

The United States - Colombia Free Trade Agreement: Beneficial for Colombian firms?

Analysis investigating the impact on firm dynamics of Colombian exporting firms

Evelien Van Depoele

R0804587

Thesis submitted to obtain the degree of
MASTER OF BUSINESS ENGINEERING
Industry, Technology and Globalization

Promotor: Prof. Dr. Hylke Vandenbussche

Supervisor: Serena Chellini

Academic year 2023-2024

The United States - Colombia Free Trade agreement: Beneficial for Colombian firms?

Analysis investigating the impact on firm dynamics of Colombian exporting firms

This dissertation investigates the impact of the United States - Colombia Free Trade Agreement (May 15th, 2012) on the export performance, product innovativeness and entry-exit rates of Colombian firms active in the US export market. Two different analyses have been conducted using a comprehensive dataset spanning from 2008 to 2016, covering 715,157 observations and employing three quantitative econometric techniques (Difference-in-Difference Estimator, Propensity Score Matching and Synthetic Control Method). The main analysis, on firm-product level, a rather novel approach, reveals significant negative average results for both export performance (measured in terms of export sales and product portfolio) and product innovation. Colombian firms exporting to the United States experience on average a decline of 10.9% in export sales, a 3.6% reduction in their product portfolio and introduce 0.13 fewer products in comparison to the situation where they benefited from the unilateral ATPA/ATPDEA agreement. While some non-fuel-related industries and small-sized companies benefit from the implementation of the agreement, the majority of medium-sized firms experience a negative impact. The secondary analysis, on country-level, whilst not being conclusive, indicates that Colombian firms were overall stimulated to enter the US export market. However, this trend was particularly driven by the high entry rates of the smallest firms. In general, the results underscore asymmetries in the FTA. This research contributes to understanding the impact of trade agreements on firm dynamics, highlighting sectoral and firm-size variations in response to trade liberalization and indicates that FTAs do not necessarily lead to average positive impacts on firm dynamics for both parties.

Acknowledgments

The author wishes to thank Hylke Vandenbussche for providing the opportunity to delve into this interesting topic and Serena Chellini for the valuable comments, discussions and guidance. Any inaccuracies or errors remain the author's responsibility.

Table of Contents¹

General Introduction.....	4
1 General Literature Review	7
1.1 <i>Introduction to Free Trade Agreements</i>	7
1.2 <i>Impact of Trade Liberalization on Firm Dynamics</i>	9
1.2.1 <i>Productivity, Entry-Exit Rates and Export Performance</i>	9
1.2.2 <i>Input Liberalization Effects</i>	10
1.2.3 <i>Firm Innovation.....</i>	11
1.3 <i>Initial Hypotheses based on Literature Review</i>	13
2 Case Study: Colombia – United States.....	14
2.1 <i>General Colombian Export Trends and Figures.....</i>	14
2.2 <i>Colombia – United States Trade Relations</i>	16
2.2.1 <i>Previous Trade Agreement Colombia – United States</i>	16
2.2.2 <i>United States – Colombia Trade Promotion Agreement (CTPA)</i>	18
2.2.3 <i>Main Export Products</i>	20
3 Theoretical Framework.....	21
3.1 <i>Difference-in-Difference Estimator</i>	21
3.2 <i>Propensity Score Matching.....</i>	25
3.3 <i>Synthetic Control Method</i>	27
4 Data	29
4.1 <i>Firm-Product-Level Dataset.....</i>	29
4.1.1 <i>Description of Relevant Variables</i>	29
4.1.2 <i>Panel Data Analysis</i>	30
4.2 <i>Additional Dataset (Gravity).....</i>	31
5 Empirical Methodology	33
5.1 <i>Firm-Product-Level Analysis.....</i>	34
5.1.1 <i>Dependent Variables.....</i>	34
5.1.2 <i>Difference-in-Difference Estimator</i>	36
5.1.3 <i>Propensity Score Matching</i>	41
5.2 <i>Country-Level Analysis.....</i>	42
5.2.1 <i>Synthetic Control Method</i>	42
6 Results: Firm-Product-Level Analysis.....	45
6.1 <i>Export Sales</i>	45
6.1.1 <i>Regression Results</i>	45
6.1.2 <i>Propensity Score Matching – Matched Control Group.....</i>	46
6.1.3 <i>Assumptions DiD Estimator.....</i>	48
6.2 <i>Product Portfolio</i>	50
6.2.1 <i>Regression Results</i>	50
6.3 <i>Product Innovation.....</i>	51

¹ This document might contain (parts of) texts from earlier submitted documents within the same educational programme, related to the Master's Thesis process of the same author as the author of this work.

6.3.1	Regression Results	51
6.4	<i>Sector and Firm Heterogeneity Analysis</i>	52
6.5	<i>Robustness Checks</i>	54
7	Results: Country-Level Analysis	55
7.1	<i>Entry and Exit Rates: Large Donor Pool SCM</i>	55
7.2	<i>Heterogeneity Analysis</i>	59
7.3	<i>Robustness Checks</i>	60
7.4	<i>Synthetic Control Model: Smaller Donor Pool</i>	61
8	Discussion	62
9	General Conclusion	67
	References	69
	List of Figures	77
	List of Tables	78
	Appendices	79

General Introduction

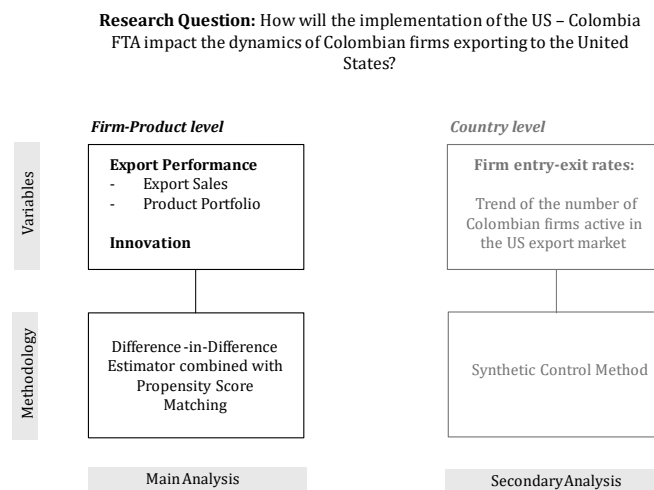
Free trade has become increasingly prevalent as of the 1990s, with a significant rise in the number of Free Trade Agreements (FTAs) concluded in the 20th and 21st centuries (World Trade Organization, n.d.). Whilst there are rising geopolitical and environmental concerns around FTAs, economists widely celebrate the effect of these agreements and numerous studies have underscored their positive economic impacts. Since much attention has been devoted to the macroeconomic dynamics and trade flows influenced by FTAs, this dissertation seeks to delve deeper and examine their effect on firm dynamics.

Several studies have already investigated the trade liberalization impact on firm growth and productivity levels (Tybout, 2000), while innovation is also considered as an important contributing factor for welfare and growth according to Grossman and Helpman (1991). This dissertation will therefore focus on and include a broader range of aspects to investigate the impact of an FTA on firm dynamics. The main analysis will investigate the impact of firms' export performance and innovation, whereas the secondary analysis will examine the impact on firm entry-exit rates in the export market.

Firstly, in the main analysis, firms' export performance, including export sales and product portfolio, and innovation will be investigated on a firm-product level. Over the last decade, research and studies have mostly focused on firm-level analysis and heterogeneity when analysing globalization implications (Bas, 2012; Fan, Lai and Qi, 2019; Melitz, 2003; Shu and Steinwender, 2019). However, a more recent extension to this literature also integrates heterogeneity at product level, besides the firm-level analysis (Görg, Kneller and Muraközy, 2012). Especially in a context where the existence of multi-product firms prevails, these different products should be taken into account to accurately assess firm-level outcome variables (Bernard, Redding and Schott, 2006; Dhyne, Petrin, Smeets and Warzynski, 2017). Working on the firm-product level allows for a more nuanced understanding of economic and trade dynamics within a firm, offering more granular insights that are not visible when analysing firms at a more aggregated level.

Secondly, the additional analysis will aggregate firm entry and exit rates at a country level to investigate the number of firms active in a certain export market and their trends.

Moreover, this research study will employ a case study to investigate the effect of the implementation of an FTA on firm dynamics. The case study utilized will cover the United States (US) – Colombia Free Trade Agreement, an interesting treaty given the Colombian export market characteristics, their high trade dependency on the United States and the existence of a previously defined unilateral trade agreement between the Andean countries (of which Colombia made part) and the United States. This dissertation aims to analyse the impact of the US-Colombia FTA on the dynamics of Colombian firms exporting to the United States, more specifically the impact on their export performance (including export sales and product portfolio), innovation and entry and exit dynamics, approached by the trend of the number of Colombian firms active in the US export market. The illustration below shows a comprehensive overview of the research question, variables of interest (main and secondary) and the corresponding econometric techniques employed.



This research question will be examined through quantitative econometric analyses conducted in STATA, employing the Difference-in-Difference Estimator combined with Propensity Score Matching on the firm-product level, while using the Synthetic Control Model for the secondary analysis on country level. The employed dataset in this dissertation spans 9 years from 2008 to 2016 and covers 715,157 observations, of which 33,628 distinct firm-product-destination combinations. The use of panel

data-specific models, allowed by the sample size and structure, will control for entity-specific effects. The dataset will be aggregated on a country level and complemented with additional variables for the secondary analysis.

This dissertation is structured as follows. The first section comprises a literature review, offering an overview of existing research, studies and documentation related to the general research question, whereas the second section provides some background information tailored towards the Colombia – United States case study. Furthermore, the third section presents a theoretical framework encompassing the rationale behind the Difference-in-Difference Estimator, Propensity Score Matching and the Synthetic Control Method. Following this, the fourth section includes a data part outlining the sources, variables and corresponding summary statistics of the employed dataset. Subsequently, the theoretical models first described will be applied to the research question and the dependent variables identified, for both the main and secondary analyses (section five). Sections six and seven present the results obtained from the STATA software for both analyses, which will be discussed in section eight, complemented by some limitations and potential future research areas. Lastly, the conclusion offers a summary of the key insights derived from the research.

1 General Literature Review

1.1 Introduction to Free Trade Agreements

The European Commission (2019) defined Free Trade Agreements (FTAs) as treaties that lower the trade restrictions for goods and services between two or more nations by removing or cutting tariff and non-tariff barriers. More broadly, they can also include provisions on customs cooperation, intellectual property rights, labour standards, investment and other areas. The countries signing these agreements provide each other with benefits and preferences in terms of market access and lower trade barriers, resulting in an increased volume of trade and consequently higher countries' trade revenues (Gurtu, Johnny and Chowdhary, 2022). The primary goal of an FTA is to strengthen economic relationships between the nations involved and their domestic economies (Haq, Saeed and Akram, 2021).

The expansion of FTAs has caught the attention of many policymakers and economists and is often discussed in debates, where the different views on the implications and consequences of free trade are often discussed (Haq et al., 2021). Proponents of Free Trade Agreements, on the one hand, claim that FTAs lead to increased international trade (thanks to the reduction or elimination of trade barriers) and thus to the following advantages (also discussed by David Ricardo (1817)). Firstly, from the perspective of the customers, they claim that free trade fosters competition, with resources being offered at the most competitive prices (partly thanks to specialization correlated with comparative advantage), leading to decreased prices for finished goods. Free trade will thus result in reduced global prices and will enable consumers to access the most affordable goods available worldwide. This will in turn ultimately increase the purchasing power of consumers overall (Ricardo, 1817; Rodrik, 2018). Secondly, from a macro-economic level, economists also argue that FTAs stimulate the liberalization of global trade and indicate that Free Trade Agreements intensify competition and policy cooperation among the participating nations and reduce costs, which consequently expands trade among them and creates a more dynamic business climate (Haq et al., 2021; Keuschnigg, Kohler, Casella and Sapir, 1996; Sarker and Jayasinghe, 2007). Lastly, proponents do not fail to point out that Free Trade Agreements can foster the development and growth of nations through the

stimulation of foreign direct investment and the corresponding technological diffusion (Fox, 2004; Haq et al., 2021; Ping and Shuai, 2011). Domestic companies, engaged in trade, are enabled to access the newest technologies from their global and multinational partners, leading to increased job opportunities as local economies are growing.

Opponents, on the other hand, argue that FTAs are not advantageous for every aspect and address some limitations. First of all, some researchers such as Stoyanov and Yildiz (2015) argue that regional integration can potentially substitute multilateralism, hampering the liberalization of global trade. Secondly, trade diversion, a phenomenon that occurs when FTAs cause imports to shift from low-cost countries (not in the agreement) to higher-cost trading partners (in the agreement), is often seen as a significant shortcoming of trade agreements and blocs (Dai, Yotov and Zylkin, 2014; Lee, Koo and Park, 2008). However, some research has challenged the traditional view of trade diversion in FTAs, which is often welfare-decreasing and argues that trade diversion can, in some circumstances, enhance welfare for both the diverting nation and the world (Wonnacott, 1996). Thirdly, critics argue that FTAs can potentially lead to intellectual property theft, displacement of domestic industries, increased job outsourcing and deteriorating working conditions if multinational firms take over in less-developed, low-wage and poorly regulated developing countries (Antons and Hilty, 2015; Burtless, 2001; Owen, 2017; Zhang and Wan, 2017). This is in line and complemented with the statement of other economists such as Paul De Grauwe (2016) who argues that, although free trade has proven to be very advantageous, it encounters some limitations as it may create a highly unequal distribution of the gains and costs of free trade, creating winners and losers, that should be compensated. Furthermore, he also acknowledges that, while specialization and extended value chains offer significant advantages, they also come with drawbacks. These practices heavily promote the shipping and transportation of goods worldwide, resulting in substantial environmental costs. As these costs are often not reflected in the final price of goods, the production and consumption of inexpensive products with a high environmental toll is stimulated.

1.2 Impact of Trade Liberalization on Firm Dynamics

This dissertation will not analyse the macro-economic impact of FTAs on country or trade-bloc level but will focus on firm dynamics and how these are affected by trade liberalization. The firm dynamics of interest are a firm's export performance, innovation and entry-and exit rates. Before diving deeper into the specific case study, the literature in the subsection below will provide some more general information.

The first part of this subsection will delve deeper into the general impact of trade liberalization on export performance and entry and exit rates, closely interlinked to productivity. Furthermore, the second part is devoted to the specific impact of input liberalization on these variables of interest, a domain that has already been extensively researched, whereas the last part will shed light on the impact of trade liberalization on the innovative and technological capabilities of the firms of interest.

1.2.1 Productivity, Entry-Exit Rates and Export Performance

Several researchers (Bernard, Eaton, Jensen and Kortum, 2003; Gu, Sawchuck and Whewell, 2003; Mao and Sheng, 2017) have proven that trade liberalization enhances the likelihood of entry for the more productive firms and the likelihood of exit for the least productive ones in the export market. These fundamental intra-industry effects of trade liberalization have been empirically analysed by Melitz (2003), who formulated a dynamic industry model with heterogeneous firms. He argues that trade liberalization stimulates the export market entry for the most productive companies, while less productive ones can continue to produce domestically and the least productive firms will even leave the market completely. This conclusion is underpinned by the idea that more productive and efficient firms generate greater revenues, making it profitable for them to pay the fixed costs required to enter the export market (differences in entry rates are also influenced by heterogeneous firm characteristics). Melitz also demonstrates that further exposure to trade can result in additional inter-firm allocations toward more efficient firms, which generates sector productivity growth, leading to an overall welfare gain. These intra-reallocations toward more efficient companies might explain why trade can offer productivity benefits without necessarily enhancing the efficiency of individual companies.

Furthermore, Bustos (2011) demonstrates that the decrease in Brazil's tariffs significantly impacted the export sales of Argentinian companies, with a 24 percentage point reduction in tariffs causing an increase in export sales by 0.68 to 0.84 log points. Bustos also states that active participation in export activities after the reduction of its trading partner tariffs spurs companies to implement measures that drive productivity improvements. This supports the finding that trade liberalization positively impacts firm-level performance and contributes to overall economic growth.

1.2.2 Input Liberalization Effects

More specifically for input liberalization, Amiti and Konings (2007) show that cheaper imported inputs can enhance companies' productivity via quality effects, variety and learning. The researchers came to the conclusion that a 10 percentage point decrease in input tariffs resulted in a productivity gain of 12 percent for companies that import their inputs, which is two times as high as compared to benefits from output tariff reductions (based on plant-level Indonesian data from 1991 to 2001). This part (1.2.2) will therefore investigate the specific impact of input liberalization on a firm's export performance and a company's decision to participate in the export market.

Other empirical studies have investigated the correlation between productivity gains and imported intermediate goods and concluded that input liberalization impacts company performance through three primary channels (Amiti and Konings, 2007; Bas and Strauss-Kahn, 2014; Halpern, Koren and Szeidl, 2009; Kasahara and Rodrigue, 2008).

First of all, input liberalization leads to a reduction in production factor costs, which consequently results in lower production costs and therefore enables companies, previously unable to be active on the export market, to afford the fixed costs associated with exporting (Bas, 2012). The second mechanism focuses on the increased availability of new imported input varieties (Goldberg, Khandelwal, Pavcnik and Topalova, 2010; Klenow and Rodriguez-Clare, 1997). Bas and Strauss-Kahn (2014) also found a notable effect of the expanded number of imported input varieties and higher diversification on both firms' Total Factor Productivity (TFP) and the amount of exported varieties. Lastly, input liberalization additionally enhances

access to inputs that are of higher quality than the domestic intermediate inputs, which affects company performance. Kugler and Verhoogen (2009) demonstrate that, based on firm-product level data from Colombia, the presence of high-quality intermediate products, only available after trade liberalization, enables companies to manufacture products of sufficiently high quality to access the export market, therefore stimulating their export market entry and presence. Furthermore, firms that are able to import higher-quality goods after trade liberalization can become more productive and gain a technological advantage.

Based on this literature research, Bas (2012) states that a 10 percentage-point reduction in input tariffs is expected to generate a 6 percent rise in the probability of exporting for an average company and that there occurs a positive correlation between firms' export-sales shares and input-tariff liberalization. In terms of export sales, he concluded that a 10 percentage-point decrease in input tariffs generates a 3 percent increase of export shares for an average company and a rise of 5 percent for an average firm that was initially not exporting. This latter finding is supported by the reasoning that input-trade liberalization enhances export profitability and therefore allows more firms to become exporters. Consistent with this, other research has concluded that when the fixed costs related to exporting are sufficiently high, a reduction in input tariffs positively impacts the probability of exporting, resulting in a growth in export sales of all exporting companies, but mostly benefiting the most productive ones (Chevassus-Lozza, Gaigné and Le Mener, 2013). However, on the contrary, in the case where fixed export costs are minimal, lower input tariffs will trigger the exit of the least productive firms from foreign markets, facilitating a rise in export sales of the high-productivity companies.

1.2.3 Firm Innovation

Diving deeper into firm innovation, literature reviews investigating the effect of trade liberalization on firm innovation often also consider productivity changes since these concepts are closely related. Productivity reflects the efficiency of processes related to production, whereas innovation drives and incubates changes in efficiency (Shu and Steinwender, 2019). While it is important to note that innovation does not necessarily always directly translate into productivity improvements, it is an important factor to consider (Hall, 2011; Syverson, 2011).

In order to have a comprehensive overview of the effect of trade liberalization on a firm's incentive to innovate, it is interesting to break down the different impacted fields. Trade liberalization may result in increased competition from foreign companies entering domestic markets and in expanded access to foreign markets. This can lead to both import competition and export opportunities for domestic companies in the output market, as well as competition from foreign inputs in the input market and access to imported intermediate products or materials (Shu and Steinwender, 2019).

The literature review indicates that, on the one hand, a firm's incentive to innovate might be decreased by import competition since there is a possibility that there are fewer rents that could be captured from innovating (Schumpeter, 1942). On the other hand, the increased import competition might also encourage firms to innovate in order to escape this competition and outplay their competitors (Arrow, 1962). Furthermore, it could also result in a reduction of managerial slack and redeployment of factors within the firm (Martin, 1978). Contrary to import competition, firm innovation and productivity across different nations are positively impacted by the improved availability of imported intermediates and export opportunities (Shu and Steinwender, 2019). This could be explained by the fact that the benefits that a firm could gain from innovating amplify since the size of the potential market increases. However, an important note to make is that this increased market size could lead to more market entry and thus increased competition in the domestic output market (Aghion, Bergeaud, Lequien and Melitz, 2017). To conclude, most literature research shows that trade has a positive impact on a company's productivity and innovation levels (Shu and Steinwender, 2019).

Complementary to the findings described above, Bustos (2011) suggests that when export and technology decisions are considered together, the increased revenue from trade liberalization can incentivize exporting firms to upgrade their technological capabilities. According to Bustos's model, the productivity thresholds for entering the export market and implementing new technologies drop more for Argentinian firms in sectors where Brazil's tariffs decrease more substantially. Moreover, a 24 percentage point decrease in Brazil's tariffs incentivized companies in the third quartile of the firm size distribution to enhance their technology expenses by 0.5 log points on average.

Research also points out that lower trading partner's tariffs increase profit margins and opportunities to learn about new production processes, new product designs, new organizational methods and new materials and technologies and hence stimulate innovation (Coe and Helpman, 1995; Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991). These findings are also supported by previous research stating that a decrease in trade costs helps to increase the share of firms in the export market that utilize technology that is characterized as the most advanced (Yeaple, 2005). Additionally, Lileeva and Trefler (2010) also demonstrate that Canadian firms that were encouraged to increase their export sales due to lower US tariffs were stimulated to engage to a greater extent in product innovation and adopt more advanced manufacturing technologies. Enhanced entry into foreign markets will consequently encourage companies to engage in exporting and investing to boost productivity. Furthermore, Grossman and Helpman (1991) and Westphal (2002) state that exporting companies may contribute to the absorption of foreign technologies through the provision of expertise or blueprints by their buyers as well as by monitoring international market trends.

