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UNIVERSITY OF PRETORIA
Department of Economics

Essays on Technological Trade Composition and Capital Goods Imports

By

BLESSING CHIPANDA

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SUPERVISOR: PROFESSOR MATTHEW CLANCE

CO-SUPERVISORS:

PROFESSOR STEVEN F. KOCH

DOCTOR CAROLYN CHISADZA

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Abstract

Recent international trade literature emphasised the importance of countries' technological trade composition structures (both exports and imports) in enhancing economic growth and development. Yet Africa's trade has been analysed at a macroeconomic aggregate level and export-led growth dominates the literature. The role played by imports is almost completely neglected, despite the continent being far removed from the world technology frontier. In the literature, those countries that are far removed from the technological frontier can benefit from importing capital technologies to the extent that can enable their ability to export such goods.

The objectives of this thesis are 1) to examine the structures of Africa's technological trade composition (both exports and imports) and determine how they have changed over the period 1980-2015 in relation to developed and other developing regions; 2) to investigate the effects of importing capital goods on the technological export composition; and (3) to establish the determinants of capital goods imports in developing countries, particularly in Africa.

The first paper provides a comprehensive analysis of Africa's trade composition spanning 1980-2015. I decompose Africa's trade into five categories: primary goods, resource-based, low, medium, and high technology manufactured goods. I find that Africa's imports are concentrated in capital goods and its export composition is highly concentrated in primary goods, which has contributed to the decline in Africa's share of global exports. I also find that regions within Africa have similar technological trade composition structures.

The second paper investigates the effect of capital goods imports on technological export composition in developing countries. The findings reveal that capital goods imports have a positive effect on technological export composition in developing countries. The findings also show that the positive effect of capital goods imports on technological export composition is larger in developing countries relative to developed economies. In Africa, capital goods imports also have a positive effect on technological export composition. However, the positive effect of capital goods imports on high technology exports is smaller in Africa relative to the average for other developing countries.

The third paper investigