labor and intermediate goods to produce output. We assume countries that are adopting a technology τ are below the world technology frontier country. If D_τ denotes the *adoption lag* that reflects the time lag between when the best vintage in use was invested and when it was invented for production in the economy, then the vintage of technology τ is defined as $V_\tau = [\tau,\ t - D_\tau]$ and represents the set of technology-τ vintages available in the economy. We also assume that new vintages (τ, V), where $V \equiv V_\tau$ hereinafter, are used in production through new intermediate goods that embody them. Intermediate goods $X_{\tau,V}$ are combined with labor $L_{\tau,V}$ to produce output $Y_{\tau,V}$ associated with a given vintage. The form of the production function for $Y_{\tau,V}$ is given by:

$$Y_{\tau,V} = a_\tau Z(\tau, V) X^{\alpha}_{\tau,V} L^{1-\alpha}_{\tau,V}. \tag{5.2}$$

In (5.2), a_τ represents the factors that reduce the effectiveness of a technology in a country. Comin and Mestieri (2014) designate it as barriers to the diffusion of technology. a_τ also determines the *long-run penetration rate* of technology in a given country, thus is usually referred to as the **intensive margin** of technology adoption.

The representative firm combines the outputs associated with the different vintages of the same technology to produce the sectoral output, Y_τ, given by

$$Y_\tau = \Big(\int_\tau^{t-D_\tau} Y_{\tau,V}^{\frac{1}{\mu}} dV \Big)^\mu \quad \text{for some} \quad \mu > 1. \tag{5.3}$$

The final output is thus obtained by aggregating sectoral outputs Y_τ:

$$Y = \Big(\int_{-\infty}^{\overline{\tau}} Y_\tau^{\frac{1}{\theta}} d\tau \Big)^\theta \quad \text{for some} \quad \theta > 1, \tag{5.4}$$

where $\overline{\tau}$ denotes the most advanced technology adopted in the economy.

As shown by Comin and Hobijn (2010), the '**factor demand**' and '**final output** can be derived straightforwardly. More precisely, taking the price of the final output as the numeraire, both he demand for an output produced with a given technology and that of a particular technology vintage are given by:

$$Y_\tau = Y P_\tau^{-\frac{\theta}{\theta-1}} \tag{5.5}$$

$$Y_{\tau,V} = Y_\tau \Big(\frac{P_{\tau,V}}{P_\tau} \Big)^{-\frac{\mu}{\mu-1}}, \tag{5.6}$$

where P_τ is the price of sector τ output and $P_{\tau,V}$ refers to the price of the (τ, V) intermediate good. Equation (5.5) indicates that both the national income (Y) and the price of the technology (P_τ) affect the demand of output produced with a given technology τ. Due to the homotheticity of the production function, the income elasticity of technology τ output is one. Thus under perfect competition, the demand for labor and intermediate goods at the vintage level are then given by:

$$(1-\alpha)\frac{P_{\tau,V} Y_{\tau,V}}{L_{\tau,V}} = w, \tag{5.7}$$

$$\alpha \frac{P_{\tau,V} Y_{\tau,V}}{X_{\tau,V}} = 1. \tag{5.8}$$

Combining (5.2) and (5.7)-(5.8) gives:

$$P_{\tau,V} = \frac{w^{1-\alpha}}{Z(\tau, V) a_\tau} (1-\alpha)^{-(1-\alpha)} \alpha^{-\alpha}. \tag{5.9}$$

From (5.3), we can thus express the production function of total output produced with technology τ as:

$$Y_\tau = Z_\tau L_\tau^{1-\alpha} X_\tau^\alpha, \tag{5.10}$$

where $L_\tau = \int_\tau^{t-D_\tau} L_{\tau,V} dV$ is the total amount of labor employed in sector τ, $X_\tau = \int_\tau^{t-D_\tau} X_{\tau,V} dV$ is the productivity level associated with technology τ, and Z_τ denotes the total amount of intermediate goods in sector τ, i.e.

$$\begin{aligned} Z_\tau &= \left(\int_\tau^{max(t-D_\tau,\tau)} Z(\tau,V)^{\frac{1}{\mu-1}} dV \right)^{\mu-1} \\ &= \left(\frac{\mu-1}{\gamma} \right)^{\mu-1} \underbrace{a_\tau}_{\text{Intensive margin}} \underbrace{e^{(\chi\tau+\gamma max\{t-D_\tau,\tau\})}}_{\text{Embodiment effect}} \underbrace{\left(1 - e^{\frac{-\gamma}{\mu-1}(max\{t-D_\tau,\tau\}-\tau)}\right)^{\mu-1}}_{\text{Variety effect}} . \end{aligned} \quad (5.11)$$

Equation (5.11) indicates clearly that the productivity of technology τ is determined by three factors: the intensive margin (a_τ), the embodiment effect (which shows the productivity of the best vintage), and the variety effect (which represents the productivity gains from using more vintages). As such, the adoption lag D_τ has two effects on Z_τ. First, the shorter D_τ the more productive are the vintages used. Second, a shorter D_τ implies that more varieties are used, which in turns leads to higher productivity.

From (5.9), we can express the price index of technology τ output's as:

$$P_\tau = \left(\int_\tau^{t-D_\tau} P_{\tau,V}^{-\frac{1}{\mu-1}} dV \right)^{-(\mu-1)} = \frac{w^{1-\alpha}}{Z_\tau} (1-\alpha)^{-(1-\alpha)} \alpha^{-\alpha}. \quad (5.12)$$

Following Comin and Hobijn (2010), the process that governs the **diffusion of technology** in this model is given by:

$$y_\tau - y = \frac{\theta}{\theta-1} [z_\tau - (1-\alpha)(y-l)], \quad (5.13)$$

where y_τ is the log of sectoral output produced with technology τ, y is the log of final (aggregate) output, hence $y_\tau - y$ is the log of the share of sectoral output with technology τ in the total output, θ is the elasticity of substitution, z_τ is the log of productivity associated with technology τ, $1-\alpha$ is the share of labor in the production of y_τ, l is the log of the total amount of labor employed in the production of Y, and $(y-l)$ represents the log of per capita output.

From (5.11), we can write z_τ when $\max\{t-D_\tau, \tau\} = t - D_\tau$ as:

$$\begin{aligned} z_\tau &= (\mu-1) ln(\frac{\mu-1}{\gamma}) + ln(\alpha_\tau) + \chi\tau + \gamma(t-D_\tau) + \\ &+ (\mu-1) ln\big(1 - e^{-\frac{\gamma}{\mu-1}(t-D_\tau-\tau)}\big). \end{aligned} \quad (5.14)$$

Applying a double Taylor expansions to (5.14) as in Comin and Hobijn (2010) yields:[2]

$$z_\tau = ln(\alpha_\tau) + (\chi+\gamma)\tau + (\mu-1)ln(t-\tau-D_\tau) + \frac{\gamma}{2}(t-\tau-D_\tau) + R(t-D_\tau-\tau;\gamma,\mu), \quad (5.15)$$

where $R(\cdot)$ is the accumulated error resulting from the two expansions and is a function of $t-\tau-D_\tau$ and the parameters γ and μ. The log intensive margin, $ln(\alpha_\tau)$, appearing on the RHS of (5.15) incorporates all the sets of barriers for the adoption of technology τ by the country, $(\chi+\gamma)\tau$ is the associated productivity level, μ is the elasticity of substitution parameter in the sectoral output production function, while D_τ is the age of the best vintage available for production in the country for technology τ.

By substituting (5.15) into (5.13), we can write $y_\tau - y$ as:

$$y_\tau - y = \delta_\tau + \gamma_1 t + \gamma_2 ln(t-\tau-D_\tau) + \delta_1 ln(\alpha_\tau) + \delta_2(y-l) + R(t-D_\tau-\tau;\gamma,\mu,\theta), \qquad (5.16)$$

where $\delta_\tau = \frac{\theta}{\theta-1}\left[(\chi+\frac{\gamma}{2})\tau - \frac{\gamma}{2}D_\tau\right]$, $\gamma_1 = \frac{\theta}{(\theta-1)}\frac{\gamma}{2}$, $\gamma_2 = \frac{\theta}{\theta-1}(\mu-1)$, $\delta_1 = \frac{\theta}{\theta-1}$, $\delta_2 = -\frac{\theta}{\theta-1}(1-\alpha)$, and $R(t-D_\tau-\tau;\gamma,\mu,\theta) = \frac{\theta}{\theta-1}R(t-D_\tau-\tau;\gamma,\mu)$. Clearly, (5.16) is the linear projection of $y_\tau - y$ on a constant, time trends t and $ln(t-\tau-D_\tau)$, the log intensive margin a_τ, and the log of per capita output, where $R(t-D_\tau-\tau;\gamma,\mu,\theta)$ can be viewed as the error associated with this projection. As such, the long-run barriers to the diffusion of technology to a country are captured by the intensive margin α_τ [similar to Comin and Ferrer (2013) and Comin and Mestieri (2014)]. In particular, Comin and Mestieri (2014) highlights that the factors that determined the intensive margin (α_τ) for a given country are: *genetic distance* from the frontier country, human capital, geographical factors (such as landlockedness, distance from the technology frontier, tropical land area), openness to trade, institutional factors and other cultural factors. Therefore, we can specify a linear model for the intensive margin (in natural log) as:

$$ln(\alpha_\tau) = \phi_0 + GD\phi_1 + \boldsymbol{X}\phi_2 + v_\tau, \qquad (5.17)$$

where GD is the measure of genetic distance from the technology frontier, $\boldsymbol{X}$ includes other control variables (landlockedness, absolute latitude, tropical land area, legal origin, language distance, and religion distance), ϕ_0 is the intercept, ϕ_1 is the coefficient on genetic distance, ϕ_2 denotes a parameter vector on $\boldsymbol{X}$, and v_τ is an error term. By substituting (5.17) into (5.16), we obtain the specification

$$y_\tau - y = \beta_\tau + \gamma_1 t + \gamma_2 ln(t-\tau-D_\tau) + GD\beta_1 + W\beta_2 + \varepsilon_\tau, \qquad (5.18)$$

[2]Where we first take a Taylor expansion of order 2 of $1 - e^{-\frac{\gamma}{\mu-1}(t-D_\tau-\tau)}$ around the starting adoption date, and then apply the log operator to the result, and take again a Taylor expansion of order 1 of the latter result.

where $\beta_\tau = \delta_\tau + \delta_1\phi_1$, $\beta_2 = (\phi_2', \delta_2')'$, $W = [\boldsymbol{X} \vdots y - l]$, and $\varepsilon_\tau = R(t - D_\tau - \tau; \gamma, \mu, \theta) + \delta_1 v_\tau$. In this study, we investigate how a relationship such as (5.16) evolves at a micro-level (i.e., at firms level), rather than a country-level as usually done in the literature on this topic.

To enable a micro-level analysis, we look at the diffusion of total factor productivity (TFP) of firms as oppose to output in the country-level specification (5.16). In particular, our main objective is to identify the effect of *genetic distance* on firms' TFP in developing countries. We stress the fact that TFP is often regarded as a measure of technology in the economy, especially in the early versions of real business cycle (RBC) models where it is well documented that growth in TFP drives growth in the long term. The main difficulty in our analysis is that genetic distance (treatment variable of interest) is measured at country-level while TFP data are available at firm-level. This render the standard panel data method such as fixed estimation useless in identifying β_1 since the variable GD will disappear after a within-type transformation. Using recent developments on quantile treatment models with group-level unobservables, we are able to identify β_1 (the effect of genetic distance on TFP) despite the presence of grup-level unobservable confounding factors. Section 6.3 details the empirical specification as well as the estimation strategy.

5.3 Empirical Specification

To identify the effect of genetic distance on TFP, we use a quantile treatment approach when group-level unobservables are present. Section 5.3.1 presents the specification used, while issues related to model identification are discussed in Section 5.3.2. Finally, Section 5.3.3 describes briefly the measurement of firms' total productivity (TFP) by the World Bank analysis unit.

5.3.1 Model

Let $\mathcal{U}$ denote a set of quantile indices and consider the framework of IV quantile regression for grouped-level treatments (Chetverikov et al., 2016):

$$Q_{TFP_{ic}|GD_c, X_{ic}, Z_c, \varepsilon_c}(u) = GD_c\beta(u) + X_{ic}'\gamma_1(u) + Z_c'\gamma_2(u) + \varepsilon_c(u) \quad (5.19)$$

$$\varepsilon_c(u) = f(u, \eta_c), \quad (5.20)$$

where $Q_{TFP_{ic}|GD_c, X_{ic}, Z_c, \varepsilon_c}(u)$ is the uth conditional quantile of TFP_{ic} given $(GD_c, X_{ic}, Z_c, \varepsilon_c)$ for firm i in country c, GD_c is a measure of genetic distance of country c with respect to the global technological frontier (here the US), X_{ic} is a vector of firm-level characteristics[3] that affect the

[3]These include age, size and ownership types.

productivity of firm i in country c, Z_c is a vector of country-level control variables,[4] $\varepsilon_c \equiv \{\varepsilon_c(u) : u \in \mathcal{U}\}$ is a set of country-level unobserved random shifters which maps the unobserved country-level covariates η_c affecting TFP_{ic} but not included in Z_c through an unknown function $f(\cdot)$. There is no parametric restriction on the form of $f(u, \eta_c)$, hence any arbitrary nonlinear effects of the country-level unobserved covariates are allowed. The parameters $\beta(u)$ and $\gamma_j(u)$ $(j = 1, 2)$ are unknown: $\beta(u)$ and $\gamma_2(u)$ represent the effect of group-level covariates, while $\gamma_1(u)$ represents those of individual-level covariates. Industry specific effect is omitted from (5.19)-(5.20) because the study focuses on manufacturing firms only and the estimation of the TFP (see Section 5.3.3) assumed homogeneity in technology within each sub-sector of industries, including the manufacturing sector.[5] We assume that X_{ic} and Z_c are exogenous, i.e., $\mathbb{E}[X_{ic}\varepsilon_c(u)] = 0$ and $\mathbb{E}[Z_c\varepsilon_c(u)] = 0$, but GD_c may be endogenous due to various reasons discussed in the next subsection.

We are particularly interested in estimating $\beta(u)$, which measures the effect of genetic distance on TFP at the uth quantile. As discussed previously, most studies on the topic have taken the mean regression approach which does not allow to account for heterogeneous effect of genetic distance across the distribution the TFP variable. For example, one expect the effect of genetic distance to be higher on the upper quantiles of the distribution of TFP than the lower quantiles, but the mean-type regression cannot pick up these differences. Chetverikov et al. (2016) outlined the difficulty to identify $\beta(u)$ using the traditional fixed effect panel data method. Indeed, the genetic distance variable (GD_c) is measured at country-level, hence is constant across firms in a given country. As such, a within-group transformation will eliminate it from the regression. Chetverikov et al. (2016) propose a quantile estimation method that can be applied even in the presence of country-level unobservables [i.e., $\varepsilon_c(u)$]. Before moving on to the description of this method, it is important discuss issues related to the identification of $\beta(u)$ in model (5.19)-(5.20).

5.3.2 Threats to Identification and Estimation Strategy

The presence of country-level unobservables render the use of standard quantile regression techniques, such as the methodology of Koenker and Bassett (1978), inconsistent, and this is true even if the country-level treatment variable, GD_c, were exogenous. Recent studies have expanded Koenker and Bassett (1978) framework to models similar to (5.19)-(5.20); see Kato et al. (2012) and Kato and Galvao (2011). However, these studies often focus on estimating $\gamma_1(u)$ (rather than $\beta(u)$) so that a within-group transformation still applies. As the focus of our study is to estimate

[4]These include GDP, per capita income, trade openness, institution, tertiary education, legal origin, language, and religion distance and geographical variables such as landlockedness, absolute latitude, tropical region, land area, distance.

[5]The World Bank classifies industries into sectors of two-digit ISIC codes, and estimates TFP of each firms by controlling for sectoral fixed effects. Due to homogeneity in the production function across firms within sub-sectors, sectoral fixed effects constitute good approximation of industries specific effects, and the latter are quite constant within each sub-sector in the classification of the World Bank.

$\beta(u)$, the techniques in Kato et al. (2012) and Kato and Galvao (2011) are not applicable and an alternative method is warranted.

Another problem is that GD_c is possibly endogenous in (5.19)-(5.20). This, along with the presence of country-level unobservables ε_c, complicate further the identification of $\beta(u)$. They are various reasons sustaining the endogeneity of GD_c in this model. First, the unobserved country specific effect (η_c) affecting firms productivity are likely to be correlated with *genetic distance* (e.g., see Spolaore and Wacziarg, 2009). Second, *genetic distance* is possibly measured with error due to migration (e.g., see Spolaore and Wacziarg, 2009; Ang and Kumar, 2014), therefore cannot be exogenous. Third, they may be a problem of reverse causality as migration could lead to a pattern of genetic distances today that is closely linked to technology adoption and productivity. To identify the causal effect of GD on TFP, it is important to account for these problems. Since we are interested only on the effect that genetic distance exert on TFP, we did not specify a full system showing all interactions between GD and TFP. Rather, we adopt the limited information approach as described in (5.19)-(5.20). In particular, we deal with the endogeneity issue by using the measure of genetic distance from the UK in 1500 relative to the English population (namely $GD^{1500}_{c,UK}$) as an instrumental variable (IV) for GD_c. We argue that $GD^{1500}_{c,UK}$ does not have a direct influence on the current TFP of laggard countries as the mass migration of the modern era started after 1500. $GD^{1500}_{c,UK}$ is also possibly a strong instrument because it likely highly correlated with the current genetic distance of laggard countries which are measured relative to the US. A failure of at least one of these two conditions constitutes a threat to identification. While the strength of $GD^{1500}_{c,UK}$ can be assessed using, for example, a weak IV test,[6] unfortunately its validity cannot be tested since the model is exactly identified (in the sense that we only have one instrument and one endogenous regressor in the specification).

Now, suppose that the orthogonality condition $\mathbb{E}[GD^{1500}_{c,UK}\varepsilon_c(u)] = 0$ is satisfied for all $u \in \mathcal{U}$, i.e., $GD^{1500}_{c,UK}$ is a valid instrument for GD at every quantile of the distribution of TFP. From Chetverikov et al. (2016), $\beta(u)$ can be consistently estimated following a two-step methodology as described below.

Step 1 : For each country c and each quantile $u \in \mathcal{U}$, estimate the uth quantile regression of TFP_{ic} on X_{ic} and Z_c using the data $\{(TFP_{ic}, X_{ic}, Z_c) : i = 1, \ldots, N_c\}$ by the classical quantile regression of Koenker and Bassett (1978):

$$\widehat{\alpha}(u) = \arg\min_a \sum_{i=1}^{N_c} \rho_u\big(TFP_{ic} - \widetilde{Z}'_{ic}a\big), \tag{5.21}$$

where $\rho_u(x) = (u - \mathbb{1}[x < 0])x$ for $x \in \mathbb{R}$, $\widehat{\gamma}(u) = [\widehat{\beta}_c(u), \widehat{\gamma}'_{1c}(u), \widehat{\gamma}'_{2c}(u)]'$, $\widetilde{Z}_{ic} = (GD_c, X'_{ic}, Z'_c)'$.

[6] See Stock and Yogo (2005).

Step 2 : Estimate a 2SLS regression of $\widehat{\beta}_c(u) \equiv \widehat{\beta}_c$ on GD_c using $GD^{1500}_{c,UK}$ as an instrument ($c = 1, \ldots, G$) to get an estimator $\widehat{\beta}(u)$ of $\beta(u)$, i.e.

$$\widehat{\beta}(u) = \left(GD' P_{GD^{1500}_{UK}} GD\right)^{-1} GD' P_{GD^{1500}_{UK}} \widehat{A}(u), \quad (5.22)$$

$GD = (GD_1, \ldots, GD_G)'$, $GD^{1500}_{UK} = (GD^{1500}_{1,UK}, \ldots, GD^{1500}_{G,UK})'$, $\widehat{A}(u) = (\widehat{\beta}_1, \ldots, \widehat{\beta}_G)'$, and for any full-columns rank matrix W, $P_W = W(W'W)^{-}W'$ is the projection matrix on the space spanned by the columns of W.

The estimator $\widehat{\beta}(u)$ in (5.22) is consistent and asymptotically normal if $G \to \infty$ and $G^{2/3} ln(N_G)/N_G \to 0$, along with other regularity conditions (Chetverikov et al., 2016, Assumptions 1–8), where $N_G = \min_{c=1,\ldots,G} N_c$. It is worth noting that the number of countries in our sample is $G = 94$, which may not be very large as required for $\widehat{\beta}(u)$ to achieve consistency and asymptotic normality. However, the Monte Carlo simulations (see Chetverikov et al., 2016, Table A.I) show that $\widehat{\beta}(u)$ has an overall good properties even when $G = 25$, which is far less than 94 groups in our sample.

5.3.3 Measurement of Total Factor Productivity (TFP)

This study uses TFP data from the World Bank (WB) analysis unit, and have been estimated following a two-step methodology. First, the production function is estimated for each industry in each country. Then, firms' TFP is deduced as a Solow residual of this production function.

More specifically, consider the following Cobb-Douglas production function:

$$Y_i = A_i K_i^{\alpha_k} L_i^{\alpha_l}, \quad (5.23)$$

where Y_i is the output of firm i, L_i is labor inputs (represented by the total annual cost of labor), K_i is the capital (represented by the replacement value of machinery, vehicles, and equipment), and A_i measures the TFP of the firm.[7] Due to the lack of physical output data, the WB analysis unit employs a revenue-based estimation of the TFP, i.e., Y_i is the total annual sales of the establishment. This approach raises some econometric issues. First, input choice is likely to be correlated with the productivity of the producers. Second, there may be a selection bias as less efficient producers are more likely to exit from the sample. Syverson (2011) argues that the selection problem is not important because producers with high productivity will likely be efficient regardless of the specific way their productivity is measured.

Another problem also is that the specification (5.23) assumes perfectly competitive markets with

[7] We have also used the estimates of TFP based on an extension of model (5.23) that includes raw material (M_i) and our main findings are quality the same with those using TFP measured from (5.23).

common production technology. This assumption is restrictive, and in order to incorporate some form of heterogeneity, the WB analysis unit estimates the production function (5.23) by grouping industries in sectors of two-digit ISIC codes. The elasticities of labor and capital (a_k and a_l) are allowed to vary by income-level categorized according to the WB classification. To control for an average economy-level and time specific effects, dummy variables for each country and year are included. More specifically, the econometric model used by the WB to estimate TFP at the sectoral level is given by:

$$
\begin{aligned}
\ln(Y_{isc}) &= \alpha_1 \ln(K_{isc}) + \alpha_2 \ln(L_{isc}) + \alpha_3 \ln(K_{isc}) \times I_c + \alpha_4 \ln(L_{isc}) \times I_c + \nu_{isc} \\
\nu_{sci} &= \omega_c + \omega_y + \lambda_s + \zeta_{isc},
\end{aligned}
\tag{5.24}
$$

where $ln(Y_{isc})$, $ln(K_{isc})$, and $ln(L_{isc})$ are the natural log of output, capital, and labor respectively, of firm i in sector s and country c; I_c is a dummy variable indicating whether country c is high or low income based on the WB classification as of the year in which each survey was conducted; ω_c and ω_y captures country and year fixed effects, while λ_s is sector specific effect, and ζ_{isc} are idiosyncratic shocks. The total factor productivity (TFP_{isc}) is the Solow residual of the production function, therefore is approximated by the residual from the regression (5.24) including the fixed effect terms, i.e.

$$
\widehat{TFP}_{isc} = \widehat{\omega}_c + \widehat{\omega}_y + \widehat{\lambda}_s + \widehat{\zeta}_{isc}. \tag{5.25}
$$

5.4 Data

The data on firms are obtained from the World Bank enterprise survey (WBES). The survey was conducted between 2006 and 2010 on more than 30,000 manufacturing firms from over 100 countries. The survey questionnaire contains identical questions for all countries and industries were stratified by size and income level. The survey provides an exhaustive information on firm-level productivity (TFP) estimates (the fraction of output that is not explained by the amount of inputs used), firms' commencement year, ownership type, sale, labor, capital and other important variables. The survey also provides a revenue-based firm-level productivity estimates (World Bank, 2017).

The macro-level variables are collected from different sources. The treatment variable (i.e., genetic distance to the world technological frontier–the US) is from Spolaore and Wacziarg (2017), and includes culture, habits, values and customs (Spolaore and Wacziarg, 2009). It is important to note this measure is based on the assumption that differences in gene distributions between populations across a range of neutral genes show the time that has passed since two populations shared common ancestors (Spolaore and Wacziarg, 2009). In this study, we view the genetic distance to the US as a measure of the extent of genetic relatedness between populations of laggard countries and the US. Following Spolaore and Wacziarg (2009), we use data on genetic distance weighted by the share of population belonging to each distinct ancestral group in each country. This variable is standardized to take values between 0 and 1, where a value of 0 shows that the two populations have identical genetics and that of 1 indicates the two populations are completely different.

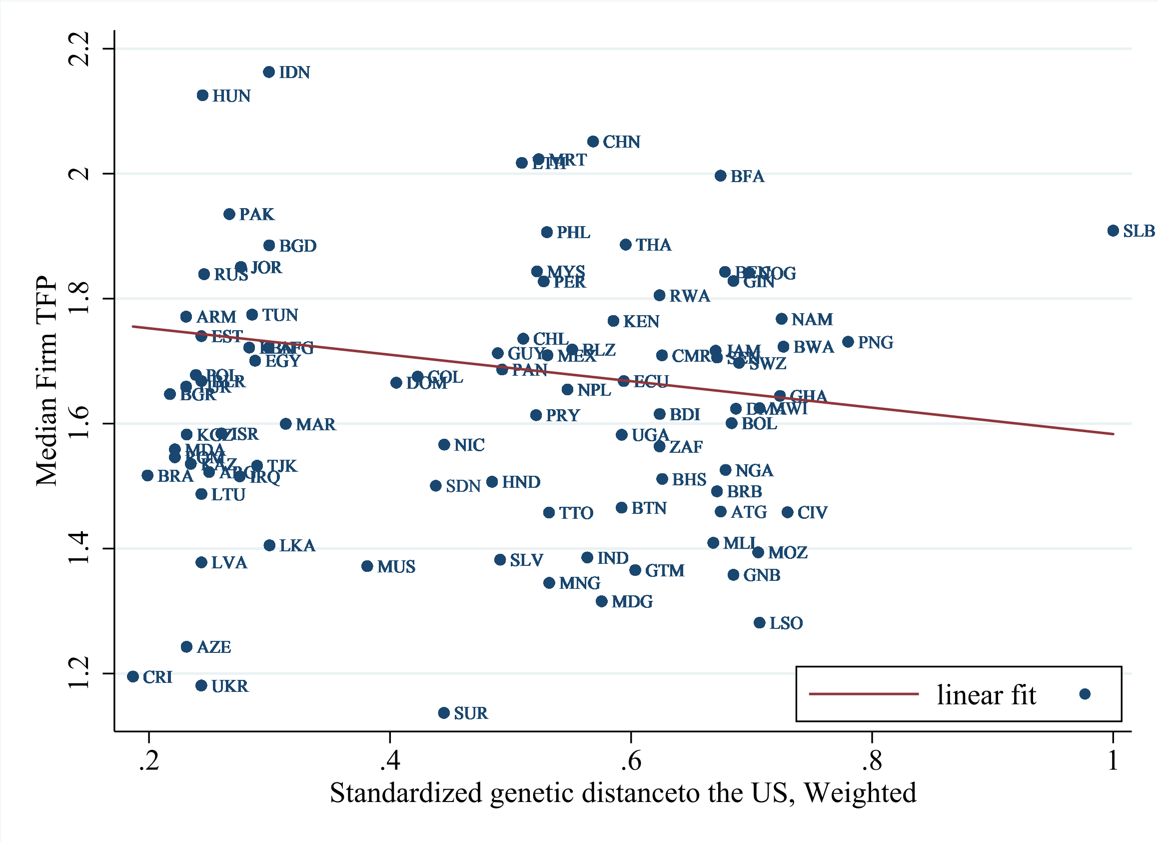


Figure 5.1: Standardized genetic distance and median TFP of firms

Figure 6.1 plots the median level of TFP against the normalized genetic distance to the US. The scatter plots show a negative relationship between genetic distance and median TFP, thus confirming the idea that genetic distance is related to barriers to the diffusion of technology from the world frontier (here the US). While countries like Costa Rica and Brazil appear closer to the US in terms of genetic distance, Papua New Guinea and Solomon Islands are genealogically very far from the US. Some African countries like Morocco, Middle East countries like Turkey, Iran and Afghanistan, and Eastern European countries like Ukraine, Russia, Lithuania, and Bulgaria also appear genealogically close to the US. The figure also illustrates some form of heterogeneity across the distribution of median TFP, meaning that a mean-type regression may under-or over-estimate the impact that genetic distance exerts on TFP. As such, our quantile regression approach is better suited to this type of analysis as it captures the heterogeneity across the distribution of TFP, as opposed to a mean-type regression analysis employed in various seminal work on the topic.

Table 5.1 provides the descriptive statistics of the main variables in the sample, this includes the first, second and third quartiles of the main firm-level characteristics and country-level variables.

Three observations stand out from the table. First, the dependent variable (TFP) and the treatment variable (genetic distance) appear quite dispersed, which translates into their first, second and third quartiles being quite different, thus highlighting some form of heterogeneity of TFP. Second, the distribution of the technology adoption in the 15 century was more heterogeneous across countries than it was in the 20 century, as showed per the growth of their quartiles. Finally, the genetic to the UK in the 15 century is quite heterogeneous across the three quartiles, thus underling that the instrument GD_{UK}^{1500} exhibits some variability in the sample, which is needed for the identification of the model.

Table 5.1: Summary Statistics

Variables	Mean	Std. Dev	Min	Max	Q 0.25	Q 0.50	Q 0.75
Total factor productivity (TFP)	1.762	1.000	-2.356	5.584	1.101	1.698	2.384
Genetic distance to US, weighted	0.031	0.011	0.008	0.07	0.020	0.036	0.040
Genetic distance to UK (1500 match)	0.017	0.012	0	0.046	0.008	0.013	0.030
Genetic distance to UK, weighted	0.018	0.013	0.001	0.058	0.005	0.013	0.030
Technology adoption (1500Ad)	0.460	0.282	0	0.9	0.166	0.466	0.758
Technology adoption (2000)	0.381	0.100	0.173	0.856	0.316	0.368	0.450
Firm age	20	16	11	214	9	15	25
Export_dummy	0.104	0.306	0	1	0	0	0
Foreign_dummy	0.095	0.293	0	1	0	0	0
log(Gross domestic product)	25.492	1.880	19.820	28.713	23.774	25.737	27.015
log (Per capita income)	7.765	1.036	5.338	10.185	6.791	7.746	8.748
log (Trade openness)	4.024	0.450	3.296	5.324	3.640	3.981	4.238
Institution quality	-2.004	3.802	-14.118	9.610	-4.648	-2.180	0.170
Language distance	0.961	0.054	0.367	1	0.933	0.974	1
Geographical distance	9880.171	3947.158	2387.768	16465.65	8069.483	10213.47	13131.91
Religious distance	0.822	0.135	0.602	1	0.661	0.890	0.921
Legal origin	0.286	0.452	0	1	0	0	1
landlockedness	0.095	0.293	0	1	0	0	0
Tropical	0.575	0.420	0	1	0.037	0.512	1
Latitude	0.236	0.236	0	1	0.111	0.222	0.333
Africa	0.267	0.442	0	1	0	0	1

Note. Table 5.1 presents the summary statistics from the pooled sample for the main firm-level and macro-level variables. Q 0.25, Q 0.50 and Q 0.75 symbolize the 25%, 50%, and 75% quantiles, respectively.

5.5 Estimation and Interpretation

To shorten the presentation of the paper, our analysis focuses on the estimated impact of the treatment variable of interest (genetic distance measure), i.e., the quantile estimates $\widehat{\beta}(u), u \in \mathcal{U}$ from model (5.19)-(5.20). To facilitate readability and understanding our results, we use a combination of graphical representations and summary tables.

5.5.1 Baseline results

Table 5.2 presents the estimated impact of genetic distance on TFP. Column (1) reports the two stage least square (2SLS) estimates obtained through a mean-regression, while columns (2)-(6) contains the 10th, 30th, 50th, 70th, and 90th quantile estimates. In *Panel A*, we do not control for micro- and macro-level covariates, while those exogenous covariates are accounted for in *Panel B*. While the robust standard errors are reported for the 2SLS estimates, the bootstrap ones are presented in all tables for the quantile estimates. Several interesting observations are of order.

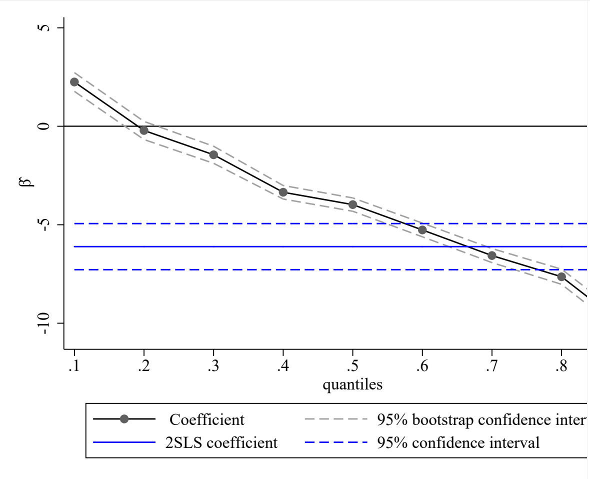
First, the estimated impact of genetic distance on TFP, both at the mean and across the quantiles, is negative after controlling micro- and macro-level exogenous covariates (*Panel B*), confirming the conjecture that *genetic distance* acts as a barrier to technology adoption by firms of laggard countries from the technological frontier (i.e., the US). Second, 2SLS method tends to overestimate the magnitude of the impact of genetic distance on TFP from the lower up to the middle upper part of the distribution of TFP, while the method overwhelmingly underestimates this impact at the upper top of the distribution of TFP. This pattern is illustrated clearly in Figure 5.2(b) where a significant range of the quantile estimates $\widehat{\beta}(u)$ are consistently above the 2SLS estimates before falling below at the very top of the distribution of TFP. These results underline a significant heterogeneous effect of genetic distance across the distribution of TFP, implying that a mean-type regression analysis– such as the 2SLS method– could be misleading. For example, while the 2SLS estimate (*Panel B*) indicates that a 1 percentage point increase in genetic distance from the technology frontier leads to a 5.34% average decline in firm productivity of laggard countries, this effect is roughly 1.65% for the countries situated at the 10th quantile of TFP, 3.50% for those at the 30th quantile, 1.92% for those at the 50th quantile, 3.71% for those at the 70th quantile, and 12.12% for those at the 90th quantile. Third, an appealing and certainly interesting finding is that the impact of genetic distance across the distribution of TFP is a near inverted U-shape, meaning that the relationship between genetic distance and TFP is not monotonically decreasing as postulates the 2SLS estimation. Indeed, it clearly from Figure 5.2(b) and others that a country with a very low technology adoption (ranked from 0 up to 30th quantile) and a country with moderate technology adoption (ranked in 30th–50th quantile) or relatively high technology adoption (ranked in 50th–70th) can be impacted identically by the same shock on current genetic distance. This may indicate why some countries that appear closer to the US (the World technology frontier) have not benefited from technology adoption compared with their peers that are genealogically relatively far from the US, or vis-versa.

Table 5.2: The effect of Genetic Distance from US on Firm Productivity

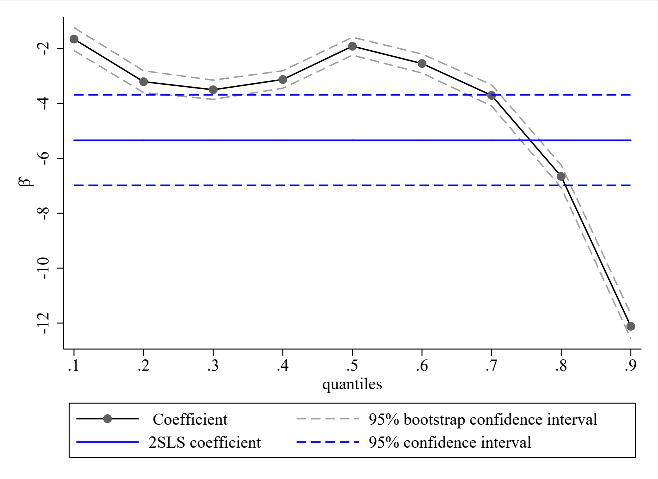
	(1)	(2)	(3)	(4)	(5)	(6)
		Quantile				
Panel A: Without controls	2SLS	0.10	0.30	0.50	0.70	0.90
F_{ST} gen. dist. to the US, weighted	-6.11*** (0.5966)	2.25*** (0.2426)	-1.45*** (0.2213)	-3.97*** (0.1728)	-6.56*** (0.1818)	-10.37*** (0.2114)
Individual Controls	No	No	No	No	No	No
Macroeconomic Controls	No	No	No	No	No	No
Country FE	No	Yes	Yes	Yes	Yes	Yes
Number of countries	94	94	94	94	94	94
Number of firms	32,038	32,276	32,276	32,276	32,276	32,276
Panel B: With all controls						
F_{ST} gen. dist. to the US, weighted	-5.3394*** (0.8409)	-1.65*** (0.2141)	-3.50*** (0.1788)	-1.92*** (0.1665)	-3.71*** (0.1965)	-12.12*** (0.2271)
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	94	94	94	94	94	94
Number of firms	31,212	31,500	31,500	31,500	31,500	31,500

Note. The micro variables include age, export dummy, firm ownership, and firm size. The macro variables include log (GDP), log (PCI), linguistic distance with the U.S., religion distance with the U.S., legal origin, landlockedness, tropical land area, absolute latitude and continent dummy. Robust standard errors for the 2SLS and bootstrap standard errors for the quantile estimates are reported in the parentheses. *$p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Figure 5.2: The Effect of the Genetic Distance on Firm Productivity



(a) Without exogenous covariates



(b) With micro and macro covariates

5.5.2 Alternative Measure of Productivity

To examine the robustness of our baseline results to the measurement of TFP, we also use the World Bank's (2017) revenue based measure of total factor productivity measure (TFPR) that excludes material inputs.

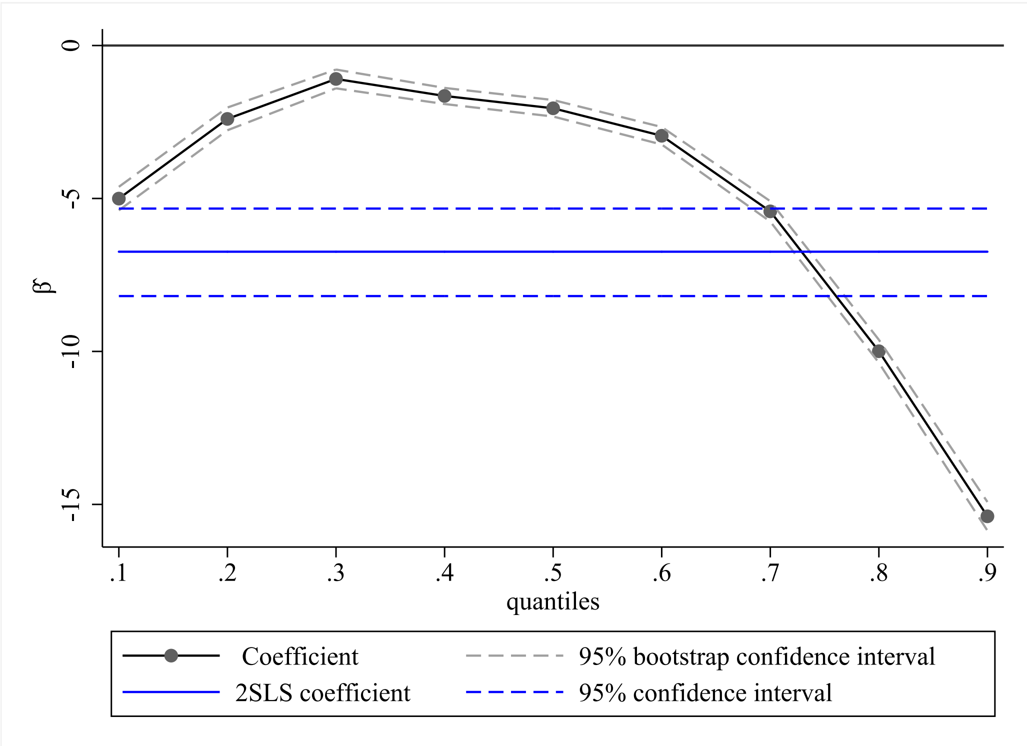
Table 5.3 and Figure 5.3 present the effect of genetic distance at the mean (2SLS) and across the distribution of TFPR, after controlling for all micro- and macro-level covariates. As before, column (1) presents the 2SLS estimate while column (2) to (6) report the estimated quantile coefficients. Robust standard errors are reported for 2SLS estimate, whereas bootstrap standard errors are used for the quantile estimates. As seen, the results are qualitatively the same as in the case of the TPF measure with material inputs included (see Table 5.2 vs. Table 5.3 and Figure 5.2(b) vs. Figure 5.3). In particular, the impact of genetic distance across the distribution of TFPR is an inverted U-shape,thus confirming that the relationship between genetic distance and TFPR is not monotonically decreasing as the 2SLS estimate tends to suggest. In general, the effects of genetic distance tend to be deeper on the distribution of TFPR than that of TFP (see Table 5.3 vs. Table 5.2), especially at the top quantiles. In addition, while the impact of genetic distance across the distribution of TFP is a near inverted U-shape, that on TFPR is an inverted U-shape, thus supporting our main result that there is a (quasi-)inverted U-shaped relationship between firm technology adoption and genetic distance.

Table 5.3: Revenue based Measure of Total Productivity (TFPR)

	(1)	(2)	(3)	(4)	(5)	(6)
		Quantiles				
	2SLS	0.10	0.30	0.50	0.70	0.90
F_{ST} gen. dist. to the US, weighted	-4.88***	-5.00***	-1.09***	-2.05***	-5.42***	-15.39***
	(0.6848)	(0.19604)	(0.1567)	(0.1373)	(0.1697)	(0.2382)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Number of countries	94	94	94	94	94	94
Number of firms	30,474	31,142	31,142	31,142	31,142	31,142

Note. The micro variables include age, export dummy, firm ownership, and firm size. The macro variables include linguistic distance with US, religion distance, legal origin, landlockedness, tropical land area, absolute latitude, continent dummy, log of average RGDP, log of average RGDP per capita, log of tertiary education and log of average openness. Robust standard errors for the 2SLS and bootstrap standard errors for the quantile are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Figure 5.3: Effect of Genetic Distance on TFPR



5.5.3 Alternative Measure of Genetic Distance

In the previous sections, we consider the US as the global technology frontier. However, several technologies were also invented in other advanced societies (Ang and Kumar, 2014) and assuming the US is the only global leader in technology may be too restrictive. To investigate the sensitivity of our results to the choice of the world leader, we use the United Kingdom (UK) as an benchmark world technology frontier. This choice is supported by Ang and Kumar (2014) and the data on weighted genetic distance of laggard countries from the UK are from Bove and Gokmen (2017).

Figure 5.4 and Table 5.4 presents the estimated impact of genetic distance on TFP. As seen, the results are very similar to the baseline ones with the US as the technology frontier; see Section 6.5. In particular, the near inverted U-shaped impact of genetic distance across the distribution of TFP is clearly demonstrated, thus indicating a non-monotonic relationship between genetic distance and the diffusion of technology.

Overall, the results of this section underscore the fact that our previous analysis in Section 6.5 are not driven by the choice of the global technology leader.

Figure 5.4: Effect of Genetic Distance from UK on Firm Productivity

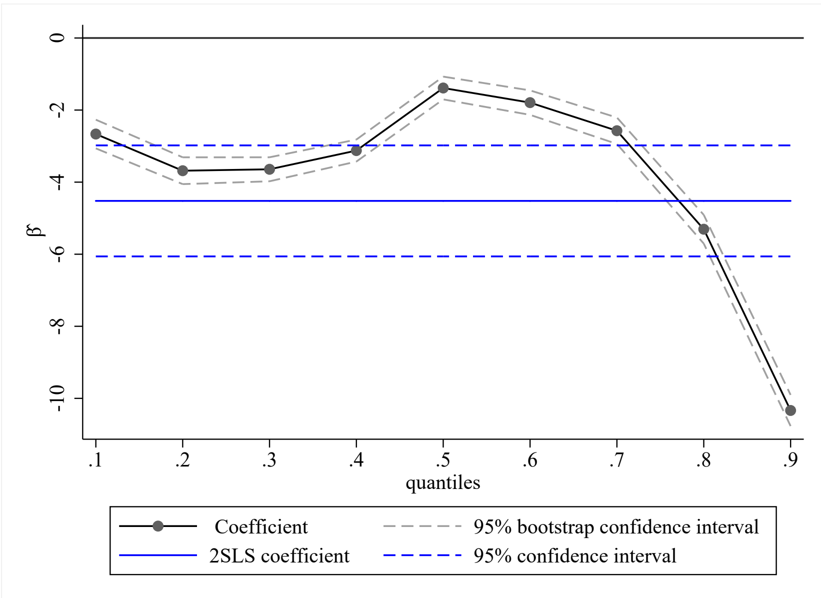


Table 5.4: Alternative Measure of Genetic Distance

	(1)	(2)	(3)	(4)	(5)	(6)
			Quantiles			
Group IV Quantile	2SLS	0.10	0.30	0.50	0.70	0.90
F_{ST} gen. dist. to the UK, weighted	-4.52***	-2.66***	-3.64***	-1.39***	-2.57***	-10.34***
	(0.7872)	(0.2028)	(0.1699)	(0.1609)	(0.1868)	(0.2205)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Number of countries	94	94	94	94	94	94
Number of firms	31,212	31,500	31,500	31,500	31,500	31,500

Note. The micro variables include age, export dummy, firm ownership, and firm size. The macro ones include linguistic distance with the US, religion distance, legal origin, landlockedness, tropical land area, absolute latitude and continent dummy, log of average RGDP, log of average RGDP per capita, and log of tertiary education. Robust standard errors for 2SLS and bootstrap standard errors for quantile estimates are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

5.6 Other Robustness checks

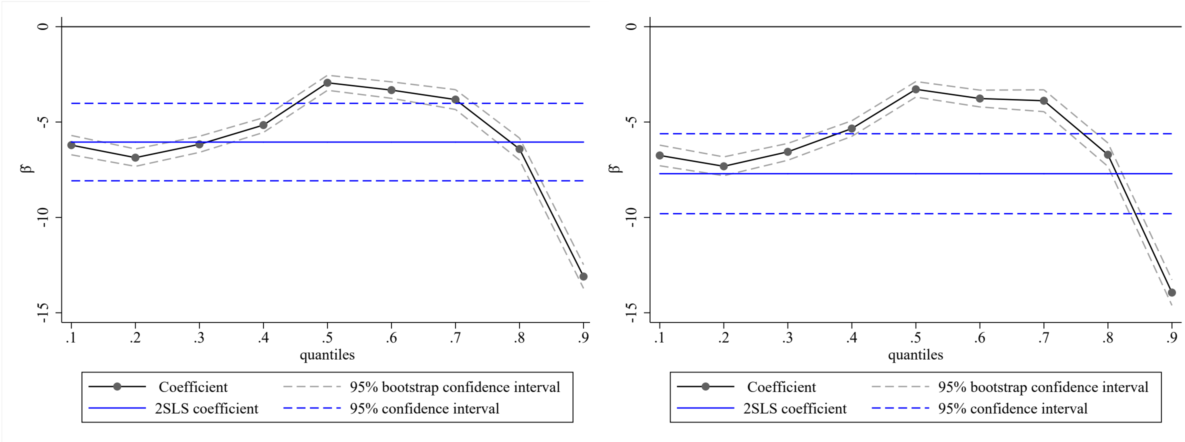
In this section, we investigate the robustness of our results to the inclusion of additional covariates and the relative weight of European countries in the sample.

5.6.1 Controlling for Additional Covariates

Spolaore and Wacziarg (2009) and Ang and Kumar (2014) highlight that technology diffusion has increased for more open economies. Therefore, the transfer of technology may be higher for countries that have good quality of institution, even after controlling for geographic and cultural factors, human capital, language and religion distance, and continent dummies, as done in Section 5.5. As such, it is important to check whether the trade openness and the quality of institutions alter our baseline results of Section 5.5. To address this concern, we also control for trade openness and institutional quality in the baseline regression. Both covariates are included in our sample.

Table 5.5 presents the estimated impact of genetic distance at the mean (2SLS) and across the distribution of TFP when trade openness and institutional quality are also controlled for. *Panel (A)* reports the results when only trade openness is controlled for, while *Panel (B)* shows the results when both trade openness and institutional quality are included. In all cases, both the 2SLS and quantile estimates of the impact of genetic distance on TFP are similar to our baseline results of Section 5.5. Interestingly, controlling for trade openness and institutional quality has even strengthened the impact of genetic distance on technology adoption, both at the mean (2SLS) and across the distribution of TFP, thus suggesting that our baseline results are not driven by the degree of globalization or institutional quality across countries. Furthermore, Figure 5.5, again, illustrates the appealing finding that the relationship between genetic distance and the distribution of TFP is a near inverted U-shape. As such, we clearly see that the 2SLS method under-and over-estimate the impact of genetic distance at important parts of the distribution of TFP. In particular, it is clear from Figure 5.5(b) that a country with a low technology adoption (ranked between 0–30th quantile) and a country with moderate technology adoption (ranked between 30th–50th quantile) or relatively high technology adoption (ranked between 50th–70th) can be impacted identically by the same shock on current genetic distance.

Figure 5.5: Genetic Distance vs. Trade Openness and Institutional Quality



(a) Trade openness only (b) Trade openness and institutional quality

Table 5.5: Controlling for Additional Covariates

	(1)	(2)	(3)	(4)	(5)	(6)
		Quantiles				
Panel A: controlling for openness only	2SLS	0.10	0.30	0.50	0.70	0.90
F_{ST} gen. dist. to the US, weighted	-6.05***	-6.21***	-6.17***	-2.94***	-3.82***	-13.10***
	(1.0377)	(0.2583)	(0.2153)	(0.2009)	(0.2647)	(0.3171)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Number of countries	94	94	94	94	94	94
Number of firms	30,885	31,142	31,142	31,142	31,142	31,142
Panel B: controlling for openness and Institution						
F_{ST} gen. dist. to the US, weighted	-7.71***	-6.75***	-6.56***	-3.28***	-3.88***	-13.94***
	(1.0696)	(0.2754)	(0.2251)	(0.2077)	(0.2920)	(0.3426)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	94	94	94	94	94	94
Number of firms	30,885	31,142	31,142	31,142	31,142	31,142

Note. The micro variables include age, export dummy, firm ownership, and firm size. The macro ones include linguistic distance with US, religion distance, legal origin, landlockedness, tropical land area, absolute latitude, continent dummy, log of average RGDP, log of average RGDP per capita, log of tertiary education and log of average openness. Robust standard errors for 2SLS and bootstrap standard errors for quantile estimates are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

5.6.2 Excluding European Countries

We investigate the stability of our baseline results to the exclusion of European countries from the sample. They are two main reasons to do so. First, the measurement error in genetic distance data for Europe is relatively smaller as the sample populations almost match the nation-state boundaries (Spolaore and Wacziarg, 2009). Second, technology spreads more easily to the east-west direction which makes European countries more advantageous over more isolated countries (such as Australasia) and over continents that are located to the north-south axis (such as Africa and Latin America); see Diamond and Renfrew (1997). The latter hypothesis is well known as "the Diamond gap." Therefore, by excluding Europe from the sample, we can: (i) check the stability of our baseline results when only the countries with a relatively larger measurement error in the genetic distance data are used; and (ii) test whether our baseline results are driven by the Diamond gap.

Figure 5.6: The effect of genetic distance on firm productivity

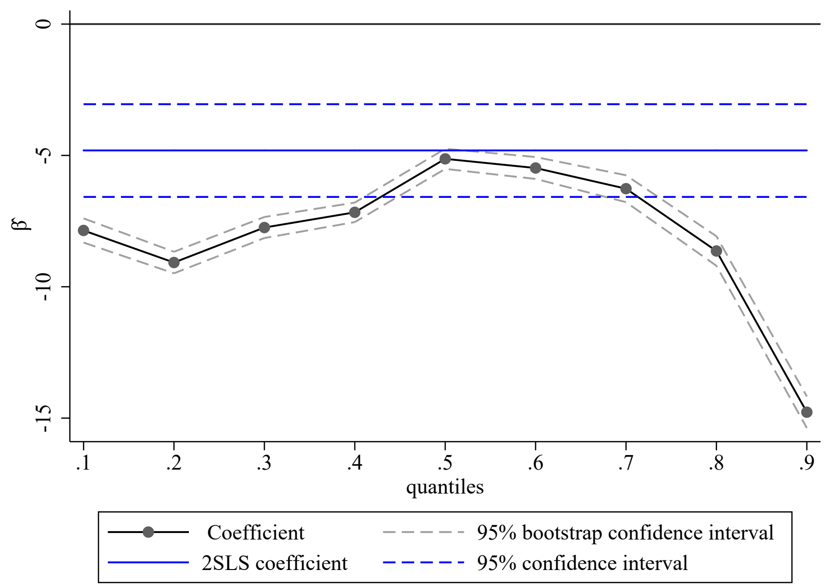


Table 5.6 and figure 5.6 presents the results. Consistent to our baseline results, genetic distance has a large negative effect on firms' productivity at the higher quantiles. Moreover, all the quantile estimates are larger in magnitude and statistically significant at 1% nominal level compared with our baseline results of Section 5.5. A close inspection of both the 2SLS and quantile estimates suggests that 2SLS under-estimates the effect of genetic distance at lower and higher parts of the distribution of TFP due the near inverted U-shape property of the relationship between the two. Clearly, our baseline results are not driven by measurement error in the genetic distance data or the Diamond gap.

Table 5.6: Excluding Europe

	(1)	(2)	(3)	(4)	(5)	(6)
			Quantiles			
Group IV Quantile	2SLS	0.10	0.30	0.50	0.70	0.90
F_{ST} gen. dist. to the US, weighted	-4.81*** (0.8997)	-7.86*** (0.2348)	-7.74*** (0.2044)	-5.13*** (0.1956)	-6.27*** (0.2613)	-14.77*** (0.3062)
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Number of countries	84	84	84	84	84	84
Number of firms	29,310	28,997	28,997	28,997	28,997	28,997

Note. The micro variables include age, export dummy, firm ownership, and firm size. The macro variables include linguistic distance with US, religion distance, legal origin, landlockedness, tropical land area, absolute latitude, continent dummy, log of average RGDP, log of average RGDP per capita, log of trade openness and log of tertiary education. Robust standard errors for the 2SLS and bootstrap standard errors for the IV quantile are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

5.7 Genetic Distance, Technology Adoption, and TFP

Section 5.5 established a robust negative and near inverted U-shape effect of genetic distance along the distribution of firms' productivity across countries. One may argue that the specification (5.19)-(5.20) that led to this result is a reduced-form, thus be willing to provide an endogenous mechanism through which genetic distance impacts on firms' TFP. Such a chain of causality could be that genetic distance influences firms' productivity through technology adoption, but this is yet to be formally demonstrated. Our goal in this section is not to provide a definitive answer to the effectiveness of such a mechanism, rather we offer suggestions that could help to advance future research in that direction.

Previous studies documented that genetic distance is one of the persistent barriers to contemporary technology adoption (Spolaore and Wacziarg, 2009; Ashraf and Galor, 2013a). Along the same vein, Figure 5.7 shows the scatter plots between country-level measures of historical technology adoption in 1500AD and standardized genetic distance to the world leader, the US. The technology option data consists of 24 technologies provided by Comin and Hobijn (2010). In this dataset, the 24 technologies are classified in five broad sectors: agriculture, industry, transportation, communication, and military. Each technology is measured as a binary variable indicating whether it was present in a given country in 1500AD. Comin and Hobijn (2010) combined them into one factor labeled '*Overall technology adoption in 1500*' (see the y-axis of Figure 5.7). This factor is simply compute as the sample average across sectors of the technology adoption levels. As it can be seen from that graph, the standardized genetic distance is negatively correlated with the overall technology adoption in the 1500AD, thus corroborating the findings of Spolaore and Wacziarg (2009) and Ashraf and Galor (2013a). To examine how this relationship has evolved over time, Figure 5.8 depicts the scatter plots between the two variables in the 2000AD for all countries in the sample. Again, the figure shows a negative correlation between genetic distance and overall technology adoption in the 2000AD, thus highlighting the persistence of their relationship over time.

In our sample, countries such as Ethiopia, Nepal, Burkina-Faso and Mali have 0.509, 0.574, 0.674, and 0.668 respectively as standardized measure of genetic distance, thus can be classified as having less genealogical similarities with the US. Yet unsurprisingly these countries had the lowest overall technology adoption level in the 2000AD. For example, the four countries (Ethiopia, Nepal, Burkina-Faso, Mali) had an overall technological adoption around 0.533, 0.3, 0.508, and 0.508 respectively in the 1500AD, which has eroded to about 0.220, 0.228, 0.236 and 0.173 respectively in the 2000AD. Meanwhile, Argentina, for example, which is genealogically close to the US (with standardized genetic measure of 0.249) has moved from 0.02 overall technology adoption in the 1500AD to about 0.484 in the 2000AD.

Figures 5.9 shows the scatter plots between overall technology adoption in the 1500AD and current median firms' TFP for all countries in the sample. As seen, overall technology adoption in the 1500AD is strongly positively correlated with current median firms' productivity. Since current genetic distance is negatively correlated with overall technology adoption in the 1500AD (as documented in Figures 5.7 & 5.8), we expect current genetic distance to have a negative impact on the distribution (at least the median) of firms' TFP, thus corroborating our main findings in Section 5.5. It is nonetheless important to note that the analysis in Figures 5.7-5.9 is only based on correlations, so more investigations are required to clarify if genetic distance influences firms' productivity through its impact on the technology adoption in the 1500AD. We leave these investigations for future research.

Figure 5.7: Genetic distance and overall technology adoption in 1500AD

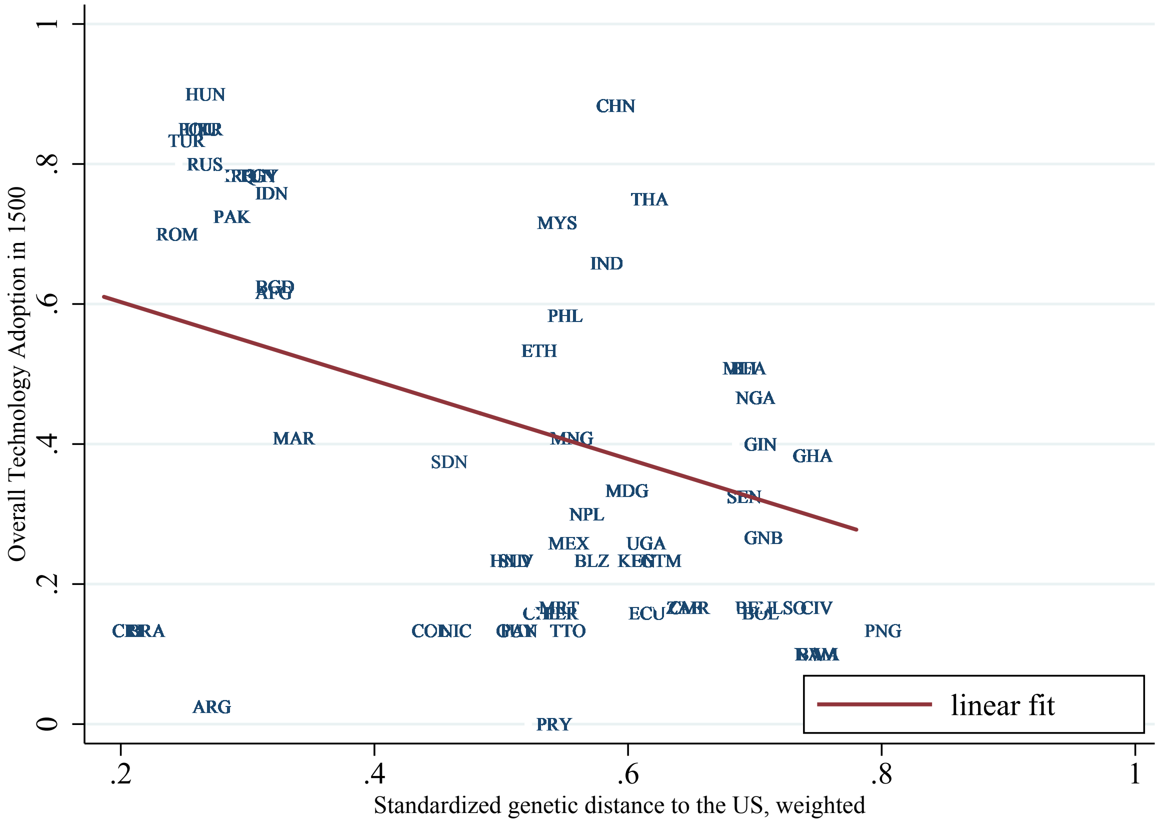


Figure 5.8: Genetic distance and overall technology adoption in 2000AD

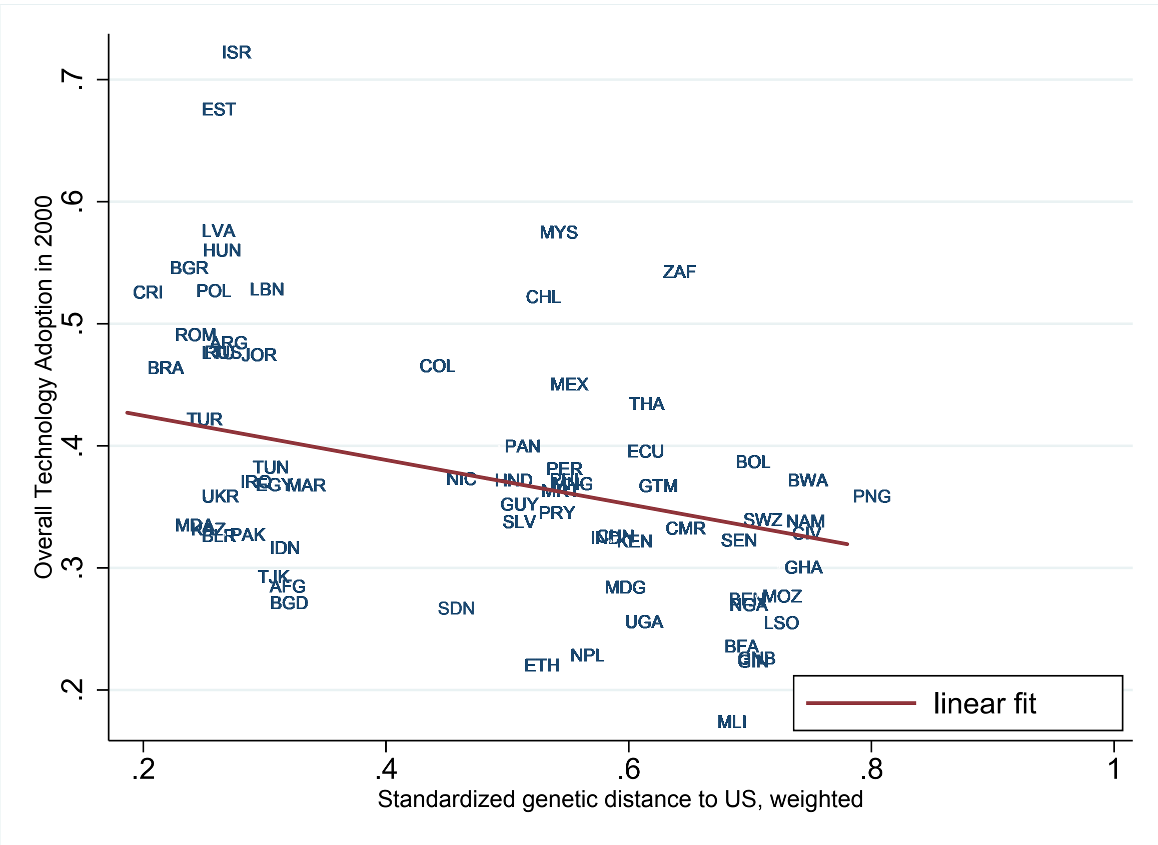
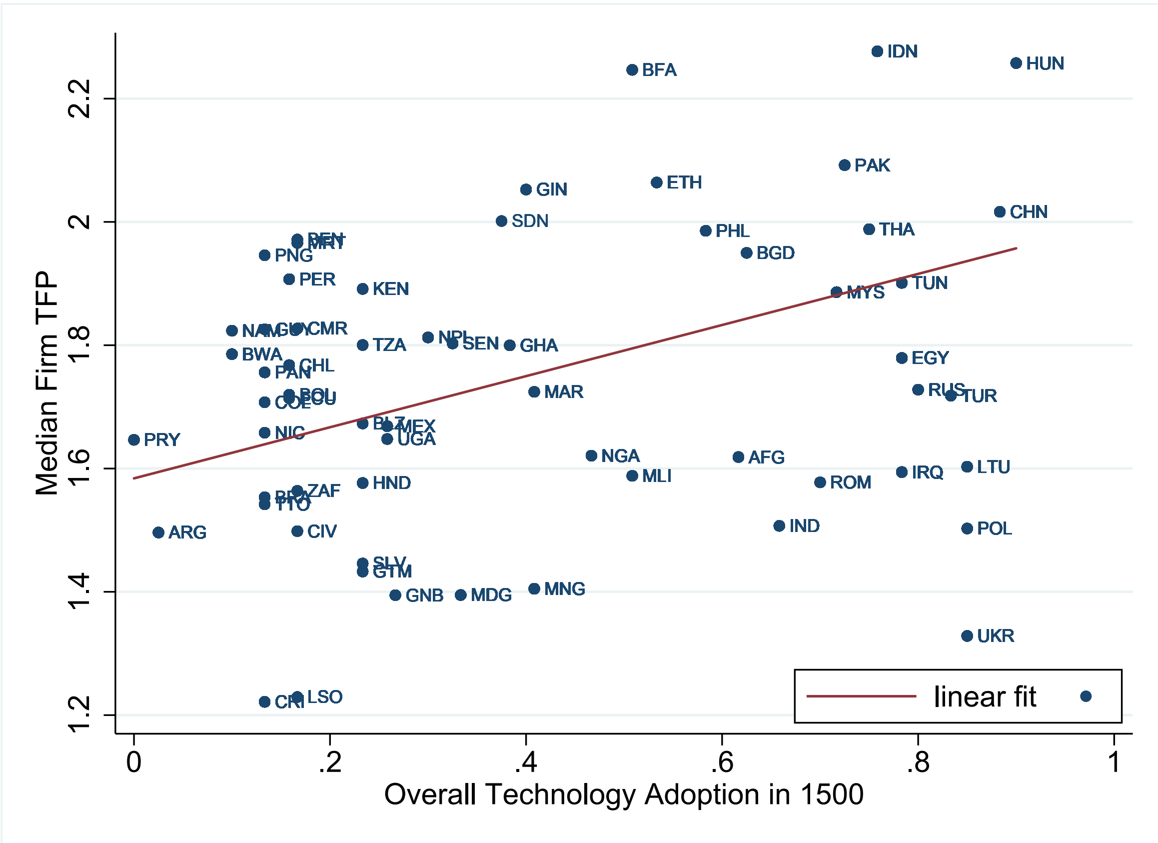


Figure 5.9: TFP and overall technology adoption in 1500AD



5.8 Conclusion

This paper exploits the theoretical framework of Comin and Hobijn (2010) to propose a mechanism through which genetic distance from the world leader, the US, acts as a barrier to technology adoption in laggard countries, thus impacting negatively on firms' TFP in those countries. There are some challenges in testing this theory empirically, and we elaborate on how those challenges can be circumvent. First, the treatment variable (genetic distance) is measured at country-level while the outcome variable (firm productivity) is available at firm-level, which makes the standard panel data method useless in identifying the causal effect since the treatment variable will be dropped out after a within-type transformation. Second, there is a substantial heterogeneity across the distribution of firms' productivity, hence a mean-type regression analysis is not appropriate. Third, due to the presence of group-level unobservables in the model (country fixed effect), a standard quantile regression such as in Koenker and Bassett (1978) will yield inconsistent estimates, thus is not also appropriate in dealing with this type of problems.

Using a novel method on quantile treatment models with group-level unobservables recently proposed by Chetverikov et al. (2016) that accommodates the above problems, we show that the impact of genetic distance on firm productivity is consistently negative and *near inverted U-shaped* across the distribution of firms' TFP. This means that firms operating in countries genealogically far from the technology leader tend on average to have lower level of productivity, but firms in two countries, one with a very low technology adoption and the other with a moderate or relatively high technology adoption can be impacted identically by the same shock on current genetic distance. This may justify why some countries that appear genealogically closer to the US have not benefited from technology adoption compared with their peers that are far from the US, or vis-versa. We provide several robustness checks that show that the near inverted U-shape property of the relationship between genetic distance and the distribution of firms' TFP is robust: (i) to alternative measures of productivity and genetic distance; (ii) to inclusion of institutional quality and trade openness in the model; (iii) to the exclusion of European countries whose genetic data are likely less measured with errors than non-European countries.