1.3 Initial Hypotheses based on Literature Review

Based on this literature review, several hypotheses related to the research question could be stated.

Hypothesis 1: Encouraged by increased market access to the United States, Colombian firms impacted by the US-Colombia Free Trade Agreement will increase their export sales and improve their export performance.

Hypothesis 2: Colombian firms exporting to the United States will innovate to a greater extent thanks to the implementation of the US- Colombia FTA.

Hypothesis 3: The implementation of the US-Colombia Free Trade Agreement will stimulate the most productive companies to enter or remain active in the export market, whereas the least productive ones will experience higher exit rates due to the inter-allocation of resources to the most productive firms.

2 Case Study: Colombia – United States

2.1 General Colombian Export Trends and Figures

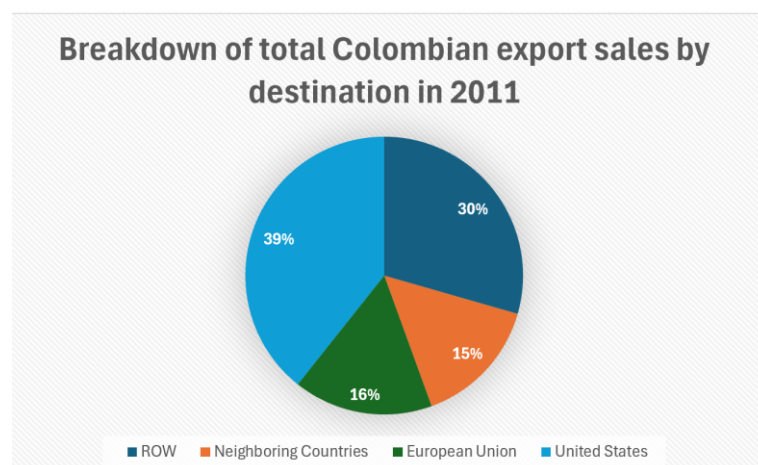
This dissertation will employ a case study to analyse the impact of trade liberalization on firm dynamics based on data from Colombian exporting firms. Before conducting further analysis and investigating Colombia's trade dynamics, it is important to consider that the Colombian export market has some notable characteristics. Research has shown that in a normal year, almost half of all Colombian exporting firms were not exporting in the previous year (Eaton, Eslava, Kugler and Tybout, 2007). Since most of these exporters have a relatively small contribution to export revenues compared to the existing exporters and have to leave the export market the year after, the Colombian export market is dominated by a few very large and stable exporters. However, the few new Colombian exporters that can survive during their first year tend to grow rapidly for multiple years and later even account for almost 50% of the total expansion in trade of goods over the period of a decade.

Diving deeper into the products mostly exported by firms active in the Colombian export market, data analysis by the author illustrates that the main export products in terms of export sales value worldwide between 2008 and 2016 consist of crude petroleum oils and crude oils obtained from bituminous minerals (43.93%), non-agglomerated bituminous coal (14.79%), unroasted and caffeinated coffee (5.51%), non-monetary unwrought gold (4.44%) and ferronickel alloy (1.81%). These figures underscore the substantial reliance of Colombian exports on the fuel industry, characterized as a commodity good whose prices are susceptible to global economic uncertainties (Karabulut, Bilgin and Doker, 2020). Furthermore, Abreo, Bustillo and Rodriguez (2022) state that instability caused by external shocks can result in a diminished growth rate for countries that are heavily reliant on commodity production such as Colombia. Therefore, given the reduced reserves of fuel-related products, it is suggested that, apart from trade openness, the Colombian government must develop an effective policy to stimulate non-fuel exports.

Over time, Colombian officials announced their willingness to engage more in international trade relations and both its membership of the General Agreement of Tariffs and Trade (the predecessor of the World Trade Organization) in 1981 and the

Organisation for Economic Cooperation and Development in 2020 as well as its geographic location with direct access to the Pacific and Atlantic ocean, actively stimulated its trade openness and corresponding initiatives (Rémont, 2016). The country concluded several Free Trade Agreements in the 21st century of which two stand out in Colombia's quest for openness, namely the agreements between the United States and the European Union respectively ratified in 2012 and 2013 (World Trade Organization, n.d.). Figure 1 illustrates the substantial share of the trade relations with the United States and European Union, since total combined exports accounted for more than half of Colombian exports in 2011, primarily led by the United States with almost 40%.

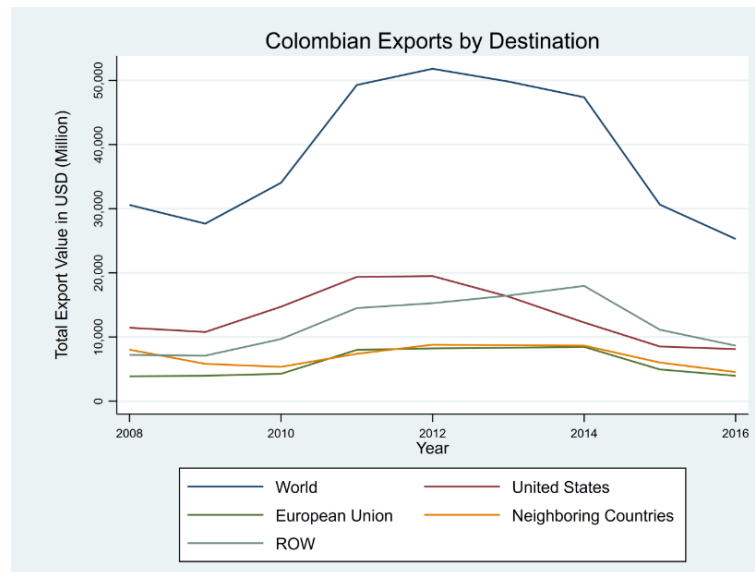
Figure 1: Breakdown of Colombian export sales by destination in 2011



Source: author's calculations

Moreover, Figure 2 illustrates the overall export evolution of Colombian exports in million USD over a period of 9 years (2008 to 2016) to the world market as well as the breakdown for the United States, the European Union, neighbouring countries (namely Panama, Venezuela, Brazil, Ecuador and Peru) and the rest of the world. This graph demonstrates that worldwide export trends are closely aligned to the export patterns with the United States, Colombia's largest trading partner in terms of overall value.

Figure 2: Evolution of Colombian export sales per destination



Source: author's calculations

2.2 Colombia – United States Trade Relations

The focus of this dissertation will therefore be on the United States - Colombia Free Trade Agreement, officially referred to as the 'United States - Colombia Trade Promotion Agreement (CFTA)'. This agreement is a wide-ranging treaty that removes tariffs and other barriers in the trade of goods and services between Colombia and the United States (Office of the United States Trade Representative, n.d.). The agreement includes important provisions related to customs administration and trade facilitation, government procurement, financial services, intellectual property rights, investment and technical barriers to trade. It also contains commitments to protect the environment and labour rights.

2.2.1 Previous Trade Agreement Colombia – United States

Before diving deeper into the FTA, it is important to recall that the United States was already involved in a regional trade preferences program with the Andean countries (Bolivia, Colombia, Ecuador and Peru), named the Andean Trade Preference Act or ATPA (Villarreal, 2011). This agreement was concluded on December 4th, 1991 and was part of a larger US strategy aimed at combatting drug trafficking in Latin America

by shifting the focus from illegal drug trafficking to legitimate economic activities, specifically with the Andean countries. Policymakers expected that enhanced unilateral access to the US market would generate employment and expand lawful economic prospects for workers in the Andean countries within alternative export industries. The United States therefore unilaterally eliminated or lowered tariffs on many import products from the qualifying beneficiary nations that complied with domestic content and other requirements. Even though the Andean Trade Preference Act was initially authorized for 10 years, it was renewed and modified in 2002 under the Andean Trade Promotion and Drug Eradication Act (ATPDEA), which expanded trade preferences even more by including additional products that were previously not included (such as certain textiles and apparel products, footwear, petroleum and petroleum products). This renewed agreement has subsequently been extended several times for short-term periods and later replaced, as regards Colombia, by the US-Colombia FTA for Colombia. Important to note that the latter was no longer a unilateral agreement, only benefiting Colombia, but an FTA containing opportunities for increased market access for both sides.

Several analysts investigated the impact on the different parties of the ATPA/ATPDEA agreement. On the one hand, the Colombian Trade Ministry has stated that in 2006, the ATPA/ATPDEA-supported exports to the United States were responsible for maintaining more than 660,000 direct jobs in Colombia (Office of the United States Trade Representative, 2007). The benefits were also observed later in time since Colombia encountered a significant rise of 70% in its export value to the United States from 2006 to 2010 (9.2 to 15.7 billion USD), of which crude petroleum oil, gold and coal constituted the leading US import items in 2010 (Villarreal, 2011). The ATPA/ATPDEA drastically boosted several economic sectors, amongst others the flower industry and textile and apparel industry. Overall, duty-free exports from Colombia specifically accounted for 92.75% of the total value exported to the United States in 2010, of which 65.16% of the exports were covered by ATPA/ ATPDEA, 1.09% by the Generalized System of Preferences (GSP) and the remainder under the most favoured nation principle (33.75%). Generally, it has been argued that the ATPA/ATPDEA agreement positively impacted the Andean Countries by generating thousands of jobs in alternative industries, bolstering investor confidence, diminishing the production of drugs and narcotics and thereby also decreasing organized crime.

Trade effects of the ATPA/ATPDEA agreement were rather minimal for the US economy given the low amount of US-Andean trade relative to its Gross Domestic Product (GDP) (0.1%) (Villarreal, 2011). Critics of the agreement argued that the unilateral agreement was ineffective for the United States and that it forced US producers to compete with lower-cost Andean imports, with displacement effects for the cut flower and asparagus industries amongst others. The lack of trading opportunities for the United States incentivized the US to conclude bilateral trade agreements.

2.2.2 United States – Colombia Trade Promotion Agreement (CTPA)

The bilateral FTA negotiations originated from a broader initiative aimed at establishing a US-Andean FTA in 2004, involving the United States and the Andean countries including Bolivia, Colombia, Ecuador and Peru (Villarreal, 2012). Yet, the multiple rounds of negotiations did not result in an agreement. Nonetheless, the United States persisted in its efforts and carried on with bilateral trade discussions with Colombia. After multiple revisions, the FTA came into force on May 15th, 2012.

On the one hand, proponents of the Free Trade Agreement argued that the agreement would significantly benefit Colombia's economy and align with the nation's broader development goals. The FTA meant a switch from temporary and often changing ATPA conditions to contractual guarantees about the permanency of trade preferences. It was assumed that this switch would enhance economic stability and growth in Colombia by expanding bilateral trade in goods and services, facilitating access to cheaper capital goods, fostering investor confidence and increasing foreign investment (Gracia and Zuleta, 2005; Romero, 2006.; Villarreal, 2012). At the same time, the opportunity to regain lost market share in the Colombian market, particularly in agriculture, was seen as the primary advantage for the United States. Furthermore, The International Trade Commission (ITC) estimated the overall expansion in US exports at more than 1.1 billion USD and a rise of 2.5 billion USD in the GDP of the United States (Office of the United States Trade Representative, n.d.). By establishing bilateral access, the FTA aimed at reducing the previously high tariffs, up to 35 percent, faced by US exporters, hence levelling the playing field and boosting economic opportunities for US workers, manufacturers, farmers and resource suppliers involved in the export business (Relyea, Tejada, Fish and Guha, 2011).

On the other hand, opponents stated that the disparities between the two parties (such as the profound technological differences, the competitive capacity and the size of the two economies) were too big to overcome when switching from a unilateral to a bilateral agreement (Romero, 2006). When the FTA came into force, the United States, the world's second-largest exporter, had a GDP 42 greater and exported 26 times more than Colombia, which only ranked 53rd globally on the export market (Rémont, 2016). More specifically, from a Colombian perspective, it was argued that the FTA presented various challenges such as a limited competitive product range, remaining non-tariff barriers, overwhelming US competitive advantage due to subsidies and technological advantage and a mismatch between the purchasing power of Colombians and the influx of US goods, potentially harming the domestic sectors and worsening poverty and unemployment (Romero, 2006). Especially the agricultural sector was subject to these risks and was therefore given a longer phase-out period in the agreement to make sure that Colombian farms could prepare themselves for the US influence and competition (Villarreal, 2012). From the United States' point of view, resistance to the agreement primarily originated from issues related to violence, labour and human rights in Colombia. To counter these concerns, Colombia initiated an action plan to address and tackle these issues (Romero, 2006; Villarreal, 2012). This commitment ultimately led to the signing of the Colombia Trade Promotion Agreement.

Considering the concerns expressed from the Colombian perspective, the question could arise as to why Colombia concluded the Free Trade Agreement with the United States rather than pursuing the ATPA/ ATPDEA agreement they already had. Therefore, it is important to bear in mind that a negotiator should always consider his/her BATNA or 'Best Alternative to a Negotiated Agreement'. In this case, not signing the FTA would have left Colombia empty-handed since the ATPA/ATPDEA agreement would have come to an end. Losing its trade preferences scheme would have placed Colombia in a weak and disadvantaged export position in comparison with its competitors in other Latin American countries (Hernández, 2014). Not only Latin American competition but also China's rising presence in the textiles and apparel industry would have been strengthened in the United States and would have posed a threat to Colombian products in case both countries would fall under the Most Favoured Nation rates (Schott, 2004). Losing its competitive advantage over other

countries could have meant a drastic closure of some of Colombia's main industries and sectors.

2.2.3 Main Export Products

Table 1 below shows the five main products exported to the United States prior to the agreement, represented by the total sales value of each product in relation to the overall value of exports to the United States during the corresponding time frame. The five most exported products collectively accounted for 88 percent of the total export sales to the United States before 2012, highlighting an exceptionally high dependence on crude oil from petroleum and bituminous minerals.

Table 1: Breakdown of 5 most exported products from Colombia to United States

HS6 product ²	Name	2008-2011 USD million (% of total exports to the United States)
270900	Crude oil from petroleum and bituminous minerals	37,100 (65.88%)
710812	Unwrought gold	4,600 (8.17%)
270112	Bituminous coal	3,630 (6.44%)
090111	Unroasted, decaffeinated coffee	3,140 (5.58 %)
060311	Flowers (Roses)	1,090 (1.93%)

Source: author's calculations

² A comprehensive explanation of the HS6 product classification is available in part 4.1.1

3 Theoretical Framework

This section will give a theoretical framework encompassing the rationale behind the three econometric techniques used in the further analysis, namely the Difference-in-Difference Estimator, Propensity Score Matching and the Synthetic Control Method. A comprehensive rationale will be offered explaining why these econometric techniques are best suited for addressing the research question in the fifth chapter, alongside the application of the techniques to the problem statement.

3.1 Difference-in-Difference Estimator

The Difference-in-Difference (DiD) estimator is a quasi-experimental design technique used to estimate the causal effect of a policy or program (treatment or intervention) (Ashenfelter, 1978; Ashenfelter and Card, 1985; Columbia Mailman School of Public Health, 2023). It models the treatment effect by comparing the variations in outcomes over time between a group that undergoes some intervention (treatment group) and a group that does not, but that would experience the same trends in the absence of the treatment (control group). The actual impact of the treatment is then estimated by comparing the group-specific differences between the groups.

The first difference, the comparison between the pre-and-post outcomes for the treatment group will account for time-invariant factors within that group, while the second difference controls for outside time-varying factors by comparing the before-and-after changes in outcomes for a group that was not affected by the treatment but was subject to the same set of environmental conditions (control group) (Gertler, Martinez, Premand, Rawlings and Vermeersch, 2011). The change in outcomes caused by the intervention can be estimated by calculating the changes within each group (intra-group) and comparing these between the treatment and control groups (inter-group), isolating the effect of time and contributing to its name, the Difference-in-Difference methodology (Figure 3) (Chi, Chang T.I. and Chang K.I. , 2022).

Overall, the DiD technique accounts for any differences between the treatment and control group that are constant over time and it ensures that any time-invariant, but unobserved, variables correlated with the selection decision into the treatment group

and the outcome variable will not influence or bias the estimated effect (Ashenfelter, 1978; Ashenfelter and Card, 1985).

While the Difference-in-Difference method offers valuable insights for causal analysis, its effectiveness hinges on several assumptions. The main assumption, the parallel trends assumption, imposes that the outcomes for the treatment and control group exhibit the same trends in absence of intervention, implying that any variation in the results between groups can be attributed to the intervention itself, rather than to diverging pre-existing trends. (Columbia Mailman School of Public Health, 2023; Dimick and Ryan, 2014; Ryan, Burgess and Dimick, 2015). Complementary to the parallel trends assumption, the common shocks assumption suggests that any external events occurring at the same time or after the initiation of the intervention impact both the treatment and control group equally (Angrist and Pischke, 2009). Therefore, it is crucial that any effects influencing only one of the two groups, besides the estimated intervention effect, do not exist or are controlled for. This underscores the importance of selecting an appropriate control group to ensure accurate estimates. Furthermore, a well-defined starting point for the treatment should be in place given that the effect of the treatment may not be present before the assigned starting date and changes in the behaviour of the treated unit, influencing their pre-treatment outcome and hence indicating the possible anticipation effect of the treatment, should be ruled out (no anticipation assumption) (Harmon, 2022). Lastly, the Stable Unit Value Treatment (SUTVA) assumption states that the outcome for any individual is solely a result of their direct exposure to the treatment and is not influenced by the treatment status of others (Rubin, 1977). This assumption does not allow potential spillover effects, attributing any observed causal effect strictly to the treatment and not to external interferences (Gerber and Green, 2012). The estimation of the causal effect will be biased when the assumptions are violated.

As mentioned above, the effect estimates of policies or programs using DiD can be computed by differencing the means for a given outcome between the treatment and control group in the pre- and post-intervention period. However, to enhance these estimates, regression analysis can be used, which allows for adjustments based on other variables that may vary between groups (Albouy, n.d; Ashenfelter, 1978; Ashenfelter and Card, 1985; Columbia Mailman School of Public Health, 2023). Applying a regression model will determine the statistical significance of the

relationship between the treatment and the outcomes by incorporating a dummy variable to indicate the pre-and post-treatment periods ($Post_t$ equals 1 if the treatment has already taken place and zero otherwise) and another indicator variable to distinguish between the units i affected by the treatment ($Treated_i = 1$) and the control group ($Treated_i = 0$). Statistically, the intervention's impact on outcome variable Y_{it} for every unit i at time t is estimated by examining the interaction between these two dummy variables. A significant interaction term, differing from zero, indicates a statistically significant effect of the intervention on the outcome. (Dimick and Ryan, 2014; Ryan et al., 2015). However, it is important to note that these techniques rely on standard statistical assumptions when employing the DiD method via regression analysis (e.g., Gauss-Markov assumptions for linear regression such as homoscedasticity, normality and no autocorrelation) (Wooldridge, 2009).

A relevant regression equation can be expressed as follows (Albouy, n.d.; Ashenfelter, 1978; Ashenfelter and Card, 1985; Columbia Mailman School of Public Health, 2023):

$$Y_{it} = \beta_0 + \beta_1 Treated_i + \beta_2 Post_t + \beta_3 (Post_t \times Treated_i) + \varepsilon_{it} \quad (1)$$

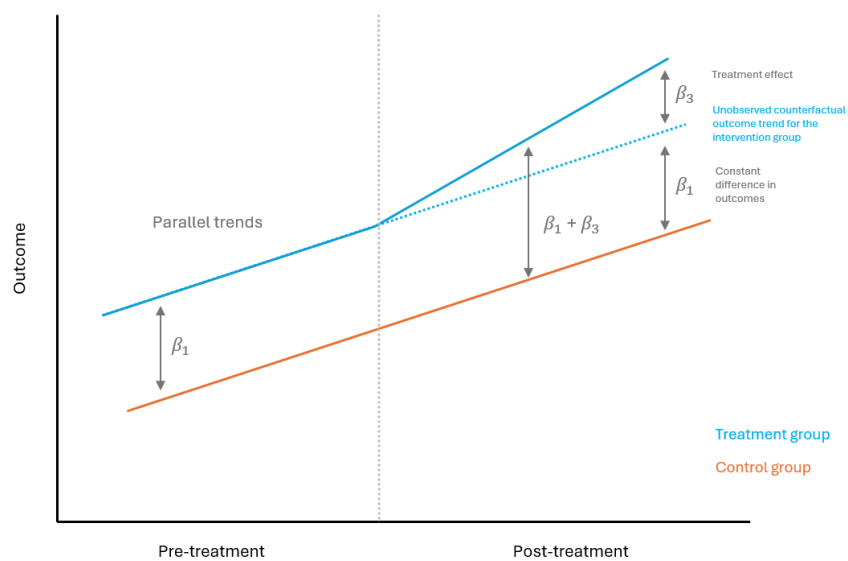
Equation (1), β_0 indicates the common constant for all observations and serves as the baseline average, whereas β_1 controls for the difference between the treatment and control group in the pre-treatment period and therefore looks at treatment group-specific effects. β_2 indicates the time trend of the control group and most importantly, β_3 , also referred to as the Average Treatment Effect of the Treated (ATT), is the coefficient of interest that demonstrates the effect of the intervention on treated units and thus measures the impact of the intervention. ε_{it} in this equation denotes an unobserved error term that is random and covers all parameters of Y_{it} omitted by the model. Table 2 and Figure 3 provide a visual clarification of the model, variables and corresponding coefficients described above.