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Appendix C

Table C1: Variable Definition

Variables	Definition
TFP	Firm -level estimates of Total factor productivity
Genetic distance to the US or UK	The genetic distance between the current national population of a given country and the US (or UK).It is calculated as the average pairwise genetic distance across all ethnic group pairs. It captures the general relatedness of the population of a particular country to US or UK
Genetic distance to the UK (1500 AD)	The genetic distance between the populations of a given country and the UK in the year 1500, prior to the major colonizations of modern times & migration calculated as the genetic distance between the two ethnic groups comprising the largest shares of each countrys population in the year 1500
Technology adoption (1500 Ad)	The overall adoption level is computed as the simple average of the sectoral adoption levels, where sector adoption levels is the simple average of the binary adoption values across the technologies in the sector in 1500
Technology Adoption (2000)	The overall adoption level is computed as the simple average of the sectoral adoption levels, where sector adoption levels is the simple average of the binary adoption values across the technologies in the sector in 2000
GDP	Average gross domestic product (2000-2005)
PCI	Average GDP per capital (2000-2005)
Export dummy	=1 if a firm export
Foreign	=1 if the firm has at least 10% of its equity held by foreigners
Small	=1 if the firm has 5-9 employee
Medium	=1 if the firm has 10-99 employee
Large	=1 if the firm has above 99 employee
Geographic distance	Measure of the great circle (geodesic) distance between the major cities of countries
Religious distance	Measure of religious relatedness based on a nomenclature of world religions
Legal origen	Dummy variable that takes a value of one if a countrys legal system is of French, German or Scandinavian Civil Law origin and zero otherwise
Landlockedness	=1 if a firm is operating in a landlocked country
Tropical	The percentage of land area classified as tropical and subtropical based on the Koeppen-Geiger system
Latitude	Absolute value of the latitude of a country, scaled between zero and one, where zero is for the location of the equator and one is for the poles

Table C2: Summary statistics

Variables	Mean	Std. Dev	Min	Max
TFP	1.762	1.000	-2.356	5.584
Genetic distance to US, weighted	0.031	0.011	0.008	0.07
Genetic distance to UK (1500 match)	0.017	0.012	0	0.046
Genetic distance to UK, weighted	0.018	0.013	0.001	0.058
Technology adoption (1500Ad)	0.460	0.282	0	0.9
Technology adoption (2000)	0.381	0.100	0.173	0.856
Age	33.5	166	11	214
Export_dummy	0.104	0.306	0	1
Foreign_dummy	0.095	0.293	0	1
log(gdp)	25.492	1.880	19.820	28.713
log (pci)	7.765	1.036	5.338	10.185
log (Trade Openness)	4.024	0.450	3.296	5.324
Institution quality	-2.004	3.802	-14.118	9.610
Language Distance	0.961	0.054	0.367	1
Geographical Distance	9880.171	3947.158	2387.768	16465.65
Religious Distance	0.822	0.135	0.602	1
Legal origin	0.286	0.452	0	1
landlockedness	0.095	0.293	0	1
Tropical	0.575	0.420	0	1
Latitude	0.236	0.236	0	1
Africa	0.267	0.442	0	1

Note: Summary statistics for firm level as well as macro data.

Chapter 6

Does the Presence of Foreign firms Reduce Domestic Firms' Financial Constraints in Sub-Saharan Africa?

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Abstract

Firms in the SSAs (*sub-Saharan African countries* for short) face severe financial constraints. Because financial markets in the SSAs are underdeveloped, policymakers have sought after the establishment of foreign-owned firms in their countries to help, among others, alleviate the financial constraints faced by domestic firms. However, there is no empirical evidence that speaks to the association between foreign firm presence and domestic firms' financial constraint. Using firm-level data spanning across 36 SSAs from the World Bank Enterprise Survey, we show that the increase in foreign firm presence can ease the financial constraints of domestic firms in the SSAs. One reason is that foreign-owned firms are not only less financially constrained, they are also less likely to apply for bank loans. Therefore, an increase in foreign firm presence may reduce the competition for loans and ease the financial constraints of domestic firms by improving their borrowing success.

Keywords: Foreign Firm Presence; Financial Constraints; Sub-Saharan Africa

JEL Code: F23, O19

6.1 Introduction

The lack of access to finance has been a major concern for businesses in sub-Saharan Africa (Beck et al., 2009; Asiedu et al., 2013; Mlachila et al., 2013; Bah and Fang, 2015). In the SSAs (*sub-Saharan African countries* for short), the financial sector is usually underdeveloped, dominated by a few big banks,[1] and lacks a stock market (Demirgüç-Kunt and Klapper, 2012; Mlachila et al., 2013).[2] This has prompted some policymakers in the SSAs to pursue foreign investments, especially the establishment of foreign-owned firms in their countries, as a way of gaining external finance as one of the benefits (Asiedu, 2002; Basu and Srinivasan, 2002; Harrison and McMillan, 2003; Adams, 2009). However, although such policies are in placed, there is no evidence that the presence of foreign-owned firms may ease the financial constraints faced by domestic firms.

In this paper, we conduct a cross-country firm-level study to shed light on this issue. It is important to emphasize that at the outset, the association between foreign firm presence and domestic firms' financial constraint is ambiguous. On the one hand, foreign-owned firms may themselves become a source of finance for local partners in the same industry (Javorcik, 2014; Newman et al., 2015), which helps to raise the productivity and thus creditworthiness of domestic firms (Javorcik and Spatareanu, 2011; Javorcik, 2014). On the other hand, because foreign-owned firms tend to be more profitable and have better reputations, local banks may favor foreign-owned firms over domestic firms in lending. The increase in market competition brought along by foreign-owned firms may also erode the profits of domestic firms and ultimately their capacity to borrow (Harrison and McMillan, 2003).[3] As such, how foreign firm presence affects the financial constraints of domestic firms is unclear.

Using cross-country firm-level data based the World Bank Enterprise Survey from 2006 to 2010, we show that in the SSAs, a larger foreign firm presence may relieve

[1]For example, the share of two largest banks' in Burundi account 45% of the total bank asset (Nkurunziza et al., 2012).

[2]In the SSAs, the average ratio of private credit to GDP is only 24%. This is dwarfed by the ratio of 77% for all other developing economies, and 172% for high income economies.

[3]Some studies looks at the mechanisms through which foreign direct investment affect financial constraints of domestic firms (see, for example, Harrison and McMillan, 2003; Héricourt and Poncet, 2009; Harrison et al., 2004).

domestic firms of their financial constraints. To measure how financially constrained a firm is, we use the firms' responses to World Bank's survey questions on credit access, as well as objective measures such as whether a firm has had access to overdraft facilities, a credit line or a bank loan, or it had applied for but was denied a loan. We find that in industries where there is a larger foreign firm presence, domestic firms tend to be less financially constrained. One reason is that foreign-owned firms are less financially constrained than domestic firms; as such, they are also less likely to borrow from banks. Given that foreign-owned firms are less likely to seek bank credit, a larger foreign firm presence would benefit domestic firms by reducing the competition for loans and enabling them to borrow more successfully.

Our study has policy relevance for the SSAs. Firstly, firms in the SSAs are the most financially constrained compared with firms elsewhere. This has implications on development, as the lack of finance (which is the case for the SSAs) can severely undermine growth (Beck and Demirguc-Kunt, 2006; Bah and Fang, 2015). Therefore, it would be helpful from a policy perspective to know if foreign firm presence may lead to improvements in financial access, which in turn may foster economic growth. Secondly, to gain access to foreign capital, several SSAs have implemented policies to attract foreign investors to establish new firms or assume the ownership of local firms (Adams and Opoku, 2015).[4] However, there is no evidence that doing so may relieve the financial constraints experienced in the host country, which this paper speaks to.[5]

Our paper is related to the literature that focuses on discovering the determinants of firms' access to finance in developing countries. The literature has identified country-level factors that affect firms' access to finance, such as legal system and regulatory frameworks (Demirgüç-Kunt and Maksimovic, 1998), stock market development (Demirgüç-Kunt and Levine, 1996), financial market development and liberalization (Laeven, 2003; Love, 2003; Abel, 1980), as well as firm-level characteristics including age, size, ownership structure, legal status and gender in

[4]For example, foreign direct investment to the SSAs has grown from $8 billion in 2000 to $18 billion in 2004, $36 billion in 2006 and $50 billion in 2012.

[5]Empirical evidence on credit constraints in the SSAs comes mainly from within-country studies, which are difficult to generalize. See, for example (Harrison and McMillan, 2003) for Cote d'Ivoire, Lashitew (2017) for Ethiopia.

determining firm's access to finance (Beck and Demirgüç-Kunt, 2008; Byiers et al., 2010; Aterido et al., 2013; Asiedu et al., 2013; Hansen and Rand, 2014a; Wagner and Weche Gelübcke, 2015). Our work complements these studies by using a cross-country firm-level analysis to explore if foreign firm presence may contribute towards financial access.

The rest of the paper is organized as follows. In Section 6.2, we briefly review the literature. In Section 6.3, we describe the data sources and the variables used in this paper. In Section 6.4, we describe our estimating equation and discusses the potential identification issues. In Sections 6.5 and 6.6, we present our baseline results and robustness checks, respectively. In Section 6.7, we present our concluding remarks.

6.2 Background

Sub-Saharan Africa is one of the fastest developing regions in the world (Young, 2012; McMillan and Harttgen, 2014). However, despite their economic progress, the financial systems in the SSAs remain among the least developed. For example, in the SSAs, the financial sector is typically characterized by a lack of a stock market (Demirgüç-Kunt and Klapper, 2012), a banking industry that is dominated by a few banks,[6] interest spreads, margins and overhead costs that are much higher than in other regions, and a very small representation by Non-Bank Financial Institutions (NBFI) in the credit market (Mlachila et al., 2013; Beck and Cull, 2014).

Studies have found that the lack of access to finance is the most formidable obstacle to growth, productivity and competitiveness in the SSAs (Nkurunziza, 2010; Bah and Fang, 2015). In fact, firms in the SSAs are the most financially constrained compared with firms elsewhere. For example, 45.6% of firms in the SSAs reported access to finance as the most important constraint in investment while the corresponding number is 14.6% for the OECD (Bah and Fang, 2015). On average, only 23.5% of firms in the SSAs have access to bank loan or line of credit while

[6] For example, the share of two largest banks' account 45% of the total bank asset in Burundi (Nkurunziza et al., 2012).

the corresponding number is 49.1% for OECD (see Appendix C). Because access to finance implicates development, there has been tremendous effort to understand the issue of financial access through cross-country or firm-level analyses.

The cross-country analyses typically aim to understand which country-level variables determine access to finance. These studies have found that there is greater access to finance in countries that has legal systems and regulatory frameworks that strongly protect property rights, contract enforcement and credit rights (Demirgüç-Kunt and Maksimovic, 1998), stock market development (Demirgüç-Kunt and Levine, 1996), developed and liberalized financial markets (Laeven, 2003; Love, 2003; Gelos and Werner, 2002), large national markets, income and savings (Demirgüç-Kunt and Klapper, 2012; Mlachila et al., 2013). The firm-level studies typically stress the importance of firm-level characteristics for firms' access to finance such as age, size, ownership structure, legal status and owners' gender (Beck et al., 2006; Aterido et al., 2013; Asiedu et al., 2013; Hansen and Rand, 2014a; Wagner and Weche Gelübcke, 2015). For example, using firm-level data from 80 countries, Beck et al. (2006) have found that larger, older and foreign-owned firms are on average less financially constrained.

What is striking about the literature is that little is said about how foreign firm presence may affect the financial constraints faced by domestic firms in the host countries. Yet, despite the lack of evidence, policymakers in the SSAs have sought after the establishment of foreign-owned firms to gain some external finance, among other benefits (Te Velde and Morrissey, 2003; Elkins et al., 2006; Foster-McGregor et al., 2015).[7] In the literature, closest to our study are works related to the effects of foreign direct investment (FDI) on domestic firms' financial constraint (Harrison and McMillan, 2003; Harrison et al., 2004). However, these studies do not focus on the effects of foreign firm ownership, nor do they combine cross-country and firm-level

[7]For example, Mali and Mozambique encourage foreign firm ownership by improving business climate, such privatization, implementing new laws, and promoting accession to international agreement related to direct foreign investment (Morisset, 2001). Botswana and Mauritius attract foreign firms by improving property rights and reducing restrictive compliance requirements (Basu and Srinivasan, 2002).

information for their analysis as we do.[8]

To our best knowledge, our paper is the first to employ a cross-country firm-level approach to directly examine how the foreign ownership of firms may affect the financial constraints of domestic firms. As such, it helps to shed light on the relationship between foreign firm presence and the financial constraints of domestic firms, which is ambiguous. For example, through knowledge spillover about new products, technologies and marketing, the presence of foreign-owned firms may improve the productivity of domestic firms in the same industry, and thus, their creditworthiness (Javorcik and Spatareanu, 2011; Javorcik, 2014).[9] Banks may also prefer to lend to industries with a large foreign firm presence, which eases the borrowing constraints of other firms in the same industries (Harrison et al., 2004). Besides, foreign-owned firms may themselves bring in capital, and as such, be a source of finance to their local business partners (Harrison et al., 2004).

By contrast, the presence of foreign-owned firms may create difficulties for domestic firms to access finance. For example, foreign enterprises in developing countries are likely to be more profitable, have more collateral and better financial ratios. As such, banks may divert credit away from domestic firms to foreign-owned firms. Foreign-owned firms also compete in the products market and potentially erode the market share of domestic firms, and consequently, their ability to borrow (Harrison and McMillan, 2003). Considering these opposing arguments, it is unclear how foreign firm presence may affect domestic firms in the SSAs.

[8]For example, based on Ivory Coast's firm-level data, Harrison and McMillan (2003) find that domestic firms could be credit credit constrained with FDI as foreign enterprises may crowd out domestic firms in the local credit markets. By contrast, Harrison et al. (2004) find that FDI inflow in 34 European countries is associated with reduced firm-level financial constraints.

[9]A direct linkage between foreign-owned firms and domestic input suppliers, or foreign firms input providers and domestic firms , can improve the reputation and creditworthiness of domestic firms (Javorcik and Spatareanu, 2009; Newman et al., 2015).

6.3 Data and Descriptive Statistics

6.3.1 Data

Our dataset is drawn from the World Bank Enterprise Survey (WBES). In this survey, a total of more than 10,000 non-repeated firms from 36 SSAs are surveyed over the course of 2006 to 2010.[10] The WBES questionnaires contain identical questions for all countries, and uses stratified sampling by size, industry and regions to collect the sample of firms for each country. The survey also covers 38 industries at the two ISIC-digit levels and contains information on the access and use of financial services as well as several other relevant firm characteristics that are used here. The definitions on all the variables used in this paper are provided in Table D1 in Appendix D.

Following Asiedu et al. (2013) and Hansen and Rand (2014a), we construct several indicators to capture how financially constrained a firm is. These measures are based on managers' responses to the WBES survey question: "to what degree is access to finance an obstacle to the current operation of this establishment?" Our main measure of financial constraint, which we call it *Financial Constraint*, is an ordinal variable that takes the value of 0, 1, 2, 3, or 4 if the firm states that finance is either not a problem (i.e. 0), a minor problem (i.e. 1) a moderate problem (i.e. 2), a major problem (i.e. 3), or a severe problem (i.e. 4). In other words, firms that reported themselves to be more financially constrained have higher *Financial Constraint* scores.

To check if our conclusion is robust, we consider three alternative indicators to measure financial constraint. Firstly, people's perception about the seriousness of their financial situation is not absolute. Thus, the distinction between moderate, major and severe financial constraint could be blurred. For this reason, our first alternative indicator of firm financial constraint is a dummy variable that indicates (i.e. = 1) if the firm responds in the survey that access to finance is a moderate,

[10] Our sample of firms obtained from Angola, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Chad, Congo, DRC, Eritrea, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritanian, Mauritius, Mozambique, Namibia, Niger, Rwanda, Sierra Leone, Senegal, South Africa, Swaziland, Tanzania, Togo, Uganda and Zambia.

major or severe problem, and 0 if otherwise. We call this indicator *Serious Constraint*, which indicates if the firm has encountered what it believes to be a moderate to severe problem of financial constraint.

Our second and third alternative indicators of firm financial constraint are based on two objective measures. The first, which we call *Credit Product Constraint*, is a dummy variable that indicates if the firm *does not* have access to any of the three credit products: overdrafts, lines of credit, or bank loans. The second, which we call *Loans Denied*, is a dummy variable that indicates if a firm had applied for but was denied a loan.

The WBES database provides information on owners' equity share. Following the literature (see, for example, Javorcik and Spatareanu, 2011; Asiedu et al., 2013), foreign-owned firms are defined as firms in the host country where at least 10% of their equity is foreign held. Domestic firms are defined as firms with less than 10% foreign ownership. We construct measures of foreign firm presence for each industry and country. These measures, described further in Section 6.4, are associated with the proportion of foreign firms, foreign firms' share of equity, or employment in the industry and country.

Additionally, the WBES database provides a range of relevant firm specific characteristics, such as firm size, ownership type, legal status, technological capacity and financial transparency, which are used here.[11] Finally, the World Bank's World Development Indicators (WDI) database is the source of our country level controls, which include a measure of financial development, legal system, and inflation (see Appendix C for the variables' descriptions).

6.3.2 Descriptive Statistics

To appreciate how severe the issue of firm financial constraint is in the SSAs, Figure 6.1 considers nine major business obstacles encountered by firms, i.e. *Access to finance*, *Access to land*, *Power outage*, *Anti-competitive practice*, *Infeasible tax rate*,

[11] Our choice of explanatory variables is based largely on the existing literature related to firms' access to finance (see, for example, Beck et al., 2006, 2008; Asiedu et al., 2013; Aterido et al., 2013; Hansen and Rand, 2014a,b).

Crime, *Corruption*, *Political instability*, and *Licensing & permits*. For each obstacle, Figure 6.1 plots the percentage of domestic and foreign-owned firms that responded that among the nine business obstacles, the obstacle in question was "most serious obstacle affecting the operation of the establishment".

Being financially constrained is among the most severe issues facing firms in the SSAs. Figure 6.1 shows that more firms, both domestic and foreign-owned, have reported the lack of access to finance as the most severe problem they face, than the number of firms reporting other obstacles as their most serious concern. In fact, the lack of finance is more severe than other traditional issues such as the lack of land, access to power, crime and corruption.

That being said, foreign-owned and domestic firms are not equally impacted by business restrictions. As Figure 6.1 shows, foreign-owned firms are less likely than domestic firms to face severe obstacles in running a business. For example, concerning the access to finance, 17.5% of domestic firms report it as the most serious constraint while only 2.5% of foreign-owned firms respond in the same way.