Table 2: Coefficients of interest in the DiD model

	Pre-Treatment Outcome ($\text{Post}_t = 0$)	Post-Treatment Outcome ($\text{Post}_t = 1$)	Difference
Control units ($\text{Treated}_i = 0$)	β_0	$\beta_0 + \beta_2$	β_2
Treated units ($\text{Treated}_i = 1$)	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_2 + \beta_3$
Difference-in-Difference	β_1	$\beta_1 + \beta_3$	β_3

Figure 3: Graphical representation of coefficients of interest in the DiD model

(Columbia Mailman School of Public Health, 2023)



3.2 Propensity Score Matching

To construct a more accurate control group, Propensity Score Matching will be opted for in this dissertation. Matching methods aim to find a non-treated or a set of non-treated units with the most similar characteristics possible for every treated unit (Gertler et al., 2011). As a result, an artificial control group is constructed of matched non-treated units, serving as the counterfactual. This technique is mostly employed to approximate the effect or impact of a treatment for which randomization is infeasible, as is the case for this research.

More specifically, Propensity Score Matching pairs treated and untreated units based on their estimated likelihood of being subject to the treatment (i.e. propensity score) rather than matching purely on the same outcome values (Rosenbaum and Rubin, 1983). This propensity score is computed as a function of some observable characteristics influencing the likelihood of being subject to the intervention and lies between 0 and 1 (Gertler et al., 2011). Commonly used matching methods that could be used after the propensity score is computed to define the measure of proximity under which untreated units are acceptably close to treated units include nearest neighbour matching, caliper matching and kernel matching (Chi et al., 2022).

The Propensity Score Matching technique is subject to the following assumptions. First of all, the propensity scores of treated and untreated units need to have sufficient overlap so that common support is guaranteed to ensure accurate matching results (Gertler et al., 2011). This assumption assures that every set of characteristics present in the treatment group will be found in the control group as well (Bryson, Dorsett and Purdon, 2002). Secondly, as described above under the SUTVA assumption, the assignment of treatment cannot be influenced by the treatment status of units and thus create spillover effects. Lastly, the conditional independence assumption poses that, conditional on some observed variables or characteristics, the treatment has been fully randomized for the observations (Caliendo and Kopeinig, 2005). This assumption stimulates the effects of random assignment, overcoming issues of selection bias (Gertler et al., 2011). A limitation of this quasi-experimental method is correlated with the fact that it can only take into account observed characteristics when constructing a control group and it therefore has to be assumed that no unobserved discrepancies between the treatment and control group influence the outcome.

Since this last assumption is often hard to impose, a combination of the DiD approach and the PSM method can lower the risk of bias in the estimation, as evidenced by Cabé-Ferret's study (2012). The study observed that using the Difference-in-Difference Estimator with matching offered a better solution than purely employing DiD, which suffered from sample bias selection. This combination of methods will, apart from the observed variables, also control for unobserved characteristics that are time-invariant between both groups. DiD not only complements the Propensity Score Matching (PSM) method but also the other way around. Instead of controlling linearly for the independent parameters in a Difference-in-Difference regression, the combination can more flexibly avoid misspecification errors, makes sure that the comparisons are made in the 'common support' region and ensures a more accurate weighting of covariates (Gebel and Voßemer, 2014).

The estimation of DID with the PSM matching method can be expressed by the following equation (Chi et al., 2022; Gebel and Voßemer, 2014):

$$\frac{1}{n} \sum_{\theta \in I_1 \cap S} \{(Y_{11} - Y_{10}) - \sum_{\lambda \in I_0 \cap S} W(P_\theta, P_\lambda)(Y_{01} - Y_{00})\} \quad (2)$$

Where n denotes the sample size, $(Y_{11} - Y_{10})$ and $(Y_{01} - Y_{00})$ refer to the difference in the outcome variable in post (Y_{11}) - and pre (Y_{i0}) - treatment period for respectively the treatment (Y_{1t}) and control (Y_{0t}) group. Additionally, S is the area of common covariate support, $\theta \in I_1$ indicates that a unit (θ) is part of the treatment group (I_1) and the units that are part of the control group are referred to as $\lambda \in I_0$. The PSM method will assign weights to untreated units that are part of the constructed control group and $W(P_\theta, P_\lambda)$ corresponds to the counterfactual sample weight used in the calculations or the later regression. The weight factor differs for the different matching techniques. However, Smith (2000) states that asymptotically all PSM matching algorithms yield the same outcomes since they all approximately compare only exact matches when the sample size becomes bigger. Nonetheless, in small sample sizes, they could yield different results. Part 5.1.3 will elaborate on the selected matching algorithm employed for this dissertation.

3.3 Synthetic Control Method

In case there is only one treated unit and many untreated ones, the Synthetic Control Model (SCM) can be employed to estimate the effect of a treatment based on a constructed counterfactual, similar to the DiD estimator (Bonander, Humphreys and Degli Esposti, 2021). This method will construct an artificial (i.e. synthetic) control group, by assigning weights to the untreated units, that exhibits similar values for trends in outcomes and predictors prior to the intervention (Gilchrist, Emery, Garoupa and Spruk, 2023). As a result, the effect of the treatment will be captured by the difference in the outcome between the treated unit and its synthetic control group (Abadie, Diamond and Hainmueller, 2010):

$$Y_{it} = Y_{it}^N + \alpha_{it}D_{it} \quad (3)$$

$$Y_{it}^N = \delta_t + \boldsymbol{\vartheta}_t \mathbf{Z}_i + \boldsymbol{\lambda}_t \boldsymbol{\mu}_i + \varepsilon_{it} \quad (4)$$

The method aims to evaluate the effect of an intervention by estimating α_{1t} , representing the treatment effect on the treated unit ($i=1$) in the post-intervention period (Abadie et al., 2010). This estimation can be made by comparing the post-intervention outcome (Y_{1t}) of unit 1 at time t with the counterfactual of what would have happened if the intervention had not taken place (Y_{1t}^N), as expressed in equation (3). Since Y_{1t}^N is unobserved, an estimation should be made, captured by the factor model indicated in equation (4), where δ_t captures common time effects, $\mathbf{Z}_i$ denotes a vector of observed covariates that are not affected by the treatment whereas $\boldsymbol{\mu}_i$ covers the permanent unobserved variables. Lastly, ε_{it} refers to the unobserved temporary shocks at the unit level with zero mean.

To synthesize a control group that simulates what would have occurred in the absence of the treatment, a vector of weights $W = (w_2, \dots, w_{J+1})'$ with each weight w_j being non-negative, including all control units under J (from 2 to $J+1$) and the sum of all weights adding up to 1, is constructed. Each value of W corresponds to a weighted average of control units, representing a synthetic control. The outcome variable for a synthetic control is calculated as follows (Abadie et al., 2010):

$$\sum_{j=2}^{J+1} \omega_j Y_{jt} = \delta_t + \boldsymbol{\vartheta}_t \sum_{j=2}^{J+1} \omega_j \mathbf{Z}_j + \boldsymbol{\lambda}_t \sum_{j=2}^{J+1} \omega_j \boldsymbol{\mu}_j + \sum_{j=2}^{J+1} \omega_j \varepsilon_{jt} \quad (5)$$

An optimal vector $w^* = (w_2^*, \dots, w_{J+1}^*)$ will be found that minimizes the difference in pre-treatment characteristics, including values of the outcome variable and the observed auxiliary covariates over the pre-intervention period, between the treated and the synthetic unit. These optimal weights will enable the estimation of the treatment effect for post-treatment periods, expressed by equation (6) (Abadie et al., 2010):

$$\hat{a}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} \omega_j^* Y_{jt} \quad (6)$$

The distinction between SCM and DiD lies in the fact that the DiD model accounts for unobserved confounding variables, assuming their impact constant over time, and hence enabling their effects to be removed by time differences (Adabie et al., 2010). However, the extended factor model described in equation (4) allows time-varying effects of these unobserved confounders, recognizing that these variables can change over time and still delivering unbiased estimators. However, in terms of assumptions, there is some overlap. Similarly to the DiD estimator, the SUTVA and no-anticipation assumption must hold to ensure non-biased results (Adabie, 2021). Moreover, post-intervention effects significantly affecting only the control group or the treatment group should be eliminated. Additionally, the auxiliary covariates, hence observable characteristics, must be chosen thoroughly to ensure the construction of an accurate synthetic control unit, which may only contain donor pool units with similar values of the defined characteristics. Overall, besides accounting for time-varying unobservable confounders, the synthetic control model allows for a transparent construction of the artificial control group and safeguards against extrapolation since the weights are required to be positive and add up to one (Adabie et al., 2010; Billmeier and Nannicini, 2013).

4 Data

The ‘Data’ section is the first part of the Empirical Study and it outlines the datasets employed for both the firm-product and country-level analyses, including the relevant variables and their descriptive statistics.

4.1 Firm-Product-Level Dataset

The dataset employed in this dissertation was retrieved from the Colombian Statistics Department managed by the Directorate of Methodology and Statistical Production (DIMPE) under the Administrative Department of National Statistics (DANE). The obtained data records the legal export of goods originating from Colombia, documented every month, but aggregated on a yearly level in the employed dataset (Dirección de Metodología y Producción Estadística – DIMPE, 2024). The collapsed dataset, which encompasses a total of 715,157 observations, lists the export sales value from a product exported by a Colombian firm in a given year to a given destination.

4.1.1 Description of Relevant Variables

The dataset covers 5 distinct variables. First, the country of destination and its corresponding destination code are covered and documented. The destination country corresponds to the final intended country where the goods and products were delivered (Dirección de Metodología y Producción Estadística – DIMPE, 2024). The dataset covers 216 unique destination countries, with the United States and Venezuela being the most frequently occurring destinations during the specified period, respectively comprising 9.85% and 9.16% of the total number of observations. The time aspect of the data is denoted by the variable ‘year’, which spans from 2008 to 2016. Thirdly, the variable ‘firm-code’, a 9-digit numeric code, identifies the specific Colombian exporting firm involved in each observation. In total, 12,675 distinct firms are participating in Colombia’s export market during the timeframe covered.

Furthermore, export products are classified under the World Customs Organization’s (WCO) Harmonised Commodity and Coding System, shortly the Harmonized System (HS). This system provides a standardized numerical method that is commonly used to classify traded goods and supports customs authorities worldwide in identifying products when gathering statistics and evaluating taxes and duties (International

Trade Administration, n.d.). It therefore allows economic operators, legislators and customs from any country to identify the same products by using this numeric code (European Commission, n.d.). Generally, codes featuring a low number of digits represent broad categories of products, while supplementary digits specify more precise definitions within those categories (WTO, n.d.). More specifically, there are 21 sections, divided into 97 chapters (HS2 or 2-digit code), further expanded into headings or HS4, and lastly broken down to the six-digit / HS6 level or the subheadings (almost 5000 commodity groups) (European Commission, n.d.). The six-digit codes (HS6) offer the most detailed standard classifications and will therefore be focused on in this dissertation, complemented by the sector or HS2 level. In the employed dataset, 4,139 distinct products on the HS6 level are included, covered by 96 chapters or sectors on the HS2 level. Countries can even add additional digits to these codes to further specify the definitions for meeting specific requirements, but this will be out of the scope of this dissertation.

Lastly, the FOB DOL or Free On Board (FOB) value expressed in US Dollars refers to the sale price of the exported products and encompasses all the expenses up to the point where the goods are loaded into the transportation vehicle (Dirección de Metodología y Producción Estadística – DIMPE, 2024). The value and costs of insurance and freight are hereby not taken into account. The values expressed in US Dollars (USD) enable comparison across different countries over time, serving as an international benchmark. The USD value was calculated based on the usage of the average market exchange rate, corresponding to the month of analysis. The average FOB value over the 715,157 observations in the dataset is 484,502 USD with a standard deviation of 2.4×10^7 and ranges from 0.01 USD to 9.57×10^9 USD.

4.1.2 Panel Data Analysis

The observations in the dataset have a cross-sectional dimension, complemented by a time series dimension, which is called panel data. The use of panel data exhibits several benefits in comparison to solely time-series or cross-sectional data (Hsiao, 2007). Panel data introduces more sample variability, more degrees of freedom and less collinearity among independent variables, resulting in an increased efficiency of econometric estimates.

The employed panel dataset in this dissertation covers 715,157 observations and 33,628 distinct firm-product-destination entities. However, since half of the data is observed for one year, possibly due to the characteristics of the Colombian export

market, not all firms have information for every year and product, resulting in an unbalanced panel dataset.

4.2 Additional Dataset (Gravity)

Since the secondary analysis will be conducted on a country level, the above-described dataset will be collapsed on an aggregated country level and will be expanded by some additional variables, that can be used as predictors for the Synthetic Control Method.

The Gravity database, retrieved from the Centre for Prospective Studies and International Information (CEPII), covers observations that all correspond to an “origin-destination-year” combination, where data is provided for both exporting and importing countries across different years (Conte, Cotterlaz and Mayer, 2022). The dataset includes a broad range of unilateral and bilateral variables encompassing trade flows, geographic information, cultural ties, trade facilitation and macroeconomic factors, defined for 252 countries over a time period from 1948 to 2019.

It encompasses unilateral variables such as ‘gdpcap_ppp’ expressed in current thousands USD, which measures GDP per capita adjusted for purchasing power parity (PPP), reflecting the economic productivity and standard of living in a country (World Health Organization, n.d.). Each of these countries is uniquely identified by its ISO3 code (Conte et al., 2022). Moreover, the dataset also indicates the historical origin of a country’s legal system before 1991 and stores this information under the ‘legal_old’ variable. Additionally, the variable ‘pop’ covers the number of inhabitants of a country expressed in thousands, offering insights into market sizes and potential consumer bases. Lastly, the ‘wto’ variable highlights the membership of a country in the World Trade Organization, indicating a nation’s position towards trade openness.

These variables are complemented by two additional parameters retrieved from the World Bank DataBank, categorized under World Development Indicators (The World Bank, n.d.). First of all, the ‘Trade (% of GDP)’ parameter represents the combined sum of exports and imports of goods and services, expressed as a percentage of the country’s GDP and covering 193 countries. Secondly, the ‘Liner Shipping connectivity index’ variable demonstrates how well-connected nations are to the global shipping networks, expressed relatively to 2004 with a maximum value of 100 and is included for 167 distinct economies. Both variables are averaged over the 2008-2011 time

period, respectively stored under 'AVGTRADE' and 'SCPRETREAT'. Table 3 below displays a summary table of the included variables with their corresponding number of observations, mean, standard deviation and minimum and maximum value. Important to note that these values are obtained after cleaning and balancing the panel dataset, resulting in a total of 765 observations, covering 85 distinct countries over 9 years (2008-2016).

Table 3: Descriptive Statistics of variables included in the additional dataset

<i>Variable</i>	<i>N</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Minimum</i>	<i>Maximum</i>
Population	765	61,059.09	198539.7	70,883	1,378,665
GDP per capita PPP	765	22.595	20.475	1.16	129.35
AVG trade	765	88.945	60.721	24.018	387.920
SC pretreat	765	29.213	25.550	1.026	124.777

5 Empirical Methodology

This section will first discuss the firm-product analysis (main analysis), investigating both export performance, consisting of export sales and product portfolio, and product innovation. The Difference-in-Difference Estimator provides a well-suited approach to investigate the causal effect of the US-Colombia Free Trade Agreement on both export performance and product innovation. By enabling a comparison before and after the implementation of the FTA (2012), the DiD method leverages the firm-product-destination panel dataset to evaluate changes over time and to make a before and after implementation comparison based on pre-treatment characteristics between the control and treatment group over the 4 pre-treatment years available (as defined under the control variables in part 5.1.2.1). This attributes any differences in the post-treatment trends to the FTA's effect. However, for a more precise definition of the control group, Propensity Score Matching emerges as a logical econometric technique. Given the greater accuracy combining both methods, but also the high number of treated units (firm-product combinations exported to the United States), the dataset provides a large number of untreated units with overlapping matching characteristics.

The second part of this section will elaborate on the country-level analysis, investigating the impact of the FTA on the trend of the number of active Colombian firms in the US export market, as a proxy for firm entry-exit rates. The Synthetic Control Method is better suited for a panel data analysis when there is only one treated unit and an extensive pool of potential control units. Hence, it proves to be a more appropriate approach for the country-level analysis where only the United States is considered as the treated unit and the donor pool is providing many possible control countries. By leveraging panel data covering four pre-treatment and post-treatment years (apart from 2012) and auxiliary covariates to construct a synthetic control country, the method allows for isolating the causal effect of the FTA on the number of Colombian firms active in the US export market.

5.1 Firm-Product-Level Analysis

Over the last decade, research and studies have mostly focused on firm-level analysis and heterogeneity when analysing globalization implications. However, a more recent extension to this literature also integrates heterogeneity at the level of the product, besides the firm-level analysis (Görg et al., 2012). Especially in a context where the existence of multi-product firms prevails, these different products should be taken into account to accurately assess firm-level outcome variables (Bernard et al., 2006; Dhyne et al., 2017). Working on the firm-product level allows for a more nuanced understanding of economic and trade dynamics within a firm, offering more granular insights that are not visible when analysing firms at a more aggregated level. As a result, the main analysis will focus on the firm-product level, considering each firm-product combination as a distinct entity, uniquely differentiated for each export destination. This approach will also consider the unique characteristics specific to each product within a firm, potentially influencing the outcome variables, rather than adopting a more generalized and broader perspective at the firm level alone. Since the analysis is investigating the impact of the FTA on firm dynamics, solely looking at the product level would not be an option either.

5.1.1 Dependent Variables

As expressed in the research question, this dissertation will investigate the effect of the US-Colombia Free Trade Agreement on Colombian firm dynamics. For the firm-product level analysis, both export performance and product innovation will be investigated.

First, to investigate whether Colombian firms have started to export more to the United States after the implementation of the US-Colombia FTA, two different variables will be taken into consideration, namely the total export sales value and the product portfolio. The former illustrates whether a firm has started to export more to the United States in relation to the export sales value of its products and hence captures the total FOB export value per firm-product combination, while the latter indicates whether a firm has decided to export a wider range of products to the United States and is constructed by calculating the number of products a firm is exporting in a given year to a given destination.

Secondly, firm innovation can be proxied by looking at a firm's R&D expenditure, patents and patent applications or total innovation expenditure (Kleinknecht, van

Montfort and Brouwer, 2002). Given the limited variables and data available, another proxy had to be considered when constructing the firm-level innovation variable. Innovation studies propose five key dimensions that encompass a firm's overall innovation strategy, namely process innovation, strategic innovation, behavioural innovation, market innovation and product innovation (Adomako, Amankwah-Amoah and Danso, 2019). Since the overall analysis is done on a firm-product level, product innovation is chosen as the most accurate proxy in this dissertation. Garcia and Calantone (2012) define firm-level product innovativeness as "the propensity for a firm to innovate or develop new products", in line with Laursen and Salter (2006) who define product innovation as "the market introduction of a new product", allowing a firm to differentiate from its competitors and hence gain market shares (Clausen, 2014; Tellis, Prabhy and Chandy, 2009). Important to note is that these definitions are referring to the domestic market but since the available dataset only covers the export market, product innovation in this dissertation is defined as the amount of new distinct products that a firm starts exporting to a given destination in a given year, tailored to exporting firms and hence their innovation degree. A new product in this context is characterized as a product that the firm has not exported before and hence indicates whether a firm decides to integrate additional products into its export portfolio. Overall, in this case, it encompasses the market introduction of a new export product by a firm, including new products exported to existing destinations by a certain firm and new products being exported to destinations the firm was previously not exporting to.

Important to note is the fact that the real relationship between the independent and other variables is often not linear. The log transformation is often used to transform data in case of heteroscedasticity or when the residuals deviate from normality (Curran-Everett, 2018). This transformation can serve as an efficient method for converting variables with significant skewness into a dataset that approximates a normal distribution more closely while reducing data variability and enhancing conformity to the normal distribution. When looking in more detail at the outcome or dependent variables of interest (Appendix A), it becomes clear that export sales and product portfolio both do not have skewness and kurtosis values within the acceptable range of -3 to +3 for skewness and between -10 and + 10 for kurtosis (Brown, 2006), leading to the conclusion that these variables are not normally distributed and heavily influenced by outliers, expressing the need for the log transformation. However, given that the variable product innovation is defined as the

number of new products exported by a certain firm to a certain destination in a certain year, a reference year is necessary to compute the incremental change. The reference year will always be the first year a certain firm-product combination was exported, imposing zeros in that year, being inherent to every firm-product combination. The Poisson Pseudo Maximum Likelihood is a more suitable approach than the traditional log-linear form if many zeros are included in the model (Santos Silva & Tenreyro, 2011) and will therefore be opted for in the regression of product innovation.

5.1.2 Difference-in-Difference Estimator

As mentioned above, further analysis will be conducted on a firm-product level with a corresponding preliminary Difference-in-Difference (DiD) specification:

DiD model export sales:

$$\ln(ExportSales_{ikdt}) = \beta_0 + \beta_1 US_{ikd} + \beta_2 Post_t + \beta_3 (US_{ikd} \times Post_t) + \varepsilon_{ikdt} \quad (7)$$

In this equation, $\ln(ExportSales_{ikdt})$ refers to the log-transformation of the export value of a given product k exported by firm i to destination d in year t . Furthermore, the treatment refers to the implementation of the US-Colombia FTA and firm-product combinations that will be affected by the agreement are indicated with a dummy equal to 1 ($US_{ikd} = 1$), corresponding to products that are exported by firms to the United States. All other firm-product pairs that are not exported to the US get a value of zero ($US_{ikd} = 0$). Since the treatment came into force on May 15th 2012, $Post_t$ equals one if the time period is greater than or equal to 2012 and zero otherwise. The table below (Table 4) shows the number of treated and control observations in both the pre- and post-treatment period.

Table 4: Distribution of observations according to treatment status and period

	Pre- Treatment Period (Post _t = 0)	Post- Treatment Period (Post _t = 1)	Total
Control units (US _{ikd} = 0)	281,900	362,792	644,692
Treated units (US _{ikd} = 1)	30,732	39,733	70,465
Total	312,632	402,525	715,157

Theoretically discussed before, but now applied to this specific case, β_0 is the constant term, β_1 controls for the differences between the treatment (firm-product pairs exported to the US) and the control group and β_2 denotes the time trend for the control group before the treatment took place, so before 2012. Most importantly, when analyzing the actual effect of the implementation of the US-Colombia FTA on the different outcome variables, β_3 is the main coefficient of interest, showing the effect of the interaction between the two identified dummy variables. Finally, ε_{ikdt} denotes a random and unobserved error term.

Even though the specifications for both product portfolio and product innovation will follow a similar structure as the one of export sales, there are some differences. Since both the product portfolio and product innovation variables are constructed based on the number of (new) products a firm is exporting, the product aspect is already captured in the construction of the dependent variable and the product index k will therefore not be included in their general specifications, but will be taken into account when including control variables and fixed effects. Furthermore, to ensure a correct analysis for the Pseudo Poisson Maximum Likelihood estimator, product innovation will be included in its specification as a dependent variable without the log transformation.

5.1.2.1 *Control Variables*

To ensure correct and non-biased results in the further analysis of this dissertation, it is crucial to construct some control variables and add them together with fixed effects in the regression equation.

The effect of the main variables of interest can be isolated more accurately when controlling for potential confounding variables that can affect the relationship between the primary independent parameters and the dependent variable (Lechner, 2010). Additionally, adding covariates can improve the precision of the primary variables' effect estimates and enhance the validity and robustness of the study findings by adjusting for background differences among subjects. Since the main analysis will be held on a firm-product level, the covariates must be also defined on this level.

Linking back to the parallel trends assumption of the Difference-in-Difference method, an important related assumption regarding the covariates in DID estimation imposes that the outcome variable's expectation may not be affected by the treatment status, given the covariates X (exogeneity assumption) (Lechner, 2010). The included covariates X should therefore encompass all variables that might influence divergent time trends between the control and treatment group. Since the possible time-varying covariates that could be constructed based on the available variables will be affected by the treatment, only covariates based on pre-treatment values, and hence, time-invariant will be included. It is still important to note that measuring only variables in the pre-treatment period does not automatically ensure exogeneity because of anticipation behaviour, which should hence be controlled for. In any case, the control variables elaborated on below will be constructed based on pre-treatment values.

First of all, as the literature review has stated, productivity is a very important factor that should be taken into account when explaining potential firm dynamics after trade liberalization. A firm's productivity will not only influence its total export sales, but more productive firms, benefiting from lower export costs, are likely to export a wider array of products, including new ones, as they have a lower consumer taste parameter threshold (Görg et al., 2012). On a firm-level, firm size could be considered as a proxy for productivity since previous research has shown that larger firms are more productive and that economies of scale, management skills etc. enable them to produce in a more efficient way in comparison to smaller companies (e.g., De and Nagaraj, 2014; Schiersch, 2013; Van Biesebroeck, 2005). In analysing firm-product

level data, firm size could be extrapolated to the average size of firm-product combination. Hence, the average size of exporting firms was calculated based on the total export sales value per firm-product combination for the pre-treatment observations. To categorize these firm-product pairings by size, dummy variables were employed based on the firm-product's size relative to the 50th and 95th percentiles. Firm-product combinations below the 50th percentile were designated with a dummy variable of 1 and those with sizes between the 50th and 95th percentiles received a dummy variable of 2. Lastly, the units with a firm size exceeding the 95th percentile were assigned a dummy variable of 3. This categorization was extrapolated to the same firm-product pairs in the post-treatment period as well. Additionally, firm-product combinations that had not been exported prior to 2012 dropped automatically as missing variables, facilitating a nuanced analysis of firm-product size and export behaviour over time and making sure they did not influence or bias the results.

The same approach was applied for the two other covariates, namely firm-product geography and firm-product differentiation, by categorizing on the 50th and 90th percentiles. Firm-product geography captures the average amount of destinations to which a firm-product pair is exported in the pre-treatment period, illustrating how geographically diverged a firm-product pair is in terms of destinations. Araujo, Mion and Ornelas (2016) define a firm's, or firm-product pair's, experience as the number of destinations it is serving, enabling firm-product geography to function as a proxy for experience, influencing export sales and innovation. Furthermore, Kafouros, Buckley, Sharp and Wang (2008) state that internationalization stimulates a firm's capacity to increase performance through innovation. Additionally, it is stated that access to different geographical markets will lead to knowledge spillovers and therefore enhance innovation and the firm's overall performance.

Moreover, firms vary in the diversity of products they export. Hence, the firm-product differentiation covariate refers to how differentiated a firm is in terms of products and captures the average number of distinct products being exported by a firm in the pre-treatment period, highlighting more differentiated firms and their influence on the firm-product pairs they export. Hitt, Hoskisson and Ireland (1994) also stated that the strategic behaviour of companies is impacted by both product and international diversification. Lastly, the sector-level HS2 is also taken into account as a categorical covariate and must be controlled for since some sectors might encounter higher

demand and thus export sales and some require and/ or enable more innovation than others.

To complement the control variables defined, some fixed effects could be added in the specifications. Since multi-product firms are included in the dataset, firm-product fixed effects will more accurately address the unobserved firm-product heterogeneity compared to relying solely on firm fixed effects (Fernandez and Paunov, 2010). These can be controlled for by including the firm-product interaction term (γ_{ik}) as a fixed effect. Additionally, adding the year fixed effect (α_t) and the destination fixed effect (δ_d) will also increase the accuracy of the results since the former will control for any macro-economic or other time-specific effects that are common for all product-firm combinations while the latter will capture the tariff changes that vary across destination countries.

To conclude, the combination of these control variables and fixed effects, ensures that there can be controlled for productivity, performance, sectoral and tariff-related differences.

An updated regression specification for the DiD model with covariates gives the following equation for the export sales for a product k exported by firm i to destination d in year t :

$$\ln(\text{Export Sales}_{ikdt}) = \beta_0 + \beta_1 US_{ikd} + \beta_2 Post_t + \beta_3 (US_{ikd} \times Post_t) + \beta_4 X_{ik} + \alpha_t + \gamma_{ik} + \delta_d + \varepsilon_{ikdt} \quad (8)$$

Furthermore, the product portfolio regression equation is provided by specification (9) for every firm i exporting products to destination d in year t :

$$\ln(\text{Product Portfolio}_{idt}) = \beta_0 + \beta_1 US_{id} + \beta_2 Post_t + \beta_3 (US_{id} \times Post_t) + \beta_4 X_{ik} + \alpha_t + \gamma_{ik} + \delta_d + \varepsilon_{idt} \quad (9)$$

Since, as previously mentioned, many crucial time-varying firm characteristics related to product innovation are not included in the dataset (e.g., R&D expenditure, patent counts, organizational decisions, ownership structure, a firm's competitiveness (Mallinguh, Wasike, Bilan and Zoltan, 2022; Özçelik and Taymaz, 2004)). It is therefore important to include the interaction of firm and time-fixed effects (λ_{ti}) to account for these. Additionally, product (θ_k) and destination fixed effects (δ_d) will also be included. Lastly, since the Pseudo Poisson Maximum

likelihood Estimator will be employed to compute the regression output, the dependent variable will be expressed in absolute values (Y_{ikdt}):

$$Y_{idt} = \beta_0 + \beta_1 US_{id} + \beta_2 Post_t + \beta_3 (US_{id} \times Post_t) + \beta_4 \mathbf{X}_{ik} + \lambda_{ti} + \theta_k + \delta_d + \varepsilon_{idt} \quad (10)$$

5.1.3 Propensity Score Matching

Finally, if the inclusion of control variables and fixed effects fails to ensure parallel trends and meet the other assumptions, another way of constructing an accurate control group should be considered, namely Propensity Score Matching. This methodology will find a set of non-treated units with the most similar characteristics possible for every treated unit. More specifically, a control group will be constructed that describes similar firm-product combinations as the ones in the treatment group, namely firm-product pairs with similar characteristics but not exported to the United States. Given the fact that the dataset covers a large number of treated units but provides a significantly greater number of untreated units with overlapping characteristics, PSM could be accurately performed.

To ensure correct comparison between the outcomes of the treatment and the control group, matching must be performed based on similar observed characteristics. These characteristics might not be affected by the treatment or the anticipation to it and must therefore be constructed based on pre-treatment information or must be fixed over time (Caliendo and Kopeinig, 2005). The covariates constructed above could serve as accurate matching variables to build the artificial control group. The validity of the required assumptions will be checked when performing the analysis and both the common support assumption as well as the conditional independence assumption can be tested in STATA.

In order to construct the correct artificial control group, logistic regression will firstly be performed to estimate the propensity score (between 0 and 1) of every firm-product combination being subject to the effects of the US-Colombia FTA, taking into account the characteristics of the covariates mentioned above. Secondly, in order to accurately match the treated and untreated units based on their propensity scores, nearest-neighbour matching will be employed without replacement. This matching

algorithm matches every treated unit i with its closest untreated unit j in terms of propensity scores (P) (Michalek, 2012):

$$C(P_i) = \min_j \|P_i - P_j\| \quad (11)$$

Imposing no replacement, making sure that each untreated unit can only be matched to one treated unit, is possible since there are enough untreated units to safeguard good matching quality. Furthermore, this restriction ensures that no untreated unit is given a considerably high weight.

5.2 Country-Level Analysis

Since the secondary analysis will be conducted on a country level, the above-described dataset will be collapsed on an aggregated country level and will be expanded by some additional variables, that can be used as predictors or auxiliary variables for the Synthetic Control Method. This subsection will first elaborate more on the employed dataset, dependent variable definition and the approach before looking into the chosen predictors, the specification equation and some placebo tests.

5.2.1 Synthetic Control Method

The aggregated dataset on country level was converted, after some adjustments eliminating 131 nations with missing values, into a balanced panel dataset spanning 9 years, from 2008 to 2016 and covering 85 worldwide countries. The general advantages discussed in part 4.1.2 can be applied to this panel dataset as well and the Synthetic Control Model will hence be able to account for entity-specific effects.

To estimate the effect of the US-Colombia FTA implementation on firm entry-exit rates of Colombian firms in the US export market, an aggregated variable was constructed. This dependent variable covers the number of unique Colombian firms exporting to the United States in every year of the analysis. Since the analysis will be conducted on country level, the treated unit under this scenario is the United States and the donor pool will consist of the other countries in the dataset. As suggested by Billmeier and Nannicini (2013), the flexibility of the model will be exploited by implementing two types of experiments in selecting the potential donor pool. The first experiment will include all the countries available in the dataset, hence

increasing sample size and the power of the test, whereas the second experiment will only include a selection of countries that are similar to the United States (based on economic, geographic, cultural and historical characteristics) and thus might ensure higher common support.

An important remark to make is that, as discussed in section 2, the United States is one of Colombia's primary export partners, inevitably resulting in a significantly high number of Colombian exporting firms to the United States (± 2000). Given the fact that only a few other countries, mostly located close to Colombia, have numbers in the same order of magnitude (e.g., Ecuador, Panama and Peru), these lagged outcome variables could heavily influence the weights assigned to countries. Therefore, a new normalized dependent variable was constructed, indicating the trend of the number of active companies in a given export market in a given year compared to the reference or base year, namely 2008, with value 1. This will allow for a more accurate synthetic control country.

Besides the lagged outcome variables in the pre-treatment period, several auxiliary covariates or predictors are included that will allow for the construction of an artificial control unit similar to the United States based on characteristics that might influence the amount of Colombian firms exporting to a given destination. Apart from a country's membership to the World Trade Organization and its average percentage of trade to GDP, demonstrating a country's trade openness, population, GDP per capita PPP, legal origin and shipping connectivity index are also taken into account. All the numeric predictors are averaged over the pre-intervention period (2008-2011) and underwent a log-transformation. The Synthetic Control Model constructs an artificial control country by weighting the other countries included in the dataset, aligning their pre-treatment trends with the one of the United States based on all the variables incorporated.

The estimated effect of the FTA on the Colombian firms' entry/exit dynamics is represented in the following equation (Adabie et al., 2010):

$$\hat{\alpha}_{USt} = Y_{USt} - \sum_{j=2}^{J+1} \omega_j^* Y_{jt} \quad (12)$$

Where Y_{USt} denotes the trend of the number Colombian exporting firms to the United States at time t . Moreover, J covers the donor pool covering multiple control countries, hence Y_{jt} refers to the trend of the amount of Colombian companies exporting to

country j in year t and ω_j^* covers the collection of weights assigned to the different countries in the donor pool.

According to Adabie, Diamond and Hainmueller (2014), SCM enables researchers to conduct a broad range of falsification exercises or placebo studies since the method systematically determines the counterfactual of interest. These placebo studies challenge the impact of an intervention, suggesting that significant effects in non-intervention scenarios would undermine confidence in the method's accuracy. A distinction can be made between "in-time placebos" and "in-space placebos". The former dismisses the validity of the result if the SCM predicts similarly large effects for periods when no treatment occurred (Heckman and Hotz, 1989), implicitly testing the anticipation assumption, while the latter reassigns the intervention not in time, but to members of the donor pool (Adabie et al., 2014). The same logic applies; hence the validity of the results would be rejected if SCM would provide more significant and hence larger estimated effects when the treatment is artificially assigned to untreated countries. Visually, the estimated effect obtained with each placebo unit run is put on a graph, which provides a visual presentation of the difference in the trend of active firms in the export market of each donor pool unit and its respective synthetic version (Adabie et al., 2010). If the effect of the real treated unit is significantly large in comparison with the others, it can be stated that the effect was significant. Another way to evaluate the effect obtained for the US with the ones for the control groups obtained after the 'placebo in space' test is to look at the distribution of the Post- over Pre-intervention Root Mean Squared Predictor Error (RMSPE) ratios.

More specifically, the Pre-intervention RMSPE, assesses the quality of the synthetic unit by comparing the actual outcome value and the one of the synthetic control unit over the pre-treatment period. Hence, a low score indicates an adequate replication of the pre-intervention trends (Adabie et al., 2014). On the other side, the post-treatment RMSPE compares the differences in outcomes in the post-intervention period. If the ratio of the latter to the former, typically above one since the Synthetic Control Model (SCM) aims to minimize pre-treatment differences, exceeds that of most other countries, the impact of the Free Trade Agreement (FTA) can be considered significant.

6 Results: Firm-Product-Level Analysis

This section presents the results obtained when applying the different methodologies described above to the employed dataset on firm-product level. The results of export sales will first be described, followed by the ones from product portfolio and product innovation. Furthermore, a sector and firm heterogeneity analysis is conducted, along with several robustness checks, which are also presented in this section.

Before interpreting the results, an explanation is provided of the structure of the regression tables presented in this section. The tables (e.g., Table 5) all exhibit a similar structure, presenting the relevant β_3 coefficient value, its significance level, the number of observations and the extent to which the variance for the relevant analysed dependent variable can be accounted for by the independent parameters in the regression model. This last value is referred to as the adjusted R squared value (modified) for the OLS regression models (export sales and product portfolio) and the pseudo R squared value for PPML regressions (product innovation). Lastly, several analyses have been conducted, differing in the inclusion of (interaction) fixed effects, control variables and matching variables. The checks and crosses in the tables indicate whether control variables are added and which fixed effects or interaction fixed effects are included (check) or excluded (cross) in every model. The first model only includes separate year, firm, product and destination fixed effects (column 2), whereas the second model also takes into account the firm-product interaction fixed effect (column 3). The third model (column 4) is an extension of the second model by including control variables. Finally, the fourth model (column 5) presents the results of the DiD analysis after performing matching.

6.1 Export Sales

6.1.1 Regression Results

Table 5 illustrates the regression results for the log transformation of export sales. When including all the firm-product combinations not exported to the United States in the control group, models 1 to 3 deliver significant positive values for the β_3 coefficient and hence demonstrate an average positive effect of the treatment on export sales value. However, when refining the control group and only including control units that perfectly match the treated units, the adjusted R squared increases

drastically and the result becomes significantly negative (model 4 – matched DiD). This points towards an average negative effect of the US-Colombia Free Trade Agreement on firm-product export sales of Colombian firms in comparison with the matched control group, contradicting hypothesis 1. Literature suggests that export sales of firms are likely to increase after concluding a Free Trade Agreement, but the obtained results do not show support for this hypothesis. Based on the data and methodology used in this dissertation, the US-Colombia FTA is estimated to decrease export sales by 10,9% on average for Colombian firms exporting to the United States when using the matched control group in the period of analysis. This significant negative result is characterized by a p-value smaller than 0.01 and a high adjusted R squared value of 0.884.

Table 5: Regression Results on β_3 Coefficient for $\ln(\text{Export Sales})$

<i>Variables</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Matched DiD</i>
β_3 Coefficient	0.069***	0.032*	0.058***	- 0.109***
<i>t</i>-Statistics	3.45	1.77	3.02	0.019
Adj. R Squared	0.486	0.668	0.662	0.884
# Observations	714,786	623,610	538,949	76,497
Year FE	✓	✓	✓	✓
Firm FE	✓	✗	✗	✗
Product FE	✓	✗	✗	✗
Destination FE	✓	✓	✓	✓
Firm-Product FE	✗	✓	✓	✓
Covariates	✗	✗	✓	✗

Notes: Significance levels: *p < 0.10; **p < 0.05; ***p < 0.01 / FE = Fixed Effects; ✓ = Included; ✗ = Not Included

6.1.2 Propensity Score Matching – Matched Control Group

The matched control group, derived by the Propensity Score Matching algorithm, can be considered a perfect match for the pool of treated units since all the biases display 0.0%, far below the generally accepted 5% (Table 6). This collection of untreated units is therefore contributing to a perfect matching quality and hence satisfying the conditional independence assumption. Furthermore, the common support assumption is also met since there are no units reported to be off-support (Table 7) and a perfect balancing of propensity scores is performed, as presented on Figure 4.

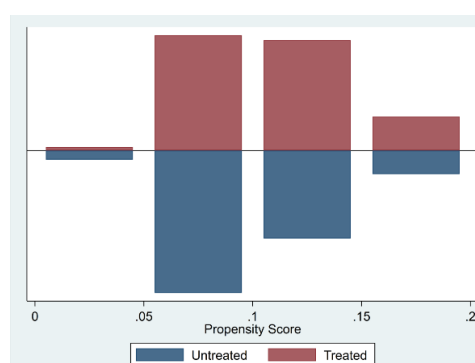
Table 6: Matching quality output retrieved from STATA

Variable	Mean		%bias	T-test		P > t	V(T) / V(C)
	Treated	Control		t			
FP differentiation	1.488	1.488	0.0	0.00		1.000	1.00
FP geography	1.639	1.639	0.0	0.02		0.985	1.00
FP size	1.327	1.327	0.0	0.00		1.000	1.00
Sector	57.662	57.671	-0.0	- 0.04		0.970	1.00

Ps R2	LR chi2	P > chi2	MeanBias	MedBias	B	R	% Var
0.000	0.00	1.000	0.0	0.0	0.0	1.00	0

Table 7: Evidence for common support

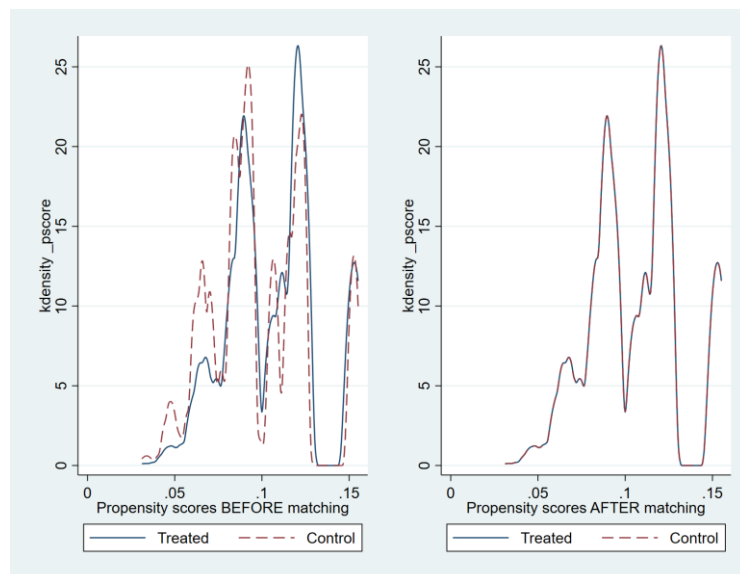
<i>Treatment assignment</i>	<i>On support</i>	<i>Total</i>
Untreated	164,595	164,595
Treated	18,017	18,017
Total	182,612	182,612

Figure 4: Propensity Score Mapping

By ensuring that the treated units are perfectly matched based on the matching variables previously defined, the quality and reliability of the results significantly increased (from model 3 to model 4 – matched DiD in Table 5). In the complete dataset, 91,083 distinct firm-product combinations can be identified, of which 18,017 are treated. Instead of using all the remaining observations as counterfactual (model 1 - 3), the matching algorithm provides a set of 18,017 similar combinations, resulting in a significant rise in the balancing the distribution of propensity scores as presented in Figure 5 and a similar representation of the means of the different matching

variables (Table 6). As supported by the literature in section 3, combining Propensity Score Matching and Difference-in-Difference provides indeed more accurate results.