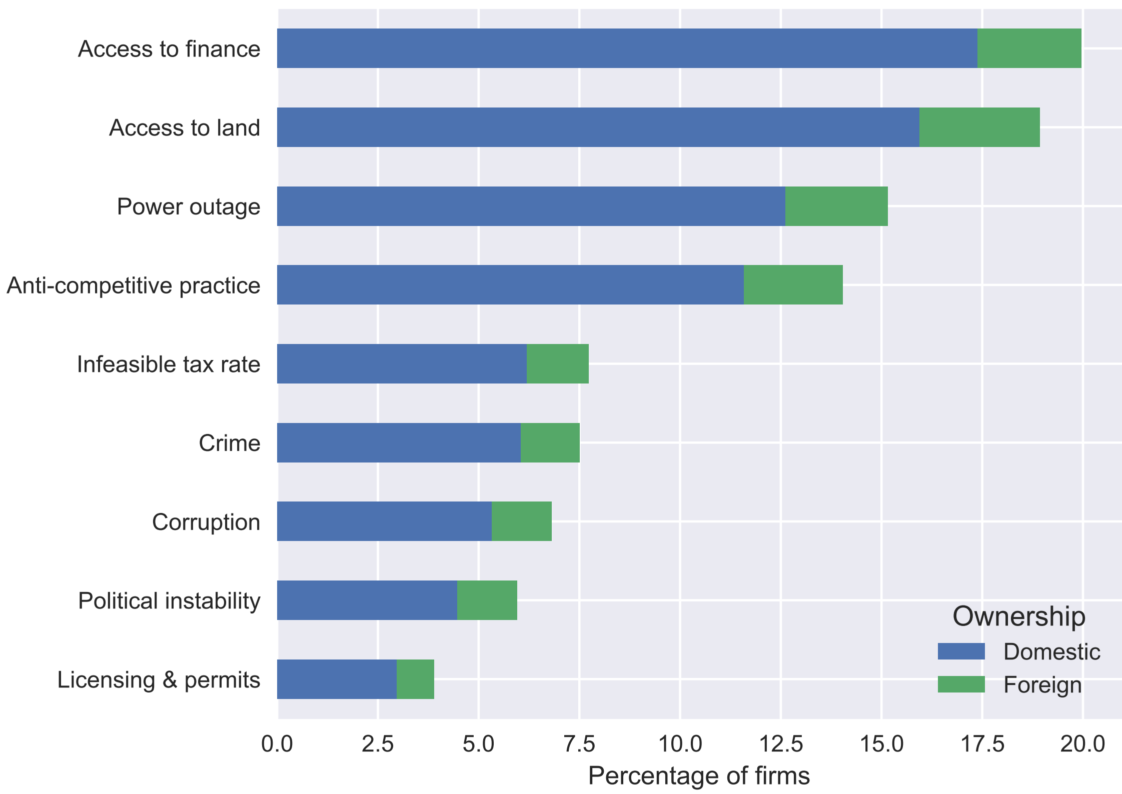

Figure 6.1: Nine Major Constraints Faced By Firms in Sub-Saharan Africa

Table 6.1: Number of Firms and Financial Constraint Indicators by Country

	All Firms				**Foreign Firms**		
	No. of Firms	% Foreign Owned	*Financial Constraint*	*Serious Constraint*	No. of Firms	*Financial Constraint*	*Serious Constraint*
Angola	785	22	2.35	.73	171	2.21	.68
Botswana	610	46	1.69	.51	283	1.36	.41
Burkina Faso	394	14	3.00	.91	54	2.42	.77
Burundi	270	17	2.30	.7	47	2.51	.72
Cameroon	363	18	2.45	.83	66	2.18	.74
Cape Verde	156	15	1.92	.64	24	2.00	.69
Chad	150	31	2.22	.67	47	1.86	.58
Congo	151	22	2.10	.66	33	1.96	.61
D.R. Congo	699	17	2.57	.77	119	2.21	.70
Eritrea	179	3	.43	.17	6	.33	.16
Gabon	179	61	1.58	.47	110	1.45	.43
Gambia	174	30	1.79	.55	52	1.36	.36
Ghana	494	5	2.65	.78	25	1.6	.52
Guinea	223	10	2.55	.73	25	2.73	.78
Guinea Bissau	159	9	2.91	.81	25	2.8	.73
Ivory Coast	526	17	2.87	.83	92	2.42	.70
Kenya	657	12	1.94	.58	80	1.72	.55
Lesotho	151	33	1.26	.36	50	.89	.22
Liberia	150	13	1.87	.56	20	1.25	.35
Madagascar	445	41	1.88	.60	185	1.66	.54
Malawi	150	32	2.08	.65	49	1.64	.52
Mali	850	7	2.29	.66	66	1.87	.52
Mauritania	237	12	2.12	.62	28	1.67	.5
Mauritius	398	11	1.88	.56	42	1.54	.52
Mozambique	473	19	2.10	.62	91	2.06	.61
Namibia	329	24	1.10	.31	79	.77	.18
Niger	150	23	2.10	.66	34	1.73	.52
Rwanda	212	16	1.50	.47	35	1.31	.37
Senegal	506	6	2.09	.61	30	1.7	.5
Sierra Leone	150	14	1.95	.62	21	1.52	.52
South Africa	937	12	.73	.22	121	.61	.19
Swaziland	307	36	1.56	.48	111	1.35	.45
Tanzania	419	12	1.82	.55	50	1.54	.48
Togo	155	30	2.28	.67	47	1.45	.43
Uganda	563	17	2.31	.73	94	1.88	.58
Zambia	484	24	1.32	.40	117	1.05	.30
All Countries	13,235	16.8	2.00	.63	2,534	1.64	.50

Note: Angola, Botswana, D.R. Congo and Mali were surveyed twice.

Next, Table 6.1 lists the countries contained in our sample. In turn, for each country, it lists the number of foreign-owned firms, its average *Financial Constraint* score, and the mean of its *Serious Constraint* indicator (which reflects the percentage of firms facing serious financial constraint).

As Table 6.1 shows, the number of foreign-owned firms across the SSAs varies substantially, where Botswana has the largest number of foreign-owned firms in the sample (i.e. 283) and Eritrea, which has half of Botswana's population, has the least (i.e. 6). Additionally, the level of financial constraint faced by firms varies substantially across the SSAs as well. For instance, South Africa has an average *Financial Constraint* score of 0.73, while Burkina Faso has an average score of 3 (where recall that a score of 0 indicates no financial constraint and a score of 4 indicates severe financial constraint).

Based on the average *Financial Constraint* and *Serious Constraint* scores for each country, we can see that on average, domestic firms across the SSAs (except for Cape Verde and Burundi) are more financially constrained than foreign-owned firms are. To visualize this result, Figure 6.2 plots the average *Serious Constraint* score for domestic firms in the y-axis and foreign-owned firms in the x-axis. The regression line that fits the cross-country data points, which correspond to the "Proportion of domestic firms facing moderate to severe financial constraint" in the y-axis and the "Proportion of foreign-owned firms facing moderate to severe financial constraint" in the x-axis, is flatter than the 45 degree line. This means that across the SSAs, the proportion of domestic firms facing serious financial constraint is larger than the proportion of foreign-owned firms facing the same.[12]

In Table 6.2, we report the share of foreign-owned firms across the SSAs for each industry. The proportion of foreign-owned firms tends to be smaller in the garment, furniture, accounting and computing machinery industries, where less than 15% of firms in these industries are foreign owned. By contrast, foreign-owned firms are more highly represented in the transport equipment, water transport and tobacco industries, and in the case of the tobacco industry, 80% of firms in the SSAs are

[12]If the proportions of domestic and foreign-owned firms facing serious financial constraints are the same, the data points will lie on the 45 degree line.

Table 6.2: Firm Ownership by Industry

Industry	Number of firms	Domestic	Foreign
Food	1629	82.20%	17.80%
Tobacco	10	20%	80%
Textiles	193	72.54%	27.46%
Garments	1036	88.13%	11.87%
Leather	106	83.96%	16.04%
Wood	327	86.54%	13.88%
Paper	73	65.75%	34.25%
Publishing, printing, and recorded media	317	86.12%	13.88%
Refined petroleum product	12	83.33%	16.67%
Chemicals	374	70.05%	29.95%
Plastics & rubber	182	66.48%	33.52%
Non metallic mineral products	203	69.46%	30.54%
Basic metals	85	72.94%	27.93%
Fabricated metal products	585	84.44%	15.56%
Machinery and equipment	111	72.94%	27.93%
Accounting and computing machinery	2	100%	0.00%
Electrical machinery and apparatus	68	75%	25%
Radio, television and communication equipment	8	75%	25%
Precision instruments	5	80%	20%
Motor vehicles, trailers and semi-trailers	33	81.81%	18.18%
Other transport equipment	15	33.33%	66.67%
Furniture	697	87.52%	12.48%
Recycling	6	83.33%	16.67%
Electricity, gas, steam and hot water supply	1	0.00%	100%
Collection, purification and distribution of water	1	100%	0.00%
Services of motor vehicles	486	75.10%	24.90%
Wholesale	592	75%	25%
Retail	2825	81.59%	18.41%
Hotel and restaurants	1195	85.36%	14.64%
Land transport	172	69.19%	30.81%
Water transport	25	44%	56%
Air transport	18	55.56%	44.44%
Travel agencies	73	71.23%	28.77%
Post and telecommunications	38	57.89%	42.11%
Activities auxiliary to financial intermediation	1	0.00%	100%
Computer and related activities	278	88.49%	11.51%
Total	10060	80%	20%

Note: These 38 industries are based on the 2-digit ISIC classification.

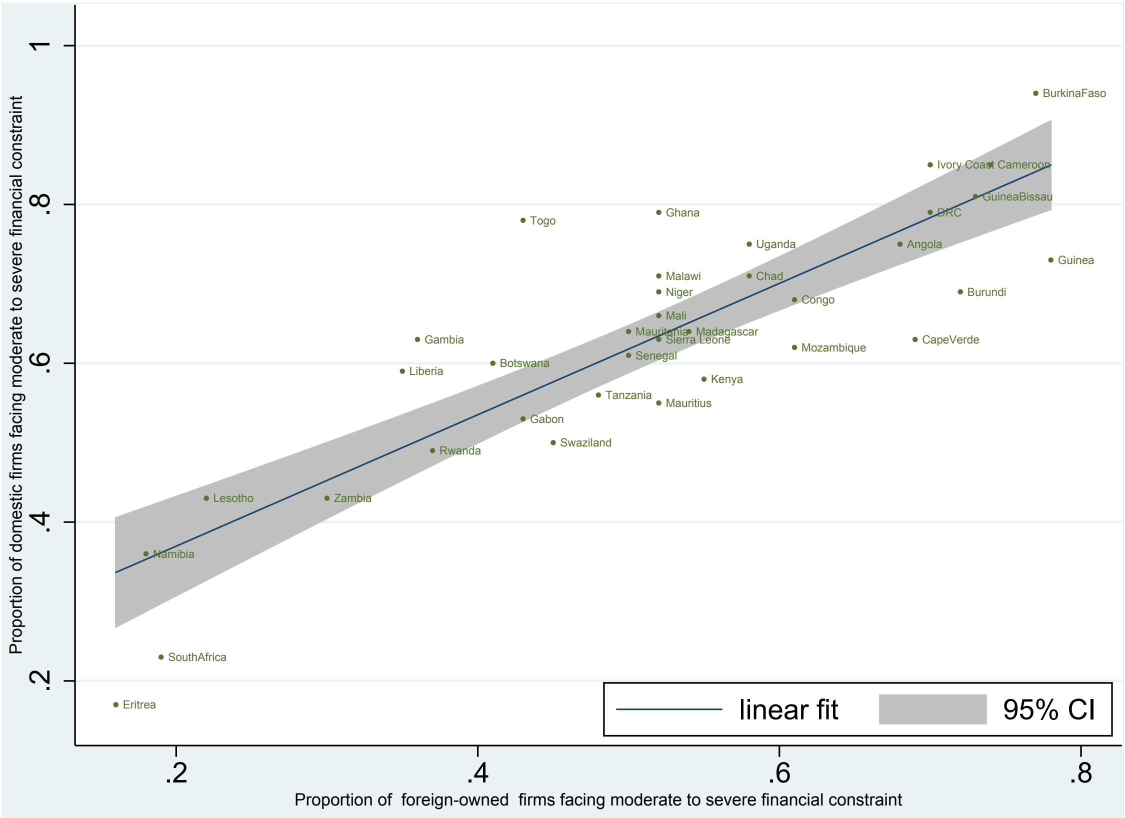

Figure 6.2: Proportion of Firms Facing Moderate to Severe Financial Constraint By Ownership Type

foreign owned.

Table 6.3: Percentage of financial constrained firms across ownership type

Financial constraint	Proportion of foreign firms	Proportion of domestic firms
Severe	13.72%	23.28 %
Major	20.53%	23.83%
Moderate	16.32%	16.01%
Minor	15.67%	12.20%
Not a Problem	33.77%	24.68%

Finally, in Table 6.3, we show the proportion of foreign firms and the proportions of domestic firms in each of the five categories of financial constraints. The table shows that domestic firms are likely to be more severely financially constrained. For example, 23.28% of domestic firms have reported that they face severe financial constraint as opposed to 13.72% of foreign firms that have reported the same. By contrast, about a third of foreign firms have reported that financial constraint is not a problem as opposed to a quarter of domestic firms that have reported the same.

For the descriptive statistics of the variables used in this study, please refer to Table D3 in Appendix C.

6.4 Empirical Approach

Our empirical approach is structured as follows.

Preliminary As a preliminary, we first show that foreign firms are less financially constrained by estimating (see Section 5.1 for findings)

$$FC_{ijkt} = c_1 + \alpha Foreign_{ijkt} + \boldsymbol{\gamma}'\mathbf{X}_{ijkt} + \boldsymbol{\delta}'\mathbf{C}_{kt} + \mu_j + \mu_k + \mu_t + \epsilon_{ijkt}. \tag{6.1}$$

The dependent variable FC_{ijkt} measures the financial constraint experienced by firm i in industry j and in country k, which is reported by this firm in year t. Throughout our paper, our main measure is *Financial Constraint*, which is an ordinal variable ranging from 0 to 4 where a score of 0 indicates that the firm is not financially constrained and a score of 4 indicates that the firm faces severe financial constraints.

The main explanatory variable in this model is *Foreign*, which is a dummy variable that indicates if the firm is foreign-owned. If domestic firms are more credit constrained than foreign-owned firms are, the coefficient on $Foreign$ will be negative. For controls, $\mathbf{X}_{ijkt}$ is a vector of firm-level variables and $\mathbf{C}_{kt}$ is a vector of country-level variables. Because the firms are surveyed once only, Eq. (6.1) (as are the other regression models estimated here) is a panel at the industry, country and year level, but not at the firm level. The term μ_j, generically represents the vector of industry dummies, μ_k represents the vector of country dummmies, and μ_t represents the vector of year dummies.

Main Estimating Equation We explore if a larger foreign firm presence may help alleviate the financial constraints of domestic firms in the same industry. To do so, we estimate (see Section 5.2 for findings)

$$FC_{ijkt} = c_2 + \beta Presence_{jkt} + \boldsymbol{\phi}'\mathbf{X}_{ijkt} + \boldsymbol{\rho}'\mathbf{C}_{kt} + \mu_j + \mu_k + \mu_t + \varepsilon_{ijkt} \tag{6.2}$$

using only the subsample of domestic firms. Our main financial constraint measure, as before, is *Financial Constraint*. In addition, we consider three alternative measures of financial constraint, namely *Serious Constraint*, *Credit Products Constraint*, and *Loans Denied* discussed in Section 6.3.1, as a robustness check. $Presence_{jkt}$, our main explanatory variable, measures the presence of foreign-owned firm in industry j in country k. We measure $Presence_{jkt}$ using the following indicators: (i) the proportion of foreign firms over the total number of firms in industry j, country k and year t,

$$Foreign\ Firms\ Proportion_{jkt} = \frac{\sum_{i=1}^{n} Foreign_{ijkt}}{Total\ number\ of\ firms_{jkt}} \tag{6.3}$$

(ii) the share of foreign firms' equity of total equity in industry j, country k and year t (Eq. (6.4))

$$Foreign\ Equity\ Share_{jkt} = \frac{\sum_{i=1}^{n}(equity_{ijkt} * Foreign_{ijkt})}{\sum_{i=1}^{n} equity_{jkt}} \tag{6.4}$$

(iii) the proportion of workers in foreign-owned firms over total number of workers in industry j, country k and year t (Eq. (6.5)):

$$Foreign\ Workers\ Share_{jkt} = \frac{\sum_{i=1}^{n}(employees_{ijkt} * Foreign_{ijkt})}{\sum_{i=1}^{n} employees_{ijkt}} \tag{6.5}$$

The larger these indices are, the larger foreign firm presence is in the industry in terms of the proportion of foreign-owned firms (Eq. (6.3)), proportion of equity held by foreign-owned firms (Eq. (6.4)), and the proportion of the workforce force employed by foreign-owned firms (Eq. (6.5)).

Unless stated otherwise, for models with an ordinal dependent variable (specifically *Financial Constraint*), we estimate them with the Ordered Probit model and report the estimated coefficients in the tables (in Table 6.10, we consider alternative estimation methods as a robustness check). For models with a binary dependent variable, we estimate them with the Probit model and report the average marginal effects associated with the regressors.

Mechanism Finally, we provide some evidence to support an explanation (there could be others) for why foreign firm presence may help to ease the financial constraint of domestic firms (see Section 5.3). Firms compete for finance, which is scarce in the SSAs. We show that foreign-owned firms are not only less financially constrained than domestic firms are, they are also less likely to borrow from banks. Since foreign-owned firms are less likely to seek bank credit, domestic firms would benefit from reduced competition in the credit market when there is greater representation of foreign-owned firms. In Section 5.3, we show that domestic firms in industries with a larger foreign firm presence are indeed more successful in their loan applications. This is one possible explanation for why foreign firm presence may ease the financial constraints of domestic firms.

6.4.1 Possible Empirical Issues

Our main estimating equation is Eq. (6.2). We highlight some concerns that could prevent us from imparting a causal interpretation on the association between foreign firm presence and domestic firms' financial constraint.

Reverse Causality The first possible concern is reverse causality. Due to our regression design, we believe that reverse causality is unlikely to be a major confounding problem. Specifically, in our estimating equation (i.e. Eq. (6.2)), our dependent variable is the financial constraint of the domestic *firm* and our main explanatory variable is the foreign firm presence of an *industry*. For reverse causality to occur in the context of Eq. (6.2), we would need FC_{ijkt} (the firm i's financial constraint) to cause $Presence_{jkt}$ (industry j's foreign firm presence); that is, domestic firms would need to drive the composition of foreign firms in the industry.