Figure 5: Distribution of propensity scores before and after matching for treated and control units



6.1.3 Assumptions DiD Estimator

Lastly, all the required assumptions to ensure unbiased and correct Difference-in-Difference estimates are met after performing Propensity Score Matching. First of all, it can be argued that the US-Colombia FTA will not influence the other units in the dataset in the timeframe available. Therefore, the assumption of SUTVA, no spillover effects between treated and control units, is met. Secondly, the event study plot of the last regression (Figure 7) illustrates that there are no significant (on the 0.05 level) differences between the coefficients of the pre-treatment years in comparison with 2008 as the base year (confidence intervals cross the zero line). As a result, the parallel trend assumption holds and a clear division can also be observed between the pre- and post-treatment trends. Lastly, since there are no significant differences between the coefficients of the pre-treatment years and hence no outlier within the other pre-treatment years can be identified, there is also no sign of an anticipation effect. In conclusion, all the Difference-in-Difference assumptions are met, allowing for an interpretation of the results without significant biases.

Figure 6: Event study plot Export Sales before matching

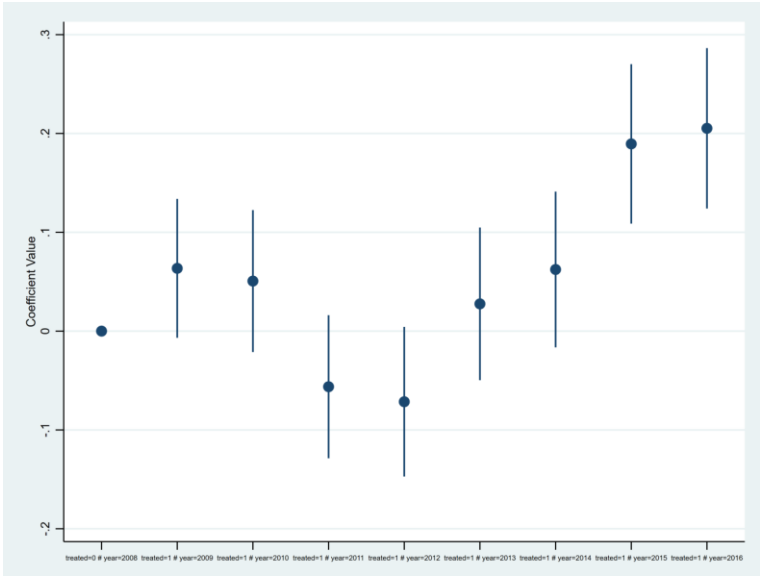
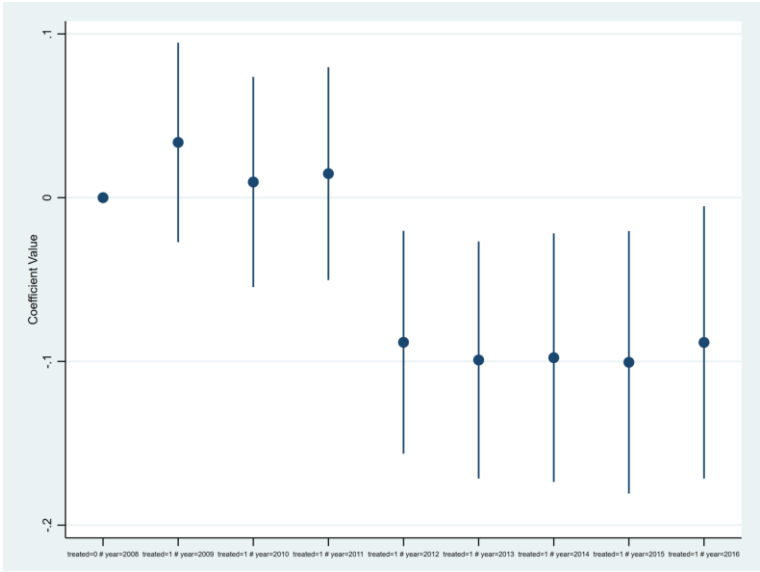


Figure 7: Event study plot Export Sales after matching



6.2 Product Portfolio

6.2.1 Regression Results

The hypothesis put forward by several literature sources for product portfolio is closely interlinked with the one from export sales. Researchers argued that after the implementation of an FTA, it is expected that export performance, both in terms of export sales value and the number of products, will be positively impacted. However, similar to the findings for export sales, a significant negative coefficient of the interaction term in the Difference-in-Difference analysis after matching can be observed for product portfolio, as demonstrated in Table 8. This once again opposes the initial hypothesis. The results obtained after matching imply that the number of products exported by Colombian firms to the United States decreased by 3.6% on average after the implementation of the FTA. The positive significant coefficients displayed for models 1 to 3 in Table 8 can not be interpreted in an unbiased way since the parallel trends assumption did not hold before matching, as presented in Appendix B. This demonstrates that matching once again significantly increases the accuracy of the regression output and ensures parallel trends. As illustrated in the previous subsection of export sales, the other required assumptions are also met for the analysis for product portfolio. So, correct conclusions can be drawn from the obtained regression results after matching and a detailed overview of the matching diagnostics can be found in Appendix C.

Table 8: Regression Results on β_3 Coefficient for $\ln(\text{Product Portfolio})$

<i>Variables</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Matched DiD</i>
β_3 Coefficient	0.031***	0.024***	0.016***	-0.036***
<i>t</i> -Statistics	5.87	4.40	2.87	-7.20
<i>R</i> Squared	0.784	0.830	0.826	0.950
# Observations	714,786	623,610	538,949	76,497
Year FE	✓	✓	✓	✓
Firm FE	✓	✗	✗	✗
Product FE	✓	✗	✗	✗
Destination FE	✓	✓	✓	✓
Firm-Product FE	✗	✓	✓	✓
Year-Firm-Product FE	✗	✗	✗	✗
Covariates	✗	✗	✓	✗

Notes: Significance levels: *p < 0.10; **p < 0.05; ***p < 0.01 / FE = Fixed Effects; ✓ = Included; ✗ = Not Included

6.3 Product Innovation

6.3.1 Regression Results

The final outcome variable investigated on a firm-product level is product innovation. Important to note that the interpretation of the results for product innovation is slightly different compared to the two previous cases (export sales and product portfolio) since regression has been performed by employing the Pseudo Poisson Maximum Likelihood Estimator and therefore the log transformation of the dependent variable has not been used. The Difference-in-Difference output results after matching illustrate a significant negative impact on the product innovation capacity of Colombian firms after the implementation of the Free Trade Agreement. This means that, also for product innovation, the hypothesis based on existing literature cannot be confirmed. The significant β_3 interaction coefficient of model 4 – matched DiD in Table 9 implies that the amount of new products exported by Colombian firms exporting to the United States will decrease on average with -0.130 units after the entry into force of the FTA.

Table 9: Regression Results on β_3 Coefficient for Product Innovation

<i>Variables</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Matched DiD</i>
β_3 Coefficient	0.087***	0.089***	0.126***	-0.130***
<i>t-Statistics</i>	5.94	5.00	6.27	-2.77
<i>Pseudo R Squared</i>	0.617	0.717	0.650	0.732
<i># Observations</i>	595,490	493,325	393,383	65,246
<i>Year FE</i>	✓	✓	✓	✓
<i>Firm FE</i>	✓	✗	✗	✗
<i>Product FE</i>	✓	✗	✗	✗
<i>Destination FE</i>	✓	✓	✓	✓
<i>Firm-Product FE</i>	✗	✓	✓	✓
<i>Year-Firm-Product FE</i>	✗	✗	✗	✗
<i>Covariates</i>	✗	✗	✓	✗

Notes: Significance levels: *p < 0.10; **p < 0.05; ***p < 0.01 / FE = Fixed Effects; ✓ = Included; ✗ = Not Included

As 2008 represents the first year in the dataset and product innovation is defined as the number of new products exported by a firm in a given year compared to the previous year, 2008 always has a value of zero. Therefore, to be able to make profound conclusions when plotting the event study plots, the year prior to the treatment (2011) is taken as the base year instead of the first pre-treatment year (2008). Similarly to product portfolio, the assumption of parallel trends does not hold after the initial regression with control variables but is met after performing matching (Appendix D), resulting in non-biased negative results after matching (with detailed matching diagnostics displayed in Appendix E). Important to note here as well is that the adjusted R squared values of the previous analyses can not be correctly compared with the Pseudo R squared values of this analysis (Mangiafico, 2016).

6.4 Sector and Firm Heterogeneity Analysis

After conducting several tests and analyses for different firm size percentiles and sectors, some interesting findings are listed below. The results displayed in Table 10 for export sales and product portfolio are obtained after matching, denoting their respective β_3 coefficient, corresponding t-value, the number of observations and lastly, the adjusted R squared. Sectors are identified on the HS2 level, whereas firms were categorized into 5 percentiles based on their firm size computed as the total amount of export sales value of a firm over the 9-year time period. Important to mention is the fact that all the results presented below are compliant with the necessary requirements and meet the corresponding required assumptions.

Table 10: Heterogeneity analysis for export sales and product portfolio

		<i>HS 41-HS 46 without 42</i>	<i>HS 68-69</i>	<i>HS 84-85</i>	<i>Firms 60-80</i>
<i>Export Sales</i>	β_3 coefficient	0.182**	0.171*	-0.118***	-0.145***
	t- value	2.08	1.85	-2.94	-3.17
	N (observations)	624	989	10,048	14,230
	Adjusted R squared	0.979	0.958	0.869	0.864
<i>Product Portfolio</i>	β_3 coefficient	0.018	0.006	-0.033**	-0.036***
	t- value	0.80	0.30	-2.42	-3.36
	N (observations)	624	989	10,048	14,230
	Adjusted R squared	0.925	0.921	0.937	0.952

This snapshot of different sectors gives a comprehensive idea of the heterogeneity effect, displayed in Table 10. While the machinery sector (HS 84-85) encounters a significant negative effect of the FTA on its export sales of 11.8%, other industries such as the building materials sector (HS 68-69) and the wood, cork and leather industries (HS 41-46) experience significant growth rates for their export sales in the post-FTA period, with a respectively positive impact of 17.1% and 18.2%. Furthermore, when comparing the effect on firms categorized into different firm size percentiles, it could be observed that Colombian middle-sized firms, between the 60th and 80th percentile (last column Table 10), encounter a remarkable negative impact on export sales and products exported to the United States after the implementation of the FTA. The Colombian exporting firms categorized in the 60th to 80th percentiles based on their firm size, experience an average decrease of 14.5% in export sales value to the United States (exceeding the average negative effect of 10.9%) and reduce the number of products they export by 3.6% after the implementation of the FTA.

Moreover, the same heterogeneity analysis also provides interesting findings for product innovation. Table 11 follows the same structure as the table above, but indicates the Pseudo R squared value instead of the adjusted R squared. It can be observed that firm innovation in some industries is fostered compared to the pre-treatment situation, especially in the building materials sector (HS 68-69) and the leather and fur industry (HS 41-43). However, more remarkable is the firm heterogeneity that prevails in terms of product innovation. The 20% smallest firms are positively impacted by the FTA implementation in terms of their innovative capacities and market introduction of new products, while the middle-sized companies (20%-95%) experience a negative impact and introduce fewer new products to the US export market than before.

Table 11: Heterogeneity analysis for product innovation

		<i>HS 68-69</i>	<i>HS 41-43</i>	<i>Firms < 20%</i>	<i>Firms 20% - 80%</i>	<i>Firms 80%- 95%</i>
<i>Product Innovation</i>	β_3 coefficient	1.205**	0.822***	0.236**	-0.255***	-0.342***
	t-value	2.05	3.68	2.52	-5.03	-3.89
	N (observations)	624	1,901	14,191	37,841	6,546
	Adjusted R squared	0.275	0.307	0.784	0.681	0.588

6.5 Robustness Checks

To ensure the quality and reliability of the obtained results, two robustness checks were performed, of which the results are displayed in Appendix F.

Firstly, as previously discussed, the main 5 export products to the United States constitute more than 80 % of total export sales value to the United States and could therefore drastically influence the obtained results. Another analysis has been computed without these products and similar results were obtained.

Secondly, during the period analyzed, Colombia not only concluded an FTA with the United States but also with other regions and nations such as Chile (2009), Northern Triangle – El Salvador, Guatemala, Honduras (2009), Canada (2011), EFTA (2011) and the European Union (2013) according to the WTO RTA database (World Trade Organization, n.d.). As generally stated by the literature and the research purpose of this dissertation, the implementation of free trade agreements can significantly impact the outcome variables of interest. An additional check has therefore been performed to investigate whether trade changes to other regions and nations after their specific FTA implementation significantly influenced the trends of the control group in the previous analysis. All the firm-product combinations that are being exported to the above-mentioned regions and countries were eliminated from the dataset before running the analyses again. This resulted in overall similar outcomes and hence affirmed the robustness and reliability of the results gathered on firm-product level.

7 Results: Country-Level Analysis

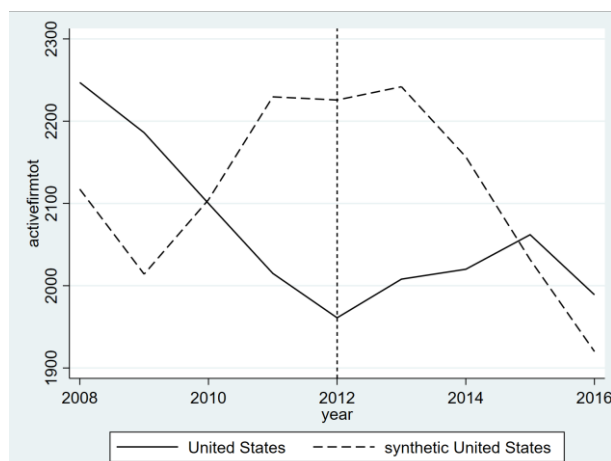
This section will analyze the impact of the US-Colombia FTA on the evolution of the entry and exit rates of Colombian firms exporting to the United States. The first subsections will elaborate on the results obtained after performing the Synthetic Control Method on the extensive donor pool (7.1), including a firm heterogeneity analysis (7.2) and several robustness checks (7.3). A detailed overview of the analysis performed on the smaller donor pool is touched upon in subsection 7.4, but in more detail exhibited in Appendices K to O.

7.1 Entry and Exit Rates: Large Donor Pool SCM

The extensive donor pool covered 84 distinct control countries, apart from the United States as treated unit. To ensure that the Synthetic Control Method was able to construct an accurate synthetic control country, several predictors were included, as discussed in part 5.2.1. The relevant predictors in this case were the log transformations of the average GDP per capita PPP variable for every country, its corresponding population size, average trade percentage expressed in function of GDP and shipping connectivity index number, complemented by the WTO membership dummy variable and the variable indicating the origin of the legal system of the countries included in the donor pool. All these auxiliary parameters were expressed as averages over the pre-treatment period and used in combination with the pre-treatment values of the outcome variable to construct an adequate synthetic control country, referred to in the figures below as ‘synthetic United States’.

Yet, the Synthetic Control Method struggled to generate an accurate synthetic control country when considering the total number of firms engaging in export activities to a specific destination as the dependent variable. Due to the significantly high number of Colombian firms exporting to the United States, the included predictors and pre-treatment outcomes fail to construct a synthetic control unit with similar pre-treatment trends (predictor balance represented in Appendix G). Figure 8 graphically illustrates the trends of the United States and the obtained synthetic control country, only including Ecuador and Panama, with assigned weights of 90.8% and 9.2% respectively.

Figure 8: Total number of Colombian firms exporting to the United States compared to synthetic control country



However, when employing the trend of the number of active firms in a given export market instead of the absolute number (2008 as reference point with a value of 1), a synthetic control unit that accurately replicates the pre-treatment trends of the United States could be constructed. Table 12 already lists the 18 countries with the highest assigned weights in the donor pool, but a complete overview of the weight assignment is available in Appendix H.

Until 2015, a remarkable increase in the trend of the number of active Colombian firms in the US export market is observed compared to the synthetic control country, as illustrated in Figures 9 and 10. However, a distinct shift becomes apparent from 2015 onward, signaling a decline in the presence of Colombian firms in the US export market. Although the SCM provides clear results, it is important to mention that, while the pre-treatment outcome variables are well replicated, the auxiliary covariates or predictors are reproduced with less precision and accuracy, as illustrated in the predictor balance (Table 13). This discrepancy may be caused by differences in the trends of the number of Colombian firms exporting to destinations that are most similar to the United States economically, geographically and culturally. Consequently, questions may arise whether the obtained results are robust and accurate.

Figure 9: Synthetic Control Model visualisation of United States and synthetic control country

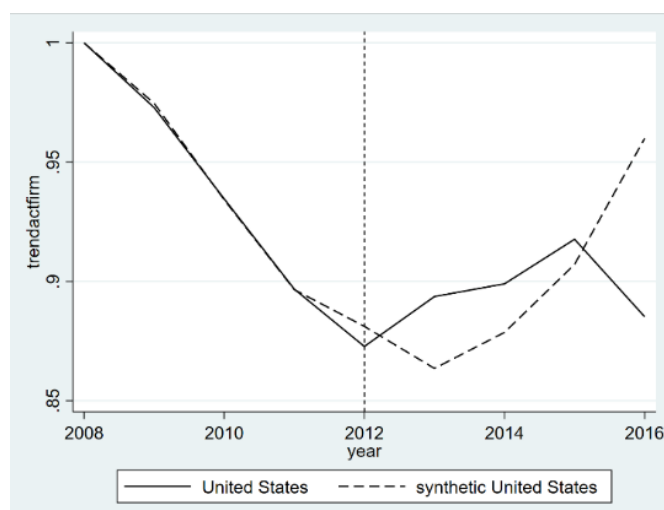


Figure 10: Difference in trends outcome variable United States and synthetic control country

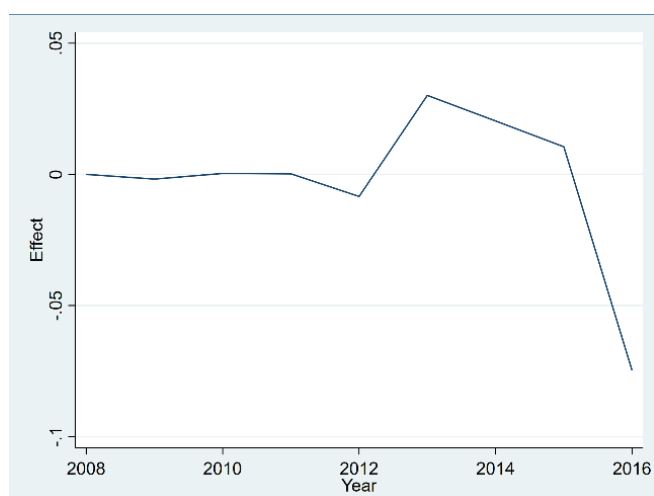


Table 12: Overview of countries with the highest assigned weights in the synthetic control country (18 out of 87)

<i>Country</i>	<i>Unit weight</i>	<i>Country</i>	<i>Unit Weight</i>	<i>Country</i>	<i>Unit Weight</i>
Bulgaria	0.247	Egypt	0.017	Jamaica	0.011
Denmark	0.043	Greece	0.014	Philippines	0.011
Fiji	0.041	Ireland	0.012	Morocco	0.011
Albania	0.035	Bangladesh	0.012	United Kingdom	0.01
Madagascar	0.023	Spain	0.011	Israel	0.01
Dominica	0.019	Guinea	0.011	Barbados	0.01

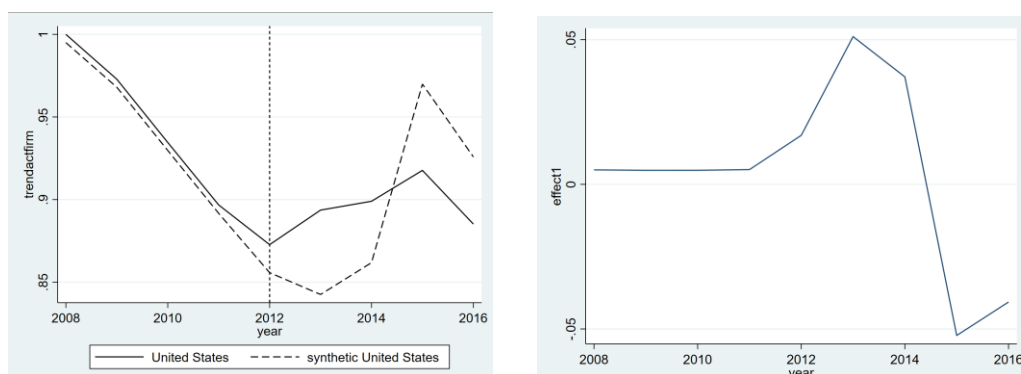
Table 13: Predictor Balance

	<i>Treated</i>	<i>Synthetic</i>
Trendactfirm(2009)	0.973	0.975
Trendactfirm(2010)	0.935	0.934
Trendactfirm(2011)	0.897	0.897
Log GDPcap PPP	3.879	2.592
Log pop	12.638	9.057
Log trade	3.347	4.458
Log shipping connectivity	4.338	2.736
WTO membership	1	0.967
Legal old	3	2.134

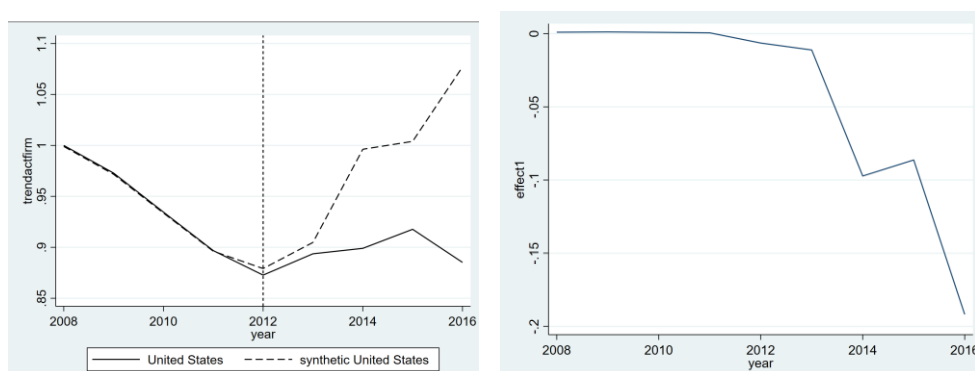
7.2 Heterogeneity Analysis

Given that the obtained results represent averages across all company sizes, an additional analysis has been performed to investigate the separate effect on different firm sizes, similar to subsection 6.4. Firms were classified based on their size, determined by their total export sales value over the investigated period, and divided into five percentiles. As illustrated in Figures 11 to 14, the smallest 20 percent of the firms experienced a more positive impact compared to the average effect until 2014 (Figure 12), while the largest 5 percent encountered a negative effect on the number of Colombian firms exporting to the United States (Figure 14). This demonstrates clear heterogeneity effects among the smallest and largest firms. Consequently, the increased number of Colombian firms active in the US export market is mostly driven by the entry of smaller firms, which happened in greater numbers and was thus able to compensate for the exit of some of the largest firms.

Figures 11 and 12: SCM plot and corresponding effect for 20 percent smallest firms



Figures 13 and 14: SCM plot and corresponding effect for 5 percent largest firms



7.3 Robustness Checks

To check and ensure the robustness and accuracy of the obtained results, several placebo tests could be performed, as described in subsection 5.2. The ‘in time placebo test’ confirms robust results when the obtained trends do not change significantly when changing the treatment date and can therefore also be used to check for anticipation effects. The ‘in space placebo test’ confirms the accuracy of the results when these are still the most significant compared to the ones of the placebo runs with random countries as treatment units. As illustrated in Figures 15 and 16, both tests are not validated. First of all, different patterns can be observed after changing the treatment date (placebo in time in Figure 15). Secondly, placebo runs for all the countries in the donor pool (placebo in space) with their corresponding post-RSMPE/pre-RMSPE ratios (Appendix I), indicate that the observed effect for the United States was not significant compared to the effect of the implementation of the Free Trade Agreement on the changes of the number of Colombian firms exporting to random control countries. Figure 16 illustrates the treatment effect for every placebo run (grey lines) and the actual treatment unit (black line). It can clearly be demonstrated that the treatment effect for the United States can not be considered significant. Additionally, the corresponding probability of finding the same post/pre RMSPE ratio as the United States is 0.61176, remarkably high for the employed dataset. This supports the conclusion that the obtained results can not be deemed robust.

Figure 15: Placebo test in time (treatment year = 2011)

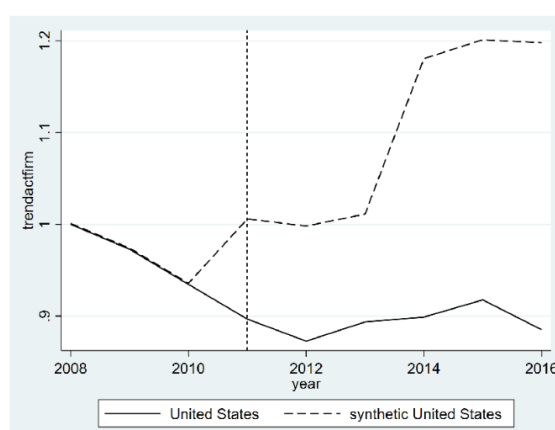
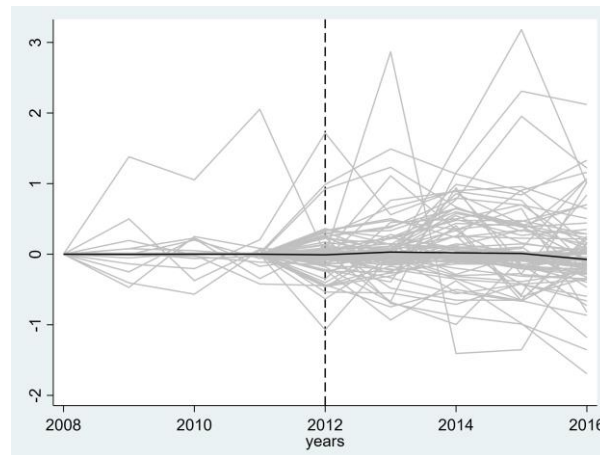


Figure 16: Visualisation of treatment effects for different placebo runs (in space)



Regarding the assumptions that should be in place when performing the Synthetic Control Method, the failed placebo test in time already indicates the non-robustness to a possible anticipation effect. Furthermore, within the context of this technique, it is crucial to ensure that none of the control countries are simultaneously entering into Free Trade Agreements with Colombia as this could potentially distort the trends and hence the estimations. The results obtained after excluding the countries that concluded an FTA with Colombia during the given timeframe significantly differed from the initial graphs, indicating that the SUTVA assumption might not hold (Appendix J).

7.4 Synthetic Control Model: Smaller Donor Pool

The same analysis has been performed on a smaller subset of 19 potential control units, only containing countries with similar economic, geographic and/ or cultural characteristics to the United States such as Australia, Germany, Switzerland, Canada and New Zealand. A detailed overview of all the results, weight assignment and robustness checks can be found in the Appendix (ranging from K to O). The estimated trend of firms active in the US market seems to be positively impacted after the implementation of the Free Trade Agreement, consistent with the results obtained over the larger donor pool until 2015. Nevertheless, the performed robustness tests also indicate that the impact of the Free Trade Agreement on the dependent variable cannot be deemed significant for the smaller donor pool.

8 Discussion

The Free Trade Agreement between Colombia and the United States, which replaced the Andean Trade Promotion and Drug Eradication Act (ATPA/ ATPDEA), has significantly reshaped the trade dynamics between the two countries. However, before further discussing the results obtained in the conducted analysis, it is important to point out that the analysis in this dissertation compares the outcomes of the defined dependent variables after the implementation of the FTA with the situation where the Free Trade Agreement would not have taken place, and thus a scenario where Colombia continued to export under the ATPA/ATPDEA tariff schedule. The findings indicate that, while the FTA was intended to enhance economic ties and boost Colombian exports by reducing tariff and non-tariff barriers, the actual outcomes have been less favourable than anticipated and simulated for Colombia. The remainder of this section will first delve deeper into the hypotheses previously stated and provide a context and explanation for the results obtained, as well as some nuances with the heterogeneity analyses for both the main and secondary examinations. Lastly, possible next steps for the Colombian government are defined, complemented with a part discussing the limitations of this study and possible areas for future research.

Hypotheses and Literature

First linking back to the literature and theory previously discussed, several hypotheses were stated. Generally, it was assumed that trade liberalization and hence the implementation of the US-Colombia FTA would enhance Colombian firms' export performance thanks to increased access to the US market. However, this access might not have been as significant in comparison to general scenarios where no unilateral agreement was previously in place. Secondly, researchers argued that, due to spillover effects and technological diffusion, Colombian firms exporting to the US market would be stimulated to innovate to a greater extent and adopt more advanced technologies. In the specific analysis conducted, innovation was approached as the market introduction of new export products and it was therefore assumed that Colombian firms exporting to the United States would introduce more new products. Lastly, in terms of entry-exit rates, there was a general stance taken that the most productive firms would enter and remain active in the export market, whereas the least productive ones would exit. Since all those hypotheses have been debunked by the results obtained, this interesting and revelatory discussion will provide the

author's own viewpoint as well as some additional literature sources supporting the obtained findings tailored towards the United States – Colombia case study.

Firm-product-level analysis

The firm-product-level analysis conducted in this dissertation demonstrated that the Free Trade Agreement negatively impacted Colombian export sales, leading to an average decrease of 10.9% in export sales value to the United States in comparison with the counterfactual ATPA/ ATPDEA situation, complemented by an average decrease of 3.6% in the number of products exported. These findings strongly oppose the first hypothesis. However, when diving deeper into the literature related to the specific case study rather than general theories, several researchers describe the trade deficit Colombia encountered with the United States after ratifying the Free Trade Agreement. Abreo et al. (2022), Arenas (2021) and Rémont (2016) concluded that the export sales to the United States were significantly lower than expected and anticipated while the US imports increased starkly, leading to an under-trading situation and a growing trade deficit. Given the availability of only Colombian export data, a clear trade balance evolution cannot be constructed. However, Rémont (2016) proves that the year after the FTA went into force, Colombian exports to the United States dropped by 15% (16,41% in the employed dataset), while imports from the United States rose by the same margin.

This negative impact not only on export sales but also on product portfolio and product innovation can also be explained by the fact that 78% of the products that Colombia exported after the FTA were already exported before under the ATPA/ ATPDEA preferential agreement (Valencia, 2022) and hence not significantly opened the US market more than before. This lack of diversification proved to be troubling, especially when contrasted with the sophisticated and higher value-added products that the United States imported into Colombia. The agreement has not effectively encouraged Colombian industries to innovate or expand their product portfolios. While American producers benefit from greater access to the Colombian market and a reduction in trade barriers, Colombian firms struggled due to inadequate state support and high domestic costs, including labour, energy and transportation, also referred to as the 'Colombia Cost' (Clavijo, 2019). Colombia was not able to become more competitive and bounce back against the US importers, which is also illustrated by its poor performance in the World Economic Forum's Global Competitiveness Report (69th place in 2012 and 66th in 2018, among 140 economies).

Furthermore, the negotiation dynamics of the FTA reveal additional complexities. The agreement pushed Colombia to remove the protection on vulnerable goods, while the US retained some protective measures and non-tariff barriers (Rémont, 2016). This asymmetry in negotiation outcomes has further disadvantaged Colombian industries, particularly in sectors where they could not meet the stringent sanitary and phytosanitary standards required for the US export market (Montiel Paternina, 2013). Martinez and Raminez (2005) also anticipated that the impact of the FTA implementation in certain areas would be negative if not all non-tariff barriers were removed by the United States.

Despite these challenges and negative outcomes, it is important to realize that the obtained results cover averages and hence not all sectors or firms have been negatively impacted. While fuel-related exports decreased significantly, partly due to a collapse in oil prices, increasing US oil production and US imports from other countries (Abreo et al., 2022), which is controlled for by the Difference-in-Difference model, growth in some non-fuel exporting sectors has been observed. Certain non-traditional industries, like the building sector and the wood, cork and leather industries, have experienced increased export performance in the post-treatment period. These sectors exhibit areas where Colombia has competitive strengths that could be further leveraged under the right conditions.

Moreover, there has been a notable positive effect on product innovation observed in certain sectors and among the smallest 20 percent of firms during the post-treatment period. However, the majority of firms, ranging from the 20th to 95th percentile, experience a considerable negative impact, which is in line with the already mentioned lack of product diversification.

Country-level analysis

On a country level, even though the outcomes obtained by the Synthetic Control Method are not robust, the analysis indicated a limited growth in the number of companies exporting to the United States until 2015, which might be viewed as conflicting with the overall negative impact on export sales, product portfolio and product innovation. Yet, the heterogeneity analysis has shown that notably the smaller companies (below the 20th percentile) were initially successful in entering the US market. They were also the only group of companies experiencing a significant positive impact on product innovation and market presence. These findings align with the Colombian export market characteristics discussed in subsection 2.1. In contrast,

larger firms encountered a negative impact regarding the number of firms exporting to the United States. Generally, it can be stated that the FTA encouraged smaller firms to enter the market and to start exporting products, which points to the (however not sustainable) dynamism of the smaller companies as compared to their larger peers. Yet, they were clearly not in sufficient numbers and size to influence the overall trade dynamics and balance. Nevertheless, it is important to note that these findings also oppose the third hypothesis stating that the most productive firms would enter and remain active in the export market after trade liberalization. As illustrated in part 5.1.2.1, firm size can be seen as a proxy for productivity and the obtained results hence reveal that the smallest and thus least productive firms (given this assumption) are the ones that experience increased entry rates in the US export market, while the largest (and hence most productive ones) experience a negative effect on their market presence.

Next steps, limitations and areas for future research

Going forward, Colombia must reassess its trade strategies and policies to better support domestic industries, install checks for better sanitary controls, enhance product diversification and innovation and create a more balanced relationship with the United States (Lombana, 2020). This reassessment should focus on improving infrastructure and technological standards, reducing the “Colombia Cost” (a.o. by making the labour market more flexible) and fostering an environment for innovation and long-term investment (Arenas, 2021; Montiel Paternina, 2013). Nowadays, discussion emerged for a renegotiation of the current FTA, indicating the need for a more beneficial treaty, notably for Colombia (Alsema, 2023).

Lastly, it is essential to acknowledge the limitations of this research. Firstly, the analysis faces a challenge as the FTA only came into force on May 15th, 2012, yet the examination is conducted on a yearly basis, resulting in five months of pre-treatment period being assigned to the post-treatment period. Moreover, the acquired dataset on firm-product level only covers a limited number of variables and solely includes data of Colombian exporting firms dealing with products. Future research could aim to expand the dataset’s scope, including data from domestic firms and other relevant factors for the assessment of the FTA, especially given the comprehensive nature of the US-Colombia FTA, which encompasses more than just provisions about goods. A more detailed assessment of the FDI investment and other factors such as trade in services etc. could potentially shed a more positive light on the impact of the US-

Colombia FTA. Furthermore, the available dataset only spans 4 post-treatment years (until 2016). Future research could explore long-term impacts to provide a more comprehensive understanding of the FTA's consequences since studies have argued that positive and more accurate effects of the implementation of an FTA are commonly observed in a long-term perspective (Rémont, 2016). Finally, this research raises the question of whether favourable unilateral agreements might undermine the success of subsequent bilateral ones, which could also be an interesting area for future research.

9 General Conclusion

In conclusion, this dissertation has delved into the impact of the US-Colombia Free Trade Agreement on the dynamics of Colombian firms, more specifically focusing on export performance in terms of export sales and product portfolio, product innovation and firm entry-exit rates. Through a comprehensive analysis, both on firm-product level as well as on country level, some interesting results were found, opposing the hypotheses supported by well-established literature. Generally, it is expected that the implementation of a Free Trade Agreement would enhance the export performance of firms due to increased market access, foster innovativeness of firms who stayed active in the market and stimulate the most productive companies to enter or remain active in the export market. However, it is important to take into account that, different than in most scenarios investigated by general literature, the analyses in this dissertation investigate the effect of the US-Colombia FTA on the defined dependent variables in comparison with the situation where Colombia continued to export under the beneficial unilateral ATPA/ATPDEA tariff schedule.

The analyses employed an extensive dataset for both the firm-product level as well as the country level spanning from 2008 to 2016, exhibiting 715,157 observations and 33,628 distinct firm-product-destination combinations.

The main analysis investigated the impact of the implementation of the FTA on export performance, both in terms of sales value and number of products, and on the product innovativeness of Colombian exporting firms. The analysis was conducted on a firm-product level, rather novel in established literature, to ensure more granular insights in a context with the presence of multi-product firms.

The combination of the Difference-in-Difference Estimator with Propensity Score Matching, provided accurate and robust results while constructing a perfectly matched control group to estimate the counterfactual situation. The average obtained results of the Difference-in-Difference Estimator for both export performance and product innovation were significantly negative, implying an unfavourable effect on Colombian firms after the FTA implementation as compared to the ATPA/ATPDEA situation active before. In short, Colombian firms experienced on average a 10.9% decrease in export sales value and a 3.6% decline in the number of exported products to the United States. In terms of product innovation, it was demonstrated that Colombian firms exporting to the US introduced on average 0.13 fewer new products.

The average negative impact of the FTA implementation on Colombian firms can be explained by factors such as the existence of a previously defined beneficial unilateral trade agreement (ATPA/ ATPDEA), limited product diversification, inadequate state support, high domestic costs, asymmetry in negotiation outcomes and challenges in meeting stringent standards for the US export market for products that were previously not yet duty-free.

However, it is important to note that these results exhibit averages and a sector heterogeneity analysis has demonstrated significantly positive effects in terms of export performance for some non-fuel related sectors (e.g., the building sector and the wood, cork and leather industries). Furthermore, apart from sectors, a firm heterogeneity analysis has also indicated a big difference between the 20 percent smallest firms and the medium-sized companies, who respectively experience a significant positive and a significant, more than the average, negative effect on their product innovativeness.

The secondary country-level analysis examined the impact of the FTA on the entry and exit rates of Colombian firms in the US export market by employing the Synthetic Control Model with predictors added from additional databases (World Bank and CEPII). An overall positive (though not conclusive) impact could be observed on the trend of the number of Colombian firms active in the US export market, primarily driven by the 20% smallest firms. The largest 5% experienced high exit rates after the FTA implementation, driving the overall negative effect investigated on the parameters analysed in the first section.

Overall, this dissertation points towards the asymmetry in the US – Colombia Free Trade Agreement, resulting in an overall negative outcome for Colombian companies. Consequently, it is therefore not surprising to see more and more attempts from the Colombian side to initiate renegotiations regarding this agreement. From a policy point of view, it should hence not be assumed that an FTA will by definition result in an average positive outcome for all parties involved. The outcome clearly depends on the specific conditions and situation of the countries involved and therefore, a thorough ex-ante assessment is essential before finalizing any Free Trade Agreement.

References

- Abadie, A. (2021). Using Synthetic Controls: Feasibility, Data Requirements, and Methodological Aspects. *Journal of Economic Literature*, 59(2), 391–425. <https://doi.org/10.1257/jel.20191450>.
- Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program. *Journal of the American Statistical Association*, 105(490), 493–505. <https://doi.org/10.1198/jasa.2009.ap08746>.
- Abadie, A., Diamond, A., & Hainmueller, J. (2014). Comparative Politics and the Synthetic Control Method. Social Science Research Network. <https://doi.org/10.2139/ssrn.1950298>.
- Abreo, C., Bustillo, R., & Rodriguez, C. (2022). An empirical analysis of Colombia's trade liberalization process and its effect on the equilibrium of its structural trade deficit. *Review of Development Economics*, 26(2), 736–755. <https://doi.org/10.1111/rode.12860>.
- Adomako, S., Amankwah-Amoah, J., & Danso, A. (2019). The effects of stakeholder integration on firm-level product innovativeness: insights from small and medium-sized enterprises in Ghana. *R & D Management*, 49(5), 734–747. <https://doi.org/10.1111/radm.12367>.
- Aghion, P., Bergeaud, A., Lequien, M., & Melitz, M. (2017). The Impact of Exports on Innovation: Theory and Evidence. Working Paper.
- Albouy, D. (n.d.). *Economics 131 Section Notes Program Evaluation and the Difference in Difference Estimator*.
- Alsema, A. (2023). Colombia to renegotiate trade pact with US: Petro. Colombia Reports. <https://colombiareports.com/colombia-to-renegotiate-trade-pact-with-us-petro/>.
- Amiti, M., & Konings, J. (2007). Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia. *The American Economic Review*, 97(5), 1611–1638. <https://doi.org/10.1257/aer.97.5.1611>.
- Angrist, J. & Pischke, J-S. (2009). Mostly Harmless Econometrics: An Empiricist's Companion.
- Antons, C., & Hilty, R. M. (Eds.). (2015). Intellectual property and free trade agreements in the Asia-Pacific region. Springer.
- Araujo, L., Mion, G., & Ornelas, E. (2016). Institutions and export dynamics, *Journal of International Economics*, 98, 2-20.
- Arenas, D. (2021). El Tratado de Libre Comercio Colombia -Estados Unidos: impacto en la economía colombiana y del Departamento de Santander.
- Arrow, K. (1962). Economic Welfare and the Allocation of Resources to Invention. In: Nelson, Richard (ed), *The Rate and Direction of economic Activity*. Princeton, NJ: Princeton University Press.
- Ashenfelter, O. (1978). Estimating the Effect of Training Programs on Earnings. *The Review of Economics and Statistics*, 60(1), 47–57. <https://doi.org/10.2307/1924332>.
- Ashenfelter, O., & Card, D. (1985). Using the Longitudinal Structure of Earnings to Estimate the Effect of Training Programs. *The Review of Economics and Statistics*, 67(4), 648–660. <https://doi.org/10.2307/1924810>.