In this regard, we believe it is empirically unlikely for our results to be driven by reverse causality. Firstly, domestic firms in the SSAs are typically smaller. In Table 6.4, we find that the great majority of domestic firms, about 69% of them, have 19 employees or fewer. Moreover, only 7% of domestic firms employ 100 or more workers, compared with 25% of foreign-owned firms. Therefore, because of their size, it is unlikely for domestic firms to drive foreign firm presence in the industry and for reverse causality to matter empirically.

Table 6.4: The Size of Domestic versus Foreign-Owned Firms

	Domestic firms	Foreign-Owned firms
Small Firm (5-19 employees)	69%	42%
Medium Firm (20-99 employees)	24%	33%
Large Firm (above 99 employees)	7%	25%
Total	100%	100%

More importantly, it is also unlikely that our conclusion is driven by reverse causal effects that are due to large domestic firms. In Section 6.4, we re-estimate our baseline regression without the top 5% and 10% largest domestic firms in the sample. We show that our conclusion (i.e. that foreign firm presence is statistically significant) still holds when these firms are omitted from the regression. Therefore, there is no evidence that our conclusion is driven by potential reverse causality stemming from these large domestic firms as well.

Self-Selection Even if we could rule out reverse causality, it does not imply that the association between foreign firm presence and domestic firms' financial constraint is causal. For example, foreign firms may still self-select into countries or industries where domestic firms are less financially constrained. Therefore, the association between foreign firm presence and domestic firms' financial constraint could be jointly determined by certain unobserved country or industry characteristics.

To address this concern, we include industry and country fixed effects to purge the possible confounding influence of unobserved industry and country heterogeneity.[13] We also control for certain time-varying macroeconomic variables such as financial development (*Financial Development*), legal system (*Legal System*) and inflation (*Inflation*) that may affect foreigners' decisions to invest in a country. Finally, in place of the country level controls, we use country-year fixed effects to partial

[13] As it turns out, we find that foreign firm presence is statistically significant for domestic firms' financial constraint whether industry or country fixed effects are controlled for. This suggests that foreign firm presence have an impact on domestic firms' financial constraint beyond the influence of industry or country fixed effects.

out all possible country determinants, whether they are observable or unobservable, time-varying or time-constant. Therefore, the country-year fixed effects will partial out financial development, country-specific policies, and other country-specific characteristics that may jointly determine foreign firm presence and the financial constraints of domestic firms.

Measurement of Credit Constraint Another concern stems from an observation by Hansen and Rand (2014a) that research on credit constraints may not be robust to how credit constraints are measured.[14] For this reason, we use different indicators to measure financial constraint (i.e. *Financial Constraint*, *Serious Constraint*, *Credit Products Constraint*, *Loan Denied*) to ensure that our results are not dependent on the way financial constraint is measured.

Multicollinearity Lastly, we could be concerned about the multicollinearity, especially when we include a sizable set of firm level and country level controls. To this end, we compute that Variance-Inflation-Factor (VIF) suggested by (Belsley et al., 2005), and to save space, we have omitted the results from the paper. We find that all the predictors have an VIF smaller than the rule-of-thumb of 10, above which there is evidence of multicollinearity. Therefore, multicollinearity does not appear to an issue here.

6.5 Results

6.5.1 Firm Ownership and Financial Constraint

Based on *Financial Constraint* as the dependent variable, we report our estimates of Eq. (6.1) in Table 6.5, which reveal if domestic firms are more financially constrained than foreign-owned firms are. In Column (1), we control for firm characteristics only. In Column (2), we additionally control for inflation, financial development and legal system. In Column (3), we add industry, country and year dummies. In Column

[14] Hansen and Rand (2014a) show how three different measures of credit constraints lead to three different estimates of the effects of gender on firms' credit situation.

(4), we use industry dummies and country times year dummies. We find that all else equal, foreign-owned firms have a *Financial Constraint* score of $0.1 - 0.14$ points smaller than domestic firms have on average. This difference is statistically significant at the 1% level across all regression specifications, suggesting that domestic firms on average are more financially constrained than foreign firms are.

Concerning the other control variables, Table 6.5 shows that firms owned by females tend to be more financially constrained than firms owned by males.[15] It also shows that firms that are financially constrained tend to be small, owned by partnerships than corporations or sole proprietors, less financially transparent, and have limited technological capacity (i.e. lacking a website). Firms in countries with better financial development and legal system tend to be less financially constrained as well.

6.5.2 Foreign Firm Presence and Domestic Firms' Financial Constraint

Previously, our results show that domestic firms tend to be more financially constrained than foreign firms. Here, we show that domestic firms are less financially constrained if there is a larger foreign firm presence in the same industry. To establish this result, we use the sample of domestic firms and regress their *Financial Constraint* scores on measures of foreign firm presence in their respective industries, along with other firm and country-level control variables and industry, country and year dummies.

In Column (1) of Table 6.6, we estimate Eq. (6.2) with the proportion of foreign-owned firms, denote by $\textit{Foreign Firms Proportion}_{jkt}$, as our measure of foreign firm presence. The negative coefficient on $\textit{Foreign Firms Proportion}_{jkt}$ suggests that domestic firms are less financially constrained when proportion of foreign-owned firms in the same industry is larger.

Next, we use alternative measures of foreign firm presence. In Column (2), we use

[15] This result is consistent with Asiedu et al. (2013) for the case of manufacturing firms in the SSAs.

Table 6.5: Financial Constraint: Foreign-Owned Versus Domestic Firms

	(1)	(2)	(3)	(4)
Dependent Variable:		*Financial Constraint*		
Foreign (owned)	-0.109***	-0.235***	-0.139***	-0.14***
	(0.000)	(0.038)	(0.000)	(0.0373)
Female Owned	0.081***	0.071***	0.085***	0.08***
	(0.027)	(0.029)	(0.009)	(0.0290)
Small (5-19 workers)	0.168***	0.208***	0.200***	0.199***
	(0.050)	(0.054)	(0.055)	(0.054)
Medium (20-99 workers)	0.082	0.088*	0.085*	0.085*
	(0.050)	(0.052)	(0.052)	(0.051)
Sole Proprietorship	0.008	-0.114***	-0.115***	-0.114 ***
	(0.037)	(0.040)	(0.040)	(0.040)
Publicly Traded	-0.444***	-0.597***	-0.593***	-0.596***
	(0.131)	(0.150)	(0.150)	(0.149)
Private or Non-traded	-0.158***	-0.154***	-0.156***	-0.156***
	(0.038)	(0.041)	(0.042)	(0.041)
Financial Transparency	-0.342***	-0.241***	-0.231***	-0.23***
	(0.029)	(0.032)	(0.032)	(0.037)
Technological Capacity	-0.311***	-0.185***	-0.181***	-0.180
	(0.036)	(0.038)	(0.038)	(0.037)
Financial Development		-0.003	-0.033**	-0.058***
		(0.001)	(0.015)	(0.012)
Legal System		-0.003	-0.133***	-0.128***
		(0.010)	(0.028)	(0.036)
Inflation		0.077***	-0.029	-0.148***
		(0.009)	(0.028)	(0.048)
Industry Dummies	No	No	Yes	Yes
Country Dummies	No	No	Yes	No
Year Dummies	No	No	Yes	No
Country-Year Dummies	No	No	No	Yes
Observations	8186	7718	7518	7718

Note: *Financial Constraint* is an ordinal variable (from 0 to 4) that indicates how financially constrained a firm is. Estimates of the coefficients from the Ordered Probit model are reported here. The constant is suppressed. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the share of employment by foreign-owned firms as a measure of foreign firm presence (i.e. *Foreign Workers Share*$_{jkt}$). In Column (3), we use the share of equity holdings by foreign-owned firms (i.e. *Foreign Equity Share*$_{jkt}$). Regardless of how foreign firm presence is measured, we find that the coefficient on foreign firm presence is negative and statistically significant at the 1% level. In other words, domestic firms tend to be less financially constrained in industries where the proportion of foreign firms is greater (Column (1)), and where foreign firms have a larger share of employment (Column (2)) and equity holdings (Column (3)). Thus, how foreign firm presence is measured does not affect our conclusion that it is positively associated with the easing of domestic firms' financial constraint.

6.5.3 Credit Competition

Why does the presence of foreign firms help domestic firms to be less financially constrained? A possible explanation (among possibly others) is that firms compete for credit, but credit is scarce in the SSAs. Because foreign firms tend to be less financially constrained (see Table 6.5), they would therefore be less likely to borrow. As such, their presence would reduce the competition for finance and increase the success of domestic firms in borrowing from banks (Wang and Wang, 2015).

We show that this explanation is empirically plausible. Given that foreign firms are less likely to be financially constrained (see Table 6.5), we first verify that foreign firms, compared with domestic firms, are also less likely to apply for a loan, controlling for firm and country-level characteristics, as well as industry, country and year dummies (see, also, Hansen and Rand, 2014a).[16] To do so, we regress a dummy variable, *Loan Application*, which indicates if a firm has applied for a bank loan, on the ownership type of the firm (i.e. domestic versus foreign-owned).

In Table 6.7, we estimate this relationship using OLS (Column (1)), Conditional Logit (Column (2)), and Probit (Column (3)).[17] All three regressions show that

[16] Just to emphasize, we consider loan application than the actual amount of loan received. Clearly, the quantum of the loan may depend not only on how needy the firm is, it also depends on the restrictions placed by banks on how much it can borrow. A loan application, however, is related only to how financially constrained a firm is, as banks do not prohibit loan applications (they could, however, deny the application received).

[17] We include country, industry fixed and year effects in the OLS and Conditional Logit regressions.

Table 6.6: Foreign Firm Presence and Domestic Firms' Financial Constraint

	(1)	(2)	(2)
Dependent Variable:	*Financial Constraint* (Domestic Firms)		
Foreign Firms Proportion	-0.318**		
	(0.153)		
Foreign Equity Share		-0.320**	
		(0.156)	
Foreign Workers Share			-0.222**
			(0.089)
Female Owned	0.055*	0.055*	0.081**
	(0.031)	(0.031)	(0.034)
Small (5-19 workers)	0.217***	0.217***	0.226***
	(0.067)	(0.065)	(0.068)
Medium (20-99 workers)	0.092	0.092	0.095
	(0.066)	(0.063)	(0.066)
Sole Proprietorship	-0.155***	-0.155***	-0.145***
	(0.044)	(0.043)	(0.046)
Publicly Traded	-0.481**	-0.481**	-0.546**
	(0.200)	(0.215)	(0.237)
Private or Non-traded	-0.180***	-0.180***	-0.202***
	(0.048)	(0.047)	(0.050)
Financial Transparency	-0.241***	-0.241***	-0.243***
	(0.035)	(0.035)	(0.037)
Technological Capacity	-0.243***	-0.243***	-0.221***
	(0.046)	(0.045)	(0.049)
Financial Development	-0.063***	-0.063***	-0.056***
	(0.015)	(0.014)	(0.015)
Legal System	-0.115***	-0.115***	-0.148***
	(0.042)	(0.041)	(0.044)
Inflation	-0.127**	-0.126**	-0.177***
	(0.055)	(0.054)	(0.059)
Industry, Country & Year Dummies	Yes	Yes	Yes
Observations	6284	6284	5409

Note: *Financial Constraint* is an ordinal variable (from 0 to 4) that indicates how financially constrained a firm is. Estimates of the coefficients from the Ordered Probit model are reported here. The constant is suppressed. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the coefficient on *Foreign* is negative and statistically significant, and therefore, foreign-owned firms are less likely than domestic firms to apply for a loan. For example, Column (3) shows that compared with domestic firms, foreign-owned firms are 14.2 percentage points less likely to apply for a loan on average.

Table 6.7: Foreign-Owned Firms, Domestic Firms and Loan Application

	(1) OLS	(2) Conditional Logit	(3) Probit
Dependent Variable:		*Loan Application*	
Foreign	-0.034**	-0.196**	-0.142**
	(0.014)	(0.085)	(0.064)
Female Owned	0.028***	0.166***	0.131***
	(0.011)	(0.063)	(0.041)
Small (5-19 workers)	-0.131***	-0.679***	-0.444***
	(0.020)	(0.108)	(0.103)
Medium (20-99 workers)	-0.063***	-0.283***	-0.204*
	(0.019)	(0.103)	(0.112)
Sole Proprietorship	-0.032**	-0.202**	-0.076
	(0.015)	(0.090)	(0.061)
Publicly Traded	-0.009	-0.077	-0.044
	(0.054)	(0.301)	(0.174)
Private or Non-traded	-0.018	-0.119	-0.053
	(0.016)	(0.092)	(0.063)
Financial Transparency	0.075***	0.448***	0.250***
	(0.012)	(0.072)	(0.078)
Technological Capacity	0.041***	0.223***	0.117*
	(0.014)	(0.081)	(0.064)
Inflation			-0.011
			(0.009)
Financial Development			-0.002**
			(0.001)
Legal System			0.011
			(0.021)
Industry, Country & Year Dummies	Yes	Yes	Yes
Observations	7583	7583	7374

Note: In Columns (1) and (2), estimates of the coefficients from the Ordinary Least Squares (OLS) regression and Conditional Logit model are reported. In Column (3), the average marginal effects from the Probit model are reported. The constant is suppressed. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

If foreign-owned firms are less likely to apply for a loan, a larger foreign firm presence may reduce the financial constraint of domestic firms by enabling them to borrow more successfully. For the sample of domestic firms, Table 6.8 regresses *Loan Denied*, a dummy that indicates if a domestic firm has had an unsuccessful loan application, on each of the foreign firm presence measures (see Eqs. (6.3)-(6.5)). Regardless of how foreign firm presence is measured, Table 6.8 shows that domestic firms are less likely to be denied a loan when foreign firm presence is larger. For example, Column (1) shows that if the proportion of foreign firms (over total number of firms in an industry) increases by 10 percentage points, domestic firms in the same industry would be 4 percentage points less likely to have had a rejected loan. Therefore, domestic firms have been more successful in securing credit when the proportion of foreign firms in the industry is larger.

These results suggest that a reduction in loans competition is one reason (among possibly others) for why foreign firm presence is negatively associated with the financial constraint of domestic firms. Foreign-owned firms are not only less financially constrained, they are also less likely to borrow from banks. Thus, the presence of foreign-owned firms reduces the competition for credit and improves the access to finance for domestic firms on average.

6.6 Robustness Checks

6.6.1 Alternative Indicators of Financial Constraint

Our main financial constraint measure (*Financial Constraint*) is an ordinal variable based on managers' perceptions on how financially constraint their firms are. However, with respect to measurements of credit constraints, Hansen and Rand (2014a) have shown that different measures may yield different conclusions.[18]

Therefore, as a robustness check, we consider three alternative measures of financial constraint. Our first measure, *Serious Constraint*, is a dummy variable that indicates if access to finance is a moderate to severe problem for the firm. Our second measure, *Credit Product Constraint*, is a dummy variable that indicates if the firm *does not* have access to at least one of the three credit products, i.e. an overdraft, line of credit, or a bank loan (Aterido et al., 2013; Love and Martínez Pería, 2014).

[18] Hansen and Rand (2014a) have found three different effects of gender on credit constraints in the SSAs when three different measures of credit constraints are used. They argue that the choice of credit constraint measurement determines the estimated effect.

Table 6.8: Foreign Firm Presence and Loan Denial to Domestic Firms

	(1)	(2)	(3)
Dependent Variable:	*Loans Denied* (Domestic Firms)		
Foreign Firms Proportion	-0.398***		
	(0.099)		
Foreign Equity Share		-0.392***	
		(0.098)	
Foreign Workers Share			-0.156*
			(0.083)
Female Owned	-0.004	-0.004	-0.008
	(0.070)	(0.070)	(0.083)
Small (5-19 workers)	0.799***	0.800***	0.683***
	(0.134)	(0.134)	(0.159)
Medium (20-99 workers)	0.383***	0.384***	0.316**
	(0.130)	(0.130)	(0.154)
Publicly Traded	0.225	0.223	0.268
	(0.390)	(0.390)	(0.481)
Private or Non-traded	-0.043	-0.043	-0.111
	(0.107)	(0.107)	(0.126)
Financial Transparency	-0.149*	-0.338***	-0.0003
	(0.077)	(0.077)	(0.089)
Technological Capacity	-0.119	-0.159	-0.056
	(0.095)	(0.095)	(0.121)
Inflation	0.059***	0.059***	0.121***
	(0.010)	(0.010)	(0.013)
Financial Development	-0.003***	-0.003***	-0.001
	(0.001)	(0.001)	(0.001)
Legal System	-0.118***	-0.118***	-0.236***
	(0.018)	(0.018)	(0.021)
Industry, Country & Year Dummies	Yes	Yes	Yes
Observations	2223	2223	1727

Note: *Loan Denied* indicates if a (domestic) firm was denied a loan application. The average marginal effects from the Probit model are reported here. The constant is suppressed. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Our third measure, *Loan Denied* (which we have used in Table 6.8), is a dummy variable that indicates if a firm has had an unsuccessful loan application.

Table 6.9 shows that all three alternative measures of financial constraint are negatively associated with foreign firm presence (measured by *Foreign Firms Proportion*), and their associations are statistically significant at the 1% level. Therefore, when the presence of foreign-owned firms is larger, domestic firms within the same industry (as these foreign firms) are *less likely* to report that they have faced moderate to severe financial constraint, have no access to credit facilities, and were denied loans. Thus, there is no evidence that our results depend on how the financial constraints of domestic firms are measured.