- Bas, M. (2012). Input-trade liberalization and firm export decisions: Evidence from Argentina. *Journal of Development Economics*, 97(2), 481–493. <https://doi.org/10.1016/j.jdeveco.2011.05.010>.
- Bas, M., & Strauss-Kahn, V. (2014). Does importing more inputs raise exports? Firm-level evidence from France. *Review of World Economics*, 150(2), 241–275. <https://doi.org/10.1007/s10290-013-0175-0>.
- Bernard, A. B., Redding, S. J., & Schott, P. K. (2006). *Multi-Product Firms and Product Switching*. National Bureau of Economic Research.
- Bernard, A.B., Eaton J., Jensen J.B. & Kortum S. (2003). Plants and Productivity in International Trade. *American Economic Review*, 93 (4): 1268-1290.
- Billmeier, A., & Nannicini, T. (2013). Assessing Economic Liberalization Episodes: A Synthetic Control Approach. *The Review of Economics and Statistics*, 95(3), 983–1001. https://doi.org/10.1162/REST_a_00324.
- Bonander, C., Humphreys, D., & Degli Esposti, M. (2021). Synthetic Control Methods for the Evaluation of Single-Unit Interventions in Epidemiology: A Tutorial. *American journal of epidemiology*, 190(12), 2700–2711. <https://doi.org/10.1093/aje/kwab211>.
- Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. Guilford Press.
- Bryson, A., Dorsett, R., & Purdon, S. (2002). The use of propensity score matching in the evaluation of active labour market policies. LSE Research Online Documents on Economics 4993, London School of Economics and Political Science, LSE Library.
- Burtless, G. (2001). Worker’s Rights: Labor standards and global trade. Brookings. <https://www.brookings.edu/articles/workers-rights-labor-standards-and-global-trade/>.
- Bustos, P. (2011). Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms. *The American Economic Review*, 101(1), 304–340. <https://doi.org/10.1257/aer.101.1.304>.
- Caliendo, M., & Kopeinig, S. (2005). Some Practical Guidance for the Implementation of Propensity Score Matching. <https://ssrn.com/abstract=721907> or <http://dx.doi.org/10.2139/ssrn.721907>.
- Chabé-Ferret, S. (2012). Matching vs Differencing when Estimating Treatment Effects with Panel Data: the Example of the Effect of Job Training Programs on Earnings. LERNA Working Papers 12.24.381, LERNA, University of Toulouse.
- Chevassus-Lozza, E., Gaigné, C., & Le Mener, L. (2013). Does input trade liberalization boost downstream firms’ exports? Theory and firm-level evidence. *Journal of International Economics*, 90(2), 391–402. <https://doi.org/10.1016/j.jinteco.2013.02.004>.
- Chi, P. Y., Chang, T. Y., & Chang, K. I. (2022). Evaluating the impact of preferential trade agreement on fishery imports: An application of difference-in-differences with matching method. *Agricultural Economics (United Kingdom)*, 53(1), 90–124. <https://doi.org/10.1111/agec.12665>.
- Clausen, T. H. (2014). The role of institutional arbitrage in the search for product innovation: Firm level evidence from Norway. *Industrial Marketing Management*, 43(3), 392–399. <https://doi.org/10.1016/j.indmarman.2013.12.007>.
- Clavijo, S. (2019). Siete años del TLC EE-UU- Colombia: balance y perspectivas. *La República*, <https://www.larepublica.co/analisis/sergio-clavijo-500041/siete-anos-del-tlc-ee-uu-colombia-balance-y-perspectivas-2937038>.

- Coe, D. T., & Helpman, E. (1993). International R&D Spillovers. National Bureau of Economic Research. <https://doi.org/10.3386/w4444>.
- Colombia University Mailman School Of Public Health. (2023). Difference-in-Difference estimation. <https://www.publichealth.columbia.edu/research/population-health-methods/difference-difference-estimation>.
- Conte, M., Cotterlaz P., & Mayer T. (2022). The CEPII Gravity database. CEPII Working Paper N°2022-05, July 2022.
- Curran-Everett, D. (2018). Explorations in statistics: The log transformation. *Advances in Physiology Education*, 42(2), 343–347. <https://doi.org/10.1152/ADVAN.00018.2018>.
- Dai, M., Yotov, Y. V., & Zylkin, T. (2014). On the trade-diversion effects of free trade agreements. *Economics Letters*, 122(2), 321–325. <https://doi.org/10.1016/j.econlet.2013.12.024>.
- De Grauwe, P. (2016). How far should we push globalization? CEPS Commentary. <https://www.ceps.eu/ceps-publications/how-far-should-we-push-globalisation/>.
- De, P. K., & Nagaraj, P. (2014). Productivity and firm size in India. *Small Bus. Econom.* 42 (4), 891–907. <http://dx.doi.org/10.1007/s11187--013--9504--x>.
- Dhyne, E., Petrin, A., Smeets, V., & Warzynski, F. (2017). *Multi Product Firms, Import Competition, and the Evolution of Firm-product Technical Efficiencies*. National Bureau of Economic Research.
- Dimick, J. B., & Ryan, A. M. (2014). Methods for Evaluating Changes in Health Care Policy: The Difference-in-Differences Approach. *JAMA : The Journal of the American Medical Association*, 312(22), 2401–2402. <https://doi.org/10.1001/jama.2014.16153>.
- Dirección de Metodología y Producción Estadística – DIMPE. (2024). Colombia - Estadísticas de exportaciones - EXPO - 2011 a 2024. <https://microdatos.dane.gov.co/index.php/catalog/472>.
- Eaton, J., Eslava, M., Kugler, M., & Tybout, J. (2007). Export Dynamics in Colombia: Firm-Level Evidence. National Bureau of Economic Research.
- European Commission. (2019). Negotiations and agreements—Trade. <https://ec.europa.eu/trade/policy/countries-and-regions/negotiations-and-agreements>.
- European Commission. (n.d.). Harmonised System. <https://trade.ec.europa.eu/access-to-markets/en/content/harmonised-system-0>.
- Fan, H., Lai, E. L.-C., & (Steffan) Qi, H. (2019). Trade liberalization and Firms’ export performance in China: Theory and evidence. *Journal of Comparative Economics*, 47(3), 640–668. <https://doi.org/10.1016/j.jce.2019.05.00>.
- Fernandes, A. M., & Paunov, C. (2010). Does Trade Stimulate Innovation?: Evidence from Firm-Product Data. In *Does Trade Stimulate Innovation? Evidence from Firm-Product Data*. OECD Publishing.
- Fox, J. W. (2004). Regional trade agreements: A tool for development? PPC Evaluation Working Paper No.15. <https://www.oecd.org/derec/unitedstates/35933797.pdf>.
- Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, Vol. 19 No. 2, pp. 110–132.

- Gebel, M., & Voßemer, J. (2014). The impact of employment transitions on health in Germany. A difference-in-differences propensity score matching approach. *Social Science and Medicine*, 108, 128–136. <https://doi.org/10.1016/j.socscimed.2014.02.039>.
- Gerber, A. S., & Green, D. P. (2012). *Field experiments : design, analysis, and interpretation*. New York: W. W. Norton.
- Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., & Vermeersch, C. M. J. (2011). *Impact Evaluation in Practice*. World Bank.
- Gilchrist, D., Emery, T., Garoupa, N., & Spruk, R. (2023). Synthetic Control Method: A tool for comparative case studies in economic history. *Journal of Economic Surveys*, 37(2), 409–445. <https://doi.org/10.1111/joes.12493>.
- Goldberg, P., Khandelwal, A., Pavcnik, N., & Topalova, P. (2010). Imported intermediate inputs and domestic product growth: evidence from India. *Quarterly Journal of Economics* 125 (4), 1727–1767.
- Görg, H., Kneller, R., & Muraközy, B. (2012). What makes a successful export? Evidence from firm-product-level. *The Canadian Journal of Economics*, 45(4), 1332–1368. <https://doi.org/10.1111/j.1540-5982.2012.01734.x>.
- Gracia, O., & Zuleta H. (2004). *The Free Trade Agreement between Colombia and USA: What can happen to Colombia?* Investigación Económica Aplicada en Colombia 1485, Fundación Pondo.
- Grossman, G. M., & Helpman, E. (1991). Trade, knowledge spillovers, and growth. *European Economic Review*, 35(2), 517–526. [https://doi.org/10.1016/0014-2921\(91\)90153-A](https://doi.org/10.1016/0014-2921(91)90153-A).
- Gu, W., Sawchuk, G., & Rennison, L. W. (2003). The Effect of Tariff Reductions on Firm Size and Firm Turnover in Canadian Manufacturing. *Review of World Economics*, 139(3), 440–459. <https://doi.org/10.1007/BF02659670>.
- Gurtu, A., Johny, J., & Chowdhary, R. (2022). Effects of Free Trade Agreements on Trade Activities of Signatory Countries. *The Indian Economic Journal*, 70(3), 490–513. <https://doi.org/10.1177/00194662221104750>.
- Hall, B. H. (2011). *Innovation and Productivity*. NBER Working Paper No. 17178, June.
- Halpern, L., Koren, M., & Szeidl, A. (2009). *Imported inputs and Productivity*. Mimeo. Older version: CEPR N. 5139, 2005.
- Harmon, N. A. (2022). *Difference-in-Differences and Efficient Estimation of Treatment Effects*. Working Paper, University of Copenhagen.
- Haq, M., Saeed, J., & Akram, M. (2021). Exploring the Advantages and Disadvantages of the China–Pakistan Free Trade Agreement. *China & World Economy*, 29(3), 83–103. <https://doi.org/10.1111/cwe.12364>.
- Heckman, J., & Hotz, V. (1989). Choosing among alternative nonexperimental methods for estimating the impact of social programs – the case of manpower training. *Journal of the American Statistical Association*, 84(408), 862–874. <https://doi.org/10.2307/2290059>.
- Hernández, G. (2014). Una revisión de los efectos del Tratado de Libre Comercio entre Colombia y Estados Unidos. *Lecturas de Economía*, (80), 49–77. <https://doi.org/10.17533/udea.le.n80a2>.

- Hitt, M.A., Hoskisson, R.E. & Ireland, R.D. (1994). A Mid-Range Theory of the Interactive Effects of International and Product Diversification on Innovation and Performance. *Journal of Management*, 20, 297-326. <https://doi.org/10.1177/014920639402000203>.
- Hsiao, C. (2007). Panel data analysis—advantages and challenges. *Test (Madrid, Spain)*, 16(1), 1–22. <https://doi.org/10.1007/s11749-007-0046-x>.
- International Trade Administration. (n.d.). Understanding HS Codes and the Schedule B. <https://www.trade.gov/harmonized-system-hs-codes>.
- Kafourous, M. I., Buckley, P. J., Sharp, J. A., & Wang, C. (2008). The role of internationalization in explaining innovation performance. *Technovation*, 28(1-2), 63-74. <https://doi.org/10.1016/j.technovation.2007.07.009>.
- Karabulut, G., Bilgin, M. H., & Doker, A. C. (2020). The relationship between commodity prices and world trade uncertainty. *Economic Analysis and Policy*, 66, 276–281. <https://doi.org/10.1016/j.eap.2020.05.001>.
- Kasahara, H., & Rodrigue, J. (2008). Does the use of imported intermediates increase productivity? Plant-level evidence. *Journal of Development Economics*, 87(1), 106–118. <https://doi.org/10.1016/j.jdeveco.2007.12.008>.
- Keuschnigg, C., Kohler W., Casella A. & Sapir A. (1996). Austria in the European Union: Dynamic gains from integration and distributional implications. *Economic Policy*, Vol. 11, No. 22, pp. 155–211.
- Kleinknecht, A., Van Montfort, K., & Brouwer, E. (2002). The Non-Trivial Choice between Innovation Indicators. *Economics of Innovation and New Technology*, 11(2), 109–121. <https://doi.org/10.1080/10438590210899>.
- Klenow, P., & Rodriguez-Clare, A. (1997). Quantifying Variety Gains from Trade Liberalization.
- Kugler, M., & Verhoogen, E. (2009). Plants and Imported Inputs: New Facts and an Interpretation. *The American Economic Review*, 99(2), 501–507. <https://doi.org/10.1257/aer.99.2.501>.
- Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, 27(2), 131–150. <https://doi.org/10.1002/smj.507>.
- Lechner, M. (2010). The Estimation of Causal Effects by Difference-in-Difference Methods. University of St. Gallen Department of Economics working paper series 2010 2010-28, Department of Economics, University of St. Gallen.
- Lee, H.-H., Koo, C. M., & Park, E. (2008). Are Exports of China, Japan and Korea Diverted in the Major Regional Trading Blocs? *World Economy*, 31(7), 841–860. <https://doi.org/10.1111/j.1467-9701.2008.01105.x>.
- Lileeva, A., & Trefler, D. (2010). Improved Access to Foreign Markets raises Plant-Level Productivity...for Some Plants. *The Quarterly Journal of Economics*, 125(3), 1051–1099. <http://www.jstor.org/stable/27867506>.
- Lombana, M. P. (2020). Free Trade Agreements Between Peru, Colombia, and the United States. *American Journal of Economics and Sociology*, 79(1), 199–232. <https://doi.org/10.1111/ajes.12312>.
- Mallinguh, E., Wasike, C., Bilan, Y., & Zoltan, Z. (2022). The impact of firm characteristics, business competitiveness, and technology upgrade hurdles on R&D costs. *Problems and Perspectives in Management*. 20. 264-277. [10.21511/ppm.20\(4\).2022.20](https://doi.org/10.21511/ppm.20(4).2022.20).

- Mangiafico, S. (2016). Summary and Analysis of Extension Program Evaluation in R.
- Mao, Q., & Sheng, B. (2017). The impact of tariff reductions on firm dynamics and productivity in China: Does market-oriented transition matter? *China Economic Review*, 45, 168–194. <https://doi.org/10.1016/j.chieco.2017.07.011>.
- Martin, C., & Ramírez, J. (2005). El impacto económico de un acuerdo parcial de libre comercio entre Colombia y Estados Unidos, Borradores de Economía-Banco de la República (326).
- Martin, J. P. (1978). X-Inefficiency, Managerial Effort and Protection. *Economica*, 45(179), 273–286.
- Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695–1725. <https://doi.org/10.1111/1468-0262.00467>.
- Michalek, J. (2012). Counterfactual impact evaluation of EU rural development programmes-Propensity Score Matching methodology applied to selected EU Member States. Volume 1: A micro-level approach.
- Montiel Paternina, S. (2013). Impacto del tlc con estados unidos sobre los sectores económicos colombianos. *Saber, Ciencia Y Libertad*, 8(1), 125–130. <https://doi.org/10.18041/2382-3240/saber.2013v8n1.1885>.
- Office of the United States Trade Representative. (n.d.). United States-Colombia Trade Promotion Agreement. <https://ustr.gov/trade-agreements/free-trade-agreements/colombia-tpa>.
- Office of the United States Trade Representative. (2007). Third Report to the Congress on the Operation of the Andean Trade Preference Act as Amended. http://www.sice.oas.org/tpd/usa_atpa/Studies/2001Report_e.pdf.
- Owen, E. (2017). Exposure to Offshoring and the Politics of Trade Liberalization: Debate and Votes on Free Trade Agreements in the US House of Representatives, 2001–2006, *International Studies Quarterly*, Volume 61, Issue 2, June 2017, Pages 297–311, <https://doi.org/10.1093/isq/sqx020>.
- Özçelik, E., & Taymaz, E. (2004). Does innovativeness matter for international competitiveness in developing countries?: The case of Turkish manufacturing industries. *Research Policy*, 33(3), 409–424. <https://doi.org/10.1016/j.respol.2003.09.011>.
- Ping, L., & Shuai, K. (2011). The effect of free trade area on technology innovation: An analysis of mechanism and empirical test. 2011 International Conference on E-Business and E-Government (ICEE), 1–4. <https://doi.org/10.1109/ICEBEG.2011.5881855>.
- Relyea, C. W., Tejada, S. L., Fish, K. E., & Guha, G.-S. (2011). Laissez faire and international trade: a critique of the proposed United States-Colombia Free Trade Agreement. *Journal of International Business Research*, 10(1), 47–.
- Rémont, A. (2016). The United States-Colombia Free Trade Agreement : Before and After. https://www.academia.edu/34791275/The_Colombia-_United_States_Free_Trade_Agreement.
- Ricardo, D. (1817). *On the Principles Of Political Economy And Taxation*, London: John Murray.
- Rivera-Batiz, L. A., & Romer, P. M. (1991). Economic Integration and Endogenous Growth. *The Quarterly Journal of Economics*, 106(2), 531–555. <https://doi.org/10.2307/2937946>.
- Rodrik, D. (2018). What Do Trade Agreements Really Do? *Journal of Economic Perspectives*, 32 (2): 73-90. DOI: 10.1257/jep.32.2.73.

- Romero, A. (2006). Colombia-USA Free Trade Agreement (El TLC Colombia-USA). *Tendencias*, Vol. VII, No. 2, pp. 29-68. <https://ssrn.com/abstract=957133>.
- Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41–55. <https://doi.org/10.1093/biomet/70.1.41>.
- Rubin, D. B. (1977). Assignment to Treatment Group on the Basis of a Covariate. *Journal of Educational Statistics*, 2(1), 1-26. <https://doi.org/10.3102/10769986002001001>.
- Ryan, A. M., Burgess Jr, J. F., & Dimick, J. B. (2015). Why We Should Not Be Indifferent to Specification Choices for Difference-in-Differences. *Health Services Research*, 50(4), 1211–1235. <https://doi.org/10.1111/1475-6773.12270>.
- Santos Silva, J. M. C., & Tenreyro, S. (2011). Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator. *Economics Letters*, 112(2), 220–222. <https://doi.org/10.1016/j.econlet.2011.05.008>.
- Sarker, R., & Jayasinghe, S. (2007). Regional trade agreements and trade in agri-food products: evidence for the European Union from gravity modeling using disaggregated data. *Agricultural Economics*, 37(1), 93–104. <https://doi.org/10.1111/j.1574-0862.2007.00227.x>.
- Schiersch, A. (2013). Firm size and efficiency in the German mechanical engineering industry. *Small Bus. Econom.* 40 (2), 335–350. <http://dx.doi.org/10.1007/s11187--012--9438--8>.
- Schott, J. (2004). *Free Trade Agreements: US Strategies and Priorities*. Washington, DC: Peterson Institute for International Economics. <https://www.piie.com/bookstore/free-trade-agreements-us-strategies-and-priorities>.
- Schumpeter, J. A. (1942). *Capitalism, Socialism, and Democracy*. New York, NY: Harper and Brothers.
- Shu, P., & Steinwender, C. (2019). The Impact of Trade Liberalization on Firm Productivity and Innovation. *Innovation Policy and the Economy*, 19(1), 39–68. <https://doi.org/10.1086/699932>.
- Smith, J. (2000). A Critical Survey of Empirical Methods for Evaluating Active Labor Market Policies. *Swiss Journal of Economics and Statistics (SJES)*. 136. 247-268.
- Stoyanov, A., & Yildiz, H. M. (2015). Preferential versus multilateral trade liberalization and the role of political economy. *European Economic Review*, 80, 140–164. <https://doi.org/10.1016/j.euroecorev.2015.09.003>.
- Syversen, C. (2011). What Determines Productivity? *Journal of Economic Literature*, 49(2), 326–365.
- Tellis, G. J., Prabhu J. C., & Chandy R. K. (2009). Radical innovation across nations: The preeminence of corporate culture. *Journal of Marketing* 73 (1): 3–23.
- The World Bank. (n.d.). DataBank – World Development Indicators. <https://databank.worldbank.org/source/world-development-indicators>
- Tybout, J. R. (2000). Manufacturing Firms in Developing Countries: How Well Do They Do, and Why? *Journal of Economic Literature*, 38(1), 11–44. <https://doi.org/10.1257/jel.38.1.11>.
- Valencia, M. (2022). Balance de los diez años del TLC con Estados Unidos: negativo y costoso en Razón Pública. <https://razonpublica.com/balance-los-diez-anos-del-tlc-estados-unidos-negativo-costoso/>.
- Van Biesebroeck, J. (2005). Firm size matters: Growth and productivity growth in african manufacturing. *Econom. Dev. Cult. Chang.* 53 (3), 545–583. <http://dx.doi.org/10.1086/426407>.

- Villarreal, M. A. (2011). ATPA Renewal: Background and Issues. CRS Report RS22548 for Congress. www.crs.gov.
- Villarreal, M. A. (2012). The United States-Colombia Free Trade Agreement: Background and Issues. *Current Politics and Economics of South and Central America*, 5(1/2), 47-.
- Westphal, L. E. (2002). Technology Strategies For Economic Development In A Fast Changing Global Economy. *Economics of Innovation and New Technology*, 11(4-5), 275-320. <https://doi.org/10.1080/10438590200000002>.
- Wonnacott, R. J. (1996). Free-trade agreements: for better or worse? *The American Economic Review*, 86(2), 62-66.
- Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics Letters*, 104(3), 112-114. <https://doi.org/10.1016/j.econlet.2009.04.026>.
- World Health Organization. (n.d.). Gross Domestic Product (GDP), per capita, international \$ (PPP-adjusted). <https://www.who.int/data/gho/indicator-metadata-registry/imr-details/1145>.
- World Trade Organization. (n.d.). Regional Trade Agreements – Database. <https://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>.
- WTO. (n.d.). Glossary term, HS 6-digit. https://www.wto.org/english/thewto_e/glossary_e/hs6_e.htm.
- Yeaple, S. R. (2005). A Simple Model of Firm Heterogeneity, International Trade and Wages. *Journal of International Economics* 65: 1-20.
- Zhang, Y., & Wan G. (2017). Exploring the Trade–Urbanization Nexus in Developing Economies: Evidence and Implications. ADBI Working Paper 636. Tokyo: Asian Development Bank Institute. Available: <https://www.adb.org/publications/exploring-tradeurbanization-nexus-developing-economies>.