Table 6.9: Robustness Check #1: Alternative Indicators of Financial Constraint

	(1)	(2)	(3)
Dependent Variable:	*Serious Constraint*	*Credit Products Constraint*	*Loan Denied*
Foreign Firms Proportion	-0.249***	-0.168***	-0.398***
	(0.054)	(0.036)	(0.099)
Female Owned	0.048***	-0.030***	-0.014
	(0.013)	(0.009)	(0.070)
Small (5-19 workers)	0.076***	0.049**	0.799***
	(0.027)	(0.021)	(0.134)
Medium (20-99 workers)	0.036	0.051**	0.383***
	(0.027)	(0.022)	(0.130)
Sole Proprietorship	-0.061**	-0.052***	-0.043
	(0.029)	(0.018)	(0.102)
Publicly Traded	-0.292***	-0.100**	0.225
	(0.044)	(0.128)	(0.390)
Private or Non-traded	-0.082***	-0.022*	-0.043
	(0.013)	(0.033)	(0.107)
Financial Transparency	-0.102***	-0.078***	-0.149*
	(0.014)	(0.010)	(0.025)
Technological Capacity	-0.101***	-0.008	-0.119
	(0.018)	(0.015)	(0.095)
Financial Development	-0.002***	-0.002***	-0.003***
	(0.000)	(0.000)	(0.001)
Legal System	-0.003	0.030***	-0.118***
	(0.003)	(0.002)	(0.018)
Inflation	0.005***	0.005***	0.059***
	(0.002)	(0.001)	(0.010)
Industry, Country & Year Dummies	Yes	Yes	Yes
Observations	6186	2223	6277

Note: *Serious Constraint* indicates if a firm faces moderate to severe financial constraint. *Credit Products Constraint* indicates if a firm has no access to credit facilities. *Loans Denied* indicates if the firm had a rejected loan application. The average marginal effects from the Probit model are reported. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.6.2 Alternative Estimation Methods

Our baseline results are obtained by estimating an Ordered Probit model. We check if these results are robust, in terms of sign and statistical significance, to the choice of estimation methods. To do so, we re-estimate our model using Ordinary Least Square (OLS) regression with industry, country, and year fixed effects to control for confounding industry and country unobserved heterogeneity and macroeconomic shocks, and Iteratively Reweighted Least Squares (IRLS) regression to mitigate the influence of outlier observations.[19] In Table 6.10, we report the OLS estimates in Column (1) and the IRLS estimates in Column (2). Both estimates show that domestic firms are less financially constraint (at a 1% level of significance) in industries where the proportion of foreign firms is larger. Therefore, our baseline results are not an artifact of the chosen estimation method.

6.6.3 Alternative Definition of Foreign Ownership

Up to this point, foreign-owned firms have been defined as firms in the host country where foreigners hold at least 10% percent of their equity.[20] We show that our conclusions are robust if we adopt a different definition of foreign ownership based on a different equity share in a local firm that is foreign held.

As a robustness check, we deliberately choose a more drastic alternative definition of foreign ownership by considering a firm to be foreign owned if 50% or more of its equity is foreign held. We find that our main conclusions are not affected even with this alternative definition of foreign ownership. This is shown, for example, in Table 6.11, where the proportion of foreign-owned firms in the industry, and the foreign share of equity and employment are all negatively and statistically significant for domestic firms' financial constraint. Therefore, our baseline results do not depend on how foreign ownership of firms are defined.

[19]This can be done by minimizing the error term in the L^1-norm (i.e. the absolute error) than the L^2-norm (i.e. the squared error) (Green, 1984).

[20]10% is a cut-off considered by others in the related literature (Asiedu et al., 2013; Javorcik and Spatareanu, 2011).

Table 6.10: Robustness Check #2: Alternative Estimation Methods

	(1) OLS	(2) IRLS
Dependent Variable:	*Financial Constraint* (Domestic Firms)	
Foreign Firms Proportion	-0.431**	-1.021***
	(0.196)	(0.186)
Female Owned	0.060	0.137***
	(0.040)	(0.045)
Small (5-19 workers)	0.215***	0.238***
	(0.083)	(0.092)
Medium (20-99 workers)	0.079	0.081
	(0.082)	(0.089)
Sole Proprietorship	-0.205***	-0.148**
	(0.057)	(0.062)
Publicly Traded	-0.675***	-0.734***
	(0.249)	(0.264)
Private and Non-traded	-0.236***	-0.270***
	(0.061)	(0.065)
Financial Transparency	-0.303***	-0.406***
	(0.045)	(0.049)
Technological Capacity	-0.307***	-0.348***
	(0.057)	(0.063)
Financial Development		-0.006***
		(0.000)
Legal System		-0.034***
		(0.010)
Inflation		0.021***
		(0.005)
Industry, Country & Year Dummies	Yes	Yes
Observations	6451	6284

Note: In Columns (1) and (2), estimates of the coefficients from Ordinary Least Squares (OLS) and Iterated Least Squares (IRLS) are reported. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6.11: Robustness Check #3: Alternative Definition of Foreign Ownership

	(1)	(2)	(3)
Dependent Variable:	*Financial Constraint* (Domestic Firms)		
Foreign Firms Proportion	-0.811***		
	(0.168)		
Foreign Equity Share		-0.220***	
		(0.067)	
Foreign Workers Share			-0.610***
			(0.106)
Female Owned	0.109***	0.125***	0.163***
	(0.034)	(0.035)	(0.042)
Small (5-19 workers)	0.178**	0.302***	0.305***
	(0.069)	(0.068)	(0.085)
Medium (20-99 workers)	0.062	0.145**	0.168**
	(0.067)	(0.066)	(0.082)
Sole Proprietorship	-0.100**	-0.086*	-0.131**
	(0.046)	(0.047)	(0.057)
Publicly Traded	-0.585***	-0.575**	-0.860***
	(0.221)	(0.241)	(0.260)
Private or Non-traded	-0.168***	-0.198***	-0.235***
	(0.049)	(0.050)	(0.060)
Financial Transparency	-0.285***	-0.281***	-0.282***
	(0.037)	(0.038)	(0.044)
Technological Capacity	-0.261***	-0.161***	-0.246***
	(0.049)	(0.039)	(0.060)
Financial Development	-0.005***	-0.005***	-0.004***
	(0.000)	(0.001)	(0.001)
Legal System	-0.016**	-0.007	0.007
	(0.007)	(0.008)	(0.009)
Inflation	0.018***	0.015***	0.008
	(0.004)	(0.005)	(0.005)
Industry, Country & Year Dummies	Yes	Yes	Yes
Observations	5377	5168	5409

Note: A firm is defined as foreign owned here if at least 50% of its equity is foreign held. *Financial Constraint* is an ordinal variable (from 0 to 4) that indicates how financially constrained a firm is. Estimates of the coefficients from the Ordered Probit model are reported here. The constant is suppressed. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.6.4 Omitting the Largest Domestic Firms

In Section 4.1, we have discussed why it is unlikely for reverse causality to occur. This is because given that domestic firms are usually small, it will be unlikely for them to have an impact on the composition of foreign firms in the industry, which is how foreign firm presence is measured.

What about the large domestic firms? Could the statistical significance of foreign firm presence be driven by reverse causality stemming from these firms? In this robustness check, we re-estimate Eq. (6.2) without the top 5% and 10% largest domestic firms and report the new results in Table 6.12 and 6.13 respectively. Even without the large domestic firms, we find that foreign firm presence is still statistically significant at the 1% level. Therefore, there is no evidence that these firms are driving the statistical significance of foreign firm presence in our baseline regressions.

Table 6.12: Robustness Check #4: Excluding the Top 5% Largest Domestic Firms

	(1)	(2)	(3)
Dependent Variable:	*Financial Constraint* (Domestic Firms)		
Foreign Firms Proportion	-0.592***		
	(0.155)		
Foreign Equity Share		-0.593***	
		(0.154)	
Foreign Workers Share			-0.551***
			(0.109)
Female Owned	0.099***	0.099***	0.156***
	(0.033)	(0.033)	(0.042)
Small (5-19 workers)	0.172**	0.172**	0.265***
	(0.079)	(0.079)	(0.100)
Medium (20-99 workers)	0.046	0.046	0.118
	(0.077)	(0.077)	(0.098)
Sole Proprietorship	-0.121***	-0.121***	-0.123**
	(0.044)	(0.044)	(0.057)
Publicly Traded	-0.376	-0.376	-0.736***
	(0.243)	(0.243)	(0.276)
Private or Non-traded	-0.196***	-0.196***	-0.224***
	(0.048)	(0.048)	(0.061)
Financial Transparency	-0.231***	-0.231***	-0.267***
	(0.035)	(0.035)	(0.045)
Technological Capacity	-0.248***	-0.248***	-0.235***
	(0.048)	(0.048)	(0.062)
Financial Development	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)
Legal System	0.014*	0.014*	0.034***
	(0.008)	(0.008)	(0.010)
Inflation	-0.010**	-0.010**	-0.008
	(0.005)	(0.005)	(0.006)
Industry, Country & Year Dummies	Yes	Yes	Yes
Observations	5914	5914	5263

Note: *Financial Constraint* is an ordinal variable (from 0 to 4) that indicates how financially constrained a firm is. Estimates of the coefficients from the Ordered Probit model are reported here. The constant is suppressed. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6.13: Robustness Check #5: Excluding the Top 10% Largest Domestic Firms

	(1)	(2)	(3)
Dependent Variable:	*Financial Constraint* (Domestic Firms)		
Foreign Firms Proportion	-0.616***		
	(0.157)		
Foreign Equity Share		-0.615***	
		(0.157)	
Foreign Workers Share			-0.601***
			(0.111)
Female Owned	0.100***	0.100***	0.160***
	(0.034)	(0.034)	(0.043)
Small (5-19 workers)	0.279	0.279	0.315
	(0.175)	(0.175)	(0.226)
Medium (20-99 workers)	0.158	0.158	0.173
	(0.175)	(0.175)	(0.225)
Sole Proprietorship	-0.124***	-0.124***	-0.120**
	(0.045)	(0.045)	(0.058)
Publicly Traded	-0.422	-0.422	-0.656**
	(0.257)	(0.257)	(0.283)
Private or Non-traded	-0.200***	-0.200***	-0.224***
	(0.049)	(0.049)	(0.062)
Financial Transparency	-0.232***	-0.232***	-0.266***
	(0.036)	(0.036)	(0.045)
Technological Capacity	-0.245***	-0.245***	-0.229***
	(0.050)	(0.050)	(0.065)
Financial Development	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)
Legal System	0.013	0.013	0.033***
	(0.008)	(0.008)	(0.011)
Inflation	-0.009*	-0.009*	-0.008
	(0.005)	(0.005)	(0.006)
Industry, Country & Year dummies	Yes	Yes	Yes
Observations	5699	5699	5060

Note: *Financial Constraint* is an ordinal variable (from 0 to 4) that indicates how financially constrained a firm is. Estimates of the coefficients from the Ordered Probit model are reported here. The constant is suppressed. Robust standard errors are reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.7 Conclusion

Because their underdeveloped financial sector, policymakers in the SSAs have encouraged the foreign ownership of firms to help, among others, improve the access to finance by domestic firms. However, there is no empirical evidence that a larger foreign presence leads to less financially constrained domestic firms. Moreover, the association between between foreign firm presence and domestic firms' financial constraint is *á priori* ambiguous.

To study this issue, we employ cross-country firm-level data that spans across 36 SSAs. We find that in industries with a larger foreign firm presence, domestic firms tend to be less financially constrained. The direction and the statistical significance of this effect is robust to the way financial constraint of domestic firms and foreign firm presence are measured, to the use of alternative estimation methods and alternative definitions of foreign ownership, among others.

Because of the richness of the WBES surveys, we are able to explore further into why the presence of foreign-owned firms may ease the financial constraints of domestic firms. we find that foreign-owned firms are not only less financially constrained, they are also less likely to borrow from banks. Moreover, in industries where foreign firm presence is larger, domestic firms tend to be more successful in securing bank credit. Therefore, there is evidence that foreign firm presence reduces the competition for bank credit, and this helps the domestic firms to improve their access to finance and ease their financial constraints.

Our paper has policy relevance, in that it offers new evidence to show that foreign firm presence may address the most commonly voiced concern in operating a business in the SSAs – the lack of finance. Because financial development is an extremely important determinant of growth, it would be useful to follow up on whether the increase in foreign firm presence in the SSAs may also lead to higher levels of growth and socio-economic development.

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Appendix D

Table D1: Access to Finance of Firms in the SSAs versus the OECD

	Sub-Saharan Africa	OECD
Firms with a bank loan/line of credit (%)	23.5	49.1
Firms using banks to finance investment (%)	17.6	31.5
Investment financed by banks (%)	11.2	18.9
Firms using bank to finance working capital (%)	22.1	68.6
Working capital financed by banks (%)	8.6	40.6
Working capital financed by supplier credit (%)	11.2	14.4
Loan requiring collateral (%)	82.26	72.6
Firms identifying finance as a major constraint (%)	42.6	15.9

Note: The number in the table are averages across firms calculated from WBES (2015) webpage. The number of SSAs and OECD countries used for this computation are 36 and 16 countries respectively.

Table D2: Definition of Variables

Variable	Definition
Dependent variables: measures of financial constraint	
Financial Constraint	Ordinal response by the firm from 0 (no financial constraint) to 4 (severe financial constraint)
Serious Constraint	=1 if the firm reports having moderate to severe financial constraint
Credit Products Constraint	=1 if the firm has no access to overdraft, line of credit or bank loan
Loans Denied	=1 if the firm has applied for but denied formal credit
Measures of foreign ownership and foreign firm presence	
Foreign	=1 if the firm has at least 10% of its equity held by foreigners
Foreign Firms Proportion	Ratio of number of foreign-owned firms to total firms
Foreign Equity Share	Ratio of equity holdings by foreign-owned firms over total firm equity
Foreign Workers Share	Ratio of foreign firms' employee to total employees
Firm-level variables	
Female Owned	=1 if at least one principal owner is female
Small	=1 if the firm has 5-19 employees
Medium	=1 if the firm has 20-99 employees
Sole Proprietorship	=1 if the firm is owned by 1 person
Publicly Traded	=1 for shareholding firm with share trade in the stock market
Private or Non-traded	=1 for shareholding firm with non-share trade in the stock market
Technological Capacity	=1 if the firm has a website
Financial Transparency	=1 if the firm's annual financial statements were audited
Country-level variables	
Inflation	Inflation rate [*WDI*]
Financial Development	Ratio of private credit to GDP [*WD*I]
Legal System	Protection of property rights index, 0 (weakest) to 10 (strongest) [WDI]

Note: Unless specified in brackets, all the variables are obtained from the World Bank Enterprise Survey. *WDI* is short for World Development Indicators. *AREAER* is short for Annual Report on Exchange Arrangements and Exchange Restrictions (from the IMF).

Table D3: Descriptive Statistics

	Mean	Std. dev.	Minimum	Maximum
Financial Constraint	2.00	1.51	0	4
Foreign Ownership	0.19	0.39	0	1
Foreign Firms Proportion	0.18	0.17	0	1
Foreign Equity Share	0.19	0.17	0	1
Foreign Workers Share	0.33	0.24	0	1
Female Ownership	0.29	0.45	0	1
Small (0-19 Workers)	0.63	0.48	0	1
Medium (20-99 Workers)	0.26	0.44	0	1
Large (over 99 Workers)	0.10	0.30	0	1
Sole Proprietorship	0.5	0.5	0	1
Public Traded	0.02	0.15	0	1
Private or Non-traded	0.31	0.46	0	1
Technological Capacity	0.2	0.40	0	1
Financial Transparency	0.47	0.50	0	1
Inflation	8.2	4.2	2.05	19.57
Financial Development	38	48.7	5.08	182.62
Legal system	5.25	2.60	2.00	10.00

Chapter 7

Conclusion Remarks

This thesis has comprehensively examined the effect of market reform and natural trade barriers–landlockedness– on international trade and firm performance in developing countries.

In Chapter 2, we find that the introduction of a Commodity Exchange has a large positive effect on coffee export in Ethiopia. In Chapter 3 , we find that an increase in trade cost due to landlockedness has substantial negative effect on trade in Ethiopia. Specifically, we find that landlockedness on average reduces export of coffee, leather, crude vegetable and hide & skin by about 43%, 49%, 80% and 72%, respectively. In addition, landlockedness has a strong negative effect on different ocean-borne import goods of Ethiopia. For example, landlockedness reduces the import of petroleum, fuel and fertilizer by 71%, 68.6% and 66.9%, respectively. For a developing economy that highly depends on agriculture, 68.6% reduction in fertilizer import, for instance, has an important implication on the productivity of the sector.

In chapter 4, we find that landlockedness reduce productivity of manufacturing firms. We hypothesize that if productivity losses from landlockedness are due to reduction in imported inputs, We would expect that importing firms would suffer the largest loss from this direct effect. Consistent with our hypothesis, we find that importing firm suffer a higher productivity loss compared to nonimporting firms. In chapter 5, we document that the role that genetic distance plays as a barrier to technology adoption and productivity of manufacturing firms. We find that firms operating in a country that are genetically far from the technology leader tend to have lower levels of productivity. However, the effect of genetic distance varies largely across the quantiles of firms' productivity, with the the largest negative impact observed at the higher quantiles. These findings indicate that cultural barriers to the diffusion of technology across countries impact firm-level productivity through firms' ability to adopt technologies from the frontier.

In chapter 6, we find that in industries with a larger foreign firm presence , domestic firms tend to be less financially constrained . In addition, we find that foreign-owned firms are not only less financially constrained, they are also less likely to borrow from banks. Moreover, where foreign firm presence is larger, domestic firms tend to have greater success in securing a bank loan. Therefore, one plausible explanation for our conclusion is that foreign firm presence reduces the competition for bank credit, which helps to improve the access to finance for domestic firms.

The finding in this dissertation suggest that landlocked developing countries are at a significant economic disadvantage due to high trade cost and dependent on other country's transit. Landlocked countries' limited integration into the global economy not only reduce their export and import but also hamper technology diffusion and productivity spill over from advanced economies. These subsequently reduce firm-level productivity. For Landlocked countries to increase their participation into global trade, they should better modernize their markets and attract foreign-owned firms. The establishment of commodity exchanges, for instance, the ECX shows that moder agricultural market made possible to increase export revenue in developing country.