List of Figures

Figure 1: Breakdown of Colombian export sales by destination in 2011	15
Figure 2: Evolution of Colombian export sales per destination	16
Figure 3: Graphical representation of coefficients of interest in the DiD model	24
Figure 4: Propensity Score Mapping.....	47
Figure 5: Distribution of propensity scores before and after matching for treated and control units	48
Figure 6: Event study plot Export Sales before matching	49
Figure 7: Event study plot Export Sales after matching	49
Figure 8: Total number of Colombian firms exporting to the United States compared to synthetic control country.....	56
Figure 9: Synthetic Control Model visualisation of United States and synthetic control country	57
Figure 10: Difference in trends outcome variable United States and synthetic control country	57
Figures 11 and 12: SCM plot and corresponding effect for 20 percent smallest firms	59
Figures 13 and 14: SCM plot and corresponding effect for 5 percent largest firms	59
Figure 15: Placebo test in time	60
Figure 16: Visualisation of treatment effects for different placebo runs (in space)	61

List of Tables

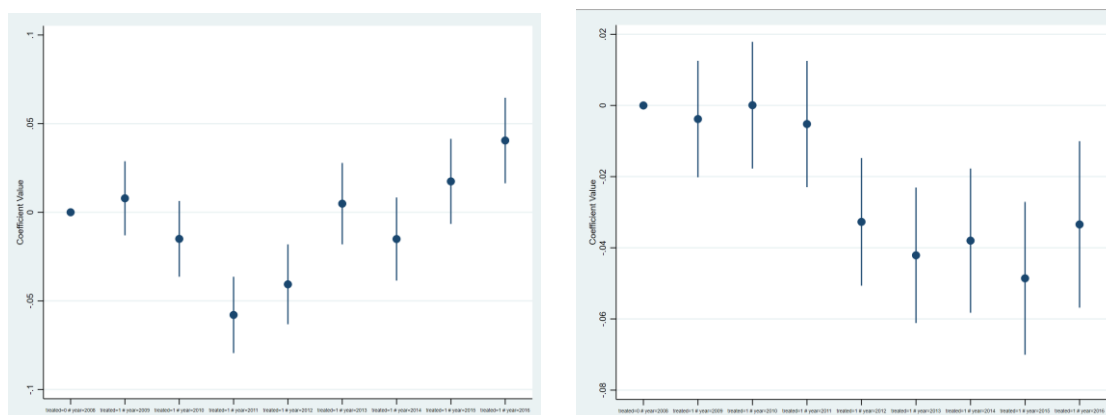
Table 1: Breakdown of 5 most exported products from Colombia to United States	20
Table 2: Coefficients of interest in the DiD model	24
Table 3: Descriptive Statistics of variables included in the additional dataset	32
Table 4: Distribution of observations according to treatment status and period	37
Table 5: Regression Results on β_3 Coefficient for $\ln(\text{Export Sales})$	46
Table 6: Matching quality output retrieved from STATA.....	47
Table 7: Evidence for common support.....	47
Table 8: Regression Results on β_3 Coefficient for $\ln(\text{Product Portfolio})$	50
Table 9: Regression Results on β_3 Coefficient for Product Innovation	51
Table 10: Heterogeneity analysis for export sales and product portfolio	52
Table 11: Heterogeneity analysis for product innovation	53
Table 12: Overview of countries with the highest assigned weights in the synthetic control country (18 out of 87).....	58
Table 13: Predictor Balance	58

Appendices

Appendix A: Skewness and Kurtosis value for Export Sales and Product Portfolio

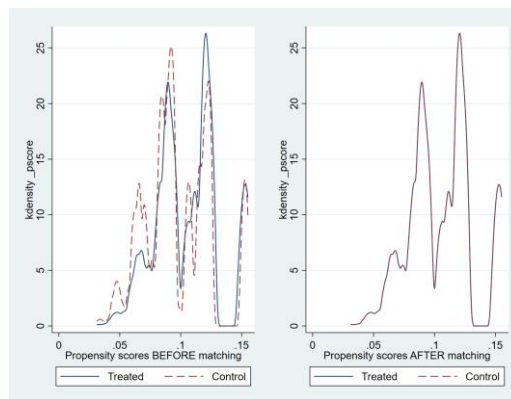
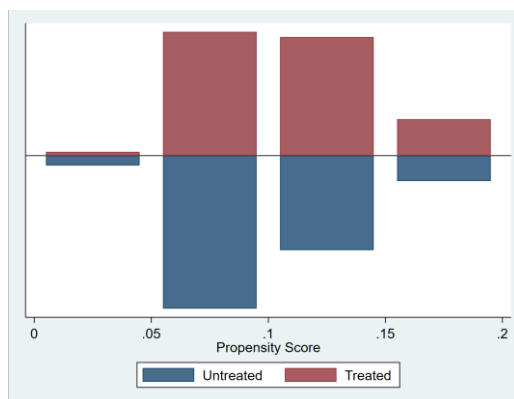
	<i>Export Sales</i>	<i>Product Portfolio</i>
Skewness Value	254.367	3.523
Pr(skewness)	0.000	0.000
Kurtosis Value	83,308.79	20.679
Pr(kurtosis)	0.000	0.000

Appendix B: Event Study Plots Product Portfolio



Appendix C: Matching diagnostics Product Portfolio

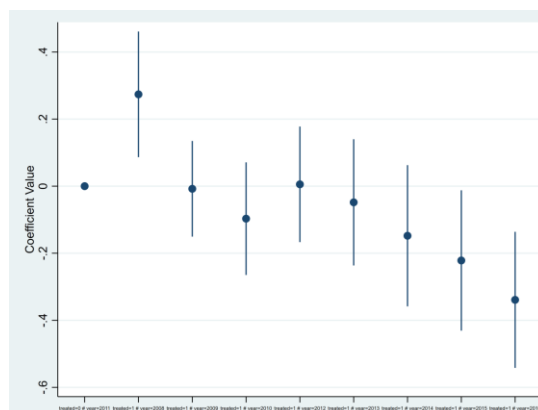
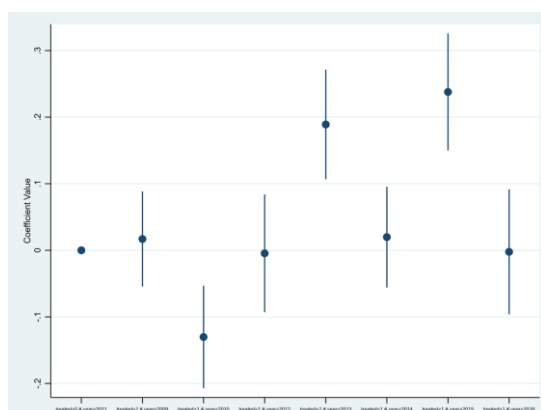
<i>Treatment assignment</i>	<i>On support</i>	<i>Total</i>
Untreated	164,595	164,595
Treated	18,017	18,017
Total	182,612	182,612



Variable	Mean		%bias	T-test		$V(T) / V(C)$
	Treated	Control		t	P > t	
FP differentiation	1.488	1.488	0.0	0.00	1.000	1.00
FP geography	1.639	1.639	0.0	0.02	0.985	1.00
FP size	1.327	1.327	0.0	0.00	1.000	1.00
Sector	57.662	57.671	-0.0	-0.04	0.970	1.00

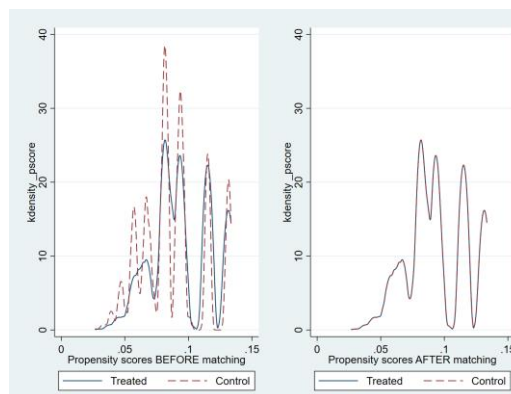
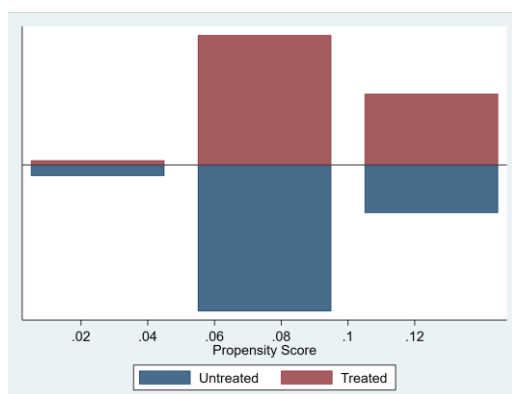
Ps R2	LR chi2	P > chi2	MeanBias	MedBias	B	R	% Var
0.000	0.00	1.000	0.0	0.0	0.0	1.00	0

Appendix D: Event Study Plots Product Innovation



Appendix E: Matching diagnostics Product Innovation

<i>Treatment assignment</i>	<i>On support</i>	<i>Total</i>
Untreated	211,822	211,822
Treated	20,415	20,415
Total	232,237	232,237



Variable	Mean		%bias	T-test		V(T) / V(C)
	Treated	Control		t	P > t	
FP differentiation	1.498	1.498	0.0	0.02	0.987	1.00
FP geography	1.581	1.581	- 0.0	-0.02	0.986	1.00
FP size	1.332	1.332	- 0.0	-0.01	0.992	1.00
Sector	57.92	57.92	0.0	0.01	0.995	1.00

Ps R2	LR chi2	P > chi2	MeanBias	MedBias	B	R	% Var
0.000	0.00	1.000	0.0	0.0	0.0	1.00	0

Appendix F: Robustness checks

<i>Export Sales</i>	<i>Top products</i>	<i>FTA</i>	<i>Product Portfolio</i>	<i>Top products</i>	<i>FTA</i>	<i>Product innovation</i>	<i>Top products</i>	<i>FTA</i>
Model 1	0.097***	0.110***	Model 1	0.034***	0.036***	Model 1	0.089***	0.162***
	4.80	5.41		6.11	6.74		6.04	10.83
	693,844	574,948		693,844	574,948		584,297	477,928
	0.4703	0.4821		0.7756	0.7925		0.6142	0.5849
Model 2	0.070***	0.073***	Model 2	0.025***	0.030***	Model 2	0.090***	0.121***
	3.80	3.97		4.33	5.38		5.02	6.14
	602,832	493,010		602,832	493,010		489,391	392,463
	0.6637	0.6737		0.8230	0.8345		0.7160	0.6986
Model 3	.0754***	0.078***	Model 3	0.017***	0.016***	Model 3	0.124***	0.111***
	3.87	4.03		2.90	2.72		6.11	5.03
	519,455	425,655		519,455	425,655		380,066	302,648
	0.6582	0.6687		0.8187	0.8308		0.6496	0.6594
Parallel trends?	Yes	No	Parallel trends?	No	No	Parallel trends?	No	No
Matching	-0.106***	-0.086***	Matching	-0.039***	-0.035***	Matching	-0.143***	-0.157***
	-5.71	-4.78		-7.44	-7.11		-3.02	-3.08
	72,288	77,706		72,288	77,706		63,393	66,741
	0.8794	0.8822		0.9462	0.9505		0.7306	0.7238
Parallel trends?	Yes	Yes	Parallel trends?	Yes	Yes	Parallel trends?	Yes	no

Appendix G: Predictor balance with total number of active firms as dependent variable

	Treated	Synthetic
ActiveFirms (2008)	2247	2117.348
ActiveFirms(2009)	2186	2014.056
ActiveFirms (2010)	2100	2104.452
ActiveFirms (2011)	2015	2229.56
Log GDPcap PPP	3.879	2.267
Log pop	12.638	9.478
Log trade	3.347	4.200
Log shipping connectivity	4.338	3.153
WTO membership	1	1
Legal old	3	1

Appendix H: Comprehensive weight assignment SCM large donor pool

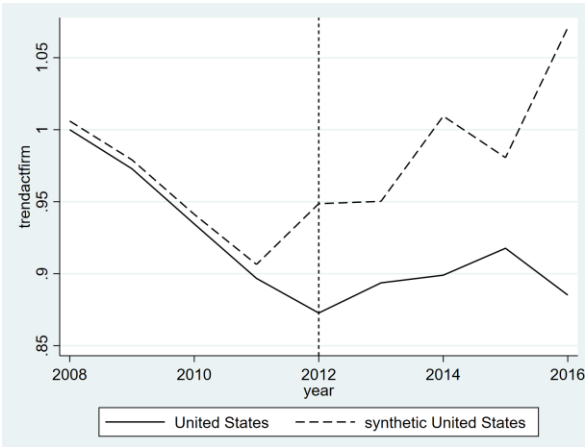
<i>Country</i>	<i>Unit Weight</i>	<i>Country</i>	<i>Unit Weight</i>	<i>Country</i>	<i>Unit Weight</i>	<i>Country</i>	<i>Unit Weight</i>
Albania	0.035	Algeria	0.003	Jamaica	0.011	Saudi Arabia	0.007
Angola	0.008	Ecuador	0.008	Jordan	0.007	Senegal	0.007
Argentina	0.008	Egypt	0.017	Japan	0.008	Singapore	0.008
Australia	0.005	Spain	0.011	Kenya	0.005	El Salvador	0.009
Belgium	0.009	Estonia	0.008	South Korea	0.007	Slovenia	0.005
Benin	0.004	Finland	0.007	Lebanon	0.006	Tunesia	0.002
United Arab Emirates	0.009	Dominican Republic	0.008	Italy	0.008	Russian Federation	0.009
Bangladesh	0.012	Fiji	0.041	Lithuania	0.005	Tanzania	0.005
Bulgaria	0.247	France	0.007	Latvia	0.008	Ukraine	0.007
Bahamas	0.009	United Kingdom	0.01	Morocco	0.011	Uruguay	0.006
Belize	0.009	Georgia	0.004	Madagascar	0.023	South Africa	0.008
Brazil	0.007	Ghana	0.005	Mexico	0.009	Dominica	0.019
Barbados	0.01	Guinea	0.011	Malta	0.007	Denmark	0.043
Canada	0.008	Greece	0.014	Nicaragua	0.009	Iceland	0.008
Chile	0.007	Guatemala	0.008	The Netherlands	0.007	Israel	0.01
China	0.006	Hong Kong SAR	0.007	Norway	0.007	Paraguay	0.007
Cote d'Ivoire	0.006	Honduras	0.008	New Zealand	0.007	Qatar	0.006
Cameroon	0.006	Croatia	0.004	Panama	0.009	Germany	0.009
Congo Rep.	0.004	Haiti	0.007	Peru	0.007	Iraq	0.006
Costa Rica	0.009	India	0.007	Philippines	0.011	Portugal	0.007
Cyprus	0.005	Ireland	0.012	Poland	0.006	Turkey	0.004

Root Mean Squared Prediction Error: 1.95e-14 (pre)

Appendix I: Placebo test in space – PRE/POST ratios

<i>Country</i>	<i>Ratio</i>	<i>Country</i>	<i>Ratio</i>	<i>Country</i>	<i>Ratio</i>	<i>Country</i>	<i>Ratio</i>
Albania	2.088	Algeria	5.652	Jamaica	48.872	Saudi Arabia	196.029
Angola	811.723	Ecuador	45.481	Jordan	231.943	Senegal	73.880
Argentina	179.975	Egypt	811.	Japan	58.979	Singapore	101.981
Australia	225.201	Spain	13.295	Kenya	151.296	El Salvador	20.816
Belgium	177.793	Estonia	4.513	South Korea	78.660	Slovenia	255.419
Benin	6.029	Finland	71.226	Lebanon	97.158	Tunesia	1.155
United Arab Emirates	103.515	Dominican Republic	33.329	Italy	23.482	Russian Federation	38.891
Bangladesh	155.205	Fiji	1.833	Lithuania	1302.202	Tanzania	3.43 e+07
Bulgaria	7.593	France	21.838	Latvia	3376.077	Ukraine	138.024
Bahamas	36.101	United Kingdom	31.393	Morocco	164.746	Uruguay	32.616
Belize	293.644	Georgia	158.632	Madagascar	2.001	South Africa	57.967
Brazil	50.148	Ghana	136.854	Mexico	8.142	Dominica	52.231
Barbados	17.795	Guinea	15.432	Malta	478.623	Denmark	21.274
Canada	16.285	Greece	438.567	Nicaragua	72.983	Iceland	1.737
Chile	28.033	Guatemala	24.403	The Netherlands	85.455	Israel	34.549
China	139.107	Hong Kong SAR	28.909	Norway	119.870	Paraguay	125.056
Cote d'Ivoire	444.975	Honduras	28.855	New Zealand	50.298	Qatar	488.453
Cameroon	199.127	Croatia	8.717	Panama	15.399	Germany	42.720
Congo Rep.	64.950	Haiti	81.770	Peru	45.418	Iraq	32.741
Costa Rica	10.229	India	245.76	Philippines	48.411	Portugal	63.327
Cyprus	20.901	Ireland	67.698	Poland	320.731	United States	40.875
Turkey	106.705						

Appendix J: SCM without countries that signed an FTA in during the period investigated



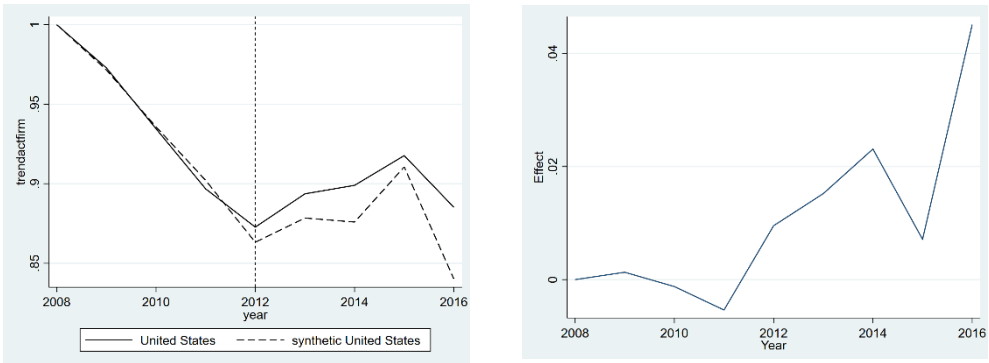
Appendix K: Weight assignment and predictor balance smaller donor pool

RMSPE | 0.0028

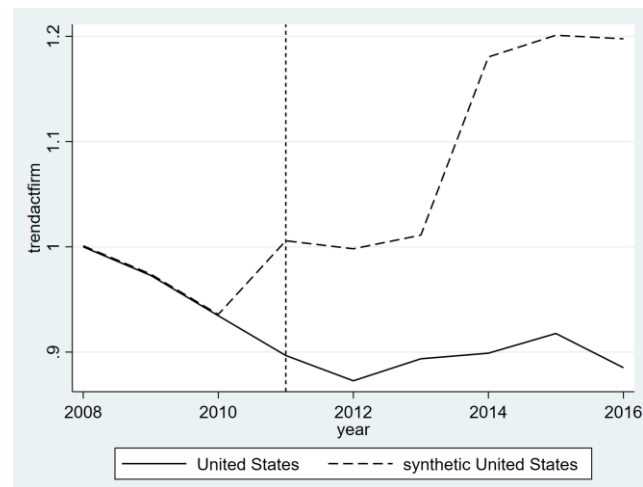
Country	Unit weight
United Kingdom	0.834
Ireland	0.054
Israel	0.112

	Treated	Synthetic
Trendactfirm(2009)	0.973	0.972
Trendactfirm(2010)	0.935	0.936
Trendactfirm(2011)	0.897	0.902
Log GDPcap PPP	3.879	3.560
Log pop	12.638	10.665
Log trade	3.347	4.149
Log shipping connectivity	4.338	4.103
Legal old	3	3

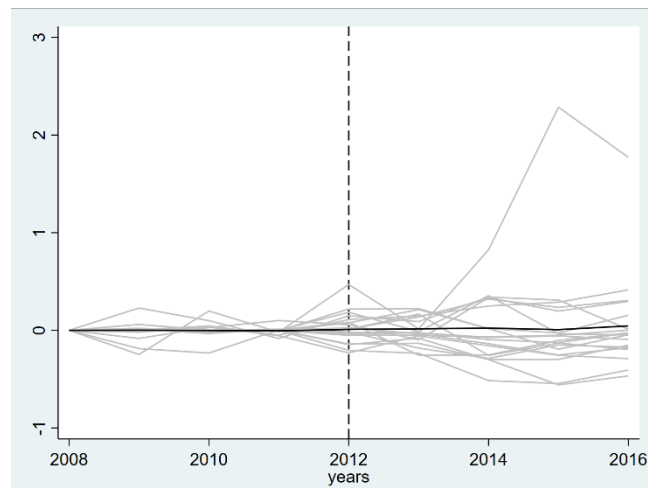
Appendix L: Visualisation of effect on outcome variable for United States and comparison with corresponding synthetic control unit smaller donor pool



Appendix M: Placebo test in time smaller donor pool



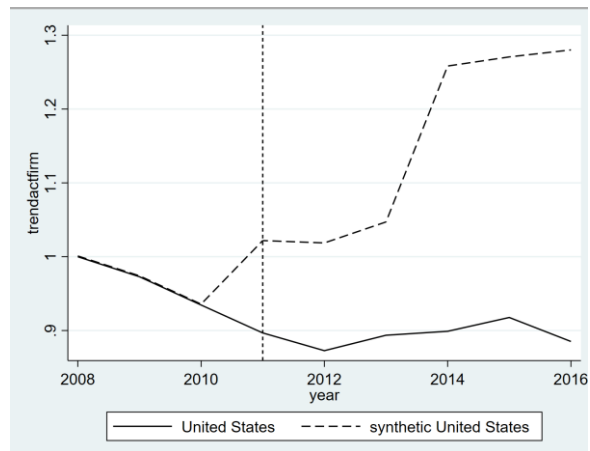
Appendix N: Placebo test in space smaller donor pool with corresponding POST/PRE RMSPE ratios



Country	Post/ Pre RMSPE ratio	Country	Post/ Pre RMSPE Ratio
United Arab Emirates	12.58015	Japan	150.8382
Argentina	332.3853	South Korea	302.664
Australia	5.63208	The Netherlands	17.17778
Brazil	4294.583	Norway	1.676116
Canada	72.20161	New Zealand	72.47582
Germany	45.53936	Qatar	8.594673
France	178.3272	Singapore	8.007604
United Kingdom	4.403615	Turkiye	3.370633
Ireland	1.14731	United States	8.56219
Israel	6.387411	South Africa	130.4325

Placebo test in space → p-value = 0.65

Appendix O: SCM without countries that signed an FTA in during the period investigated smaller donor pool



FACULTY OF BUSINESS AND ECONOMICS

Naamsestraat 69 bus 3500

3000 LEUVEN, België

feb.leuven@kuleuven.be

www.feb.kuleuven.be



LID VAN **ASSOCIATIE
KU LEUVEN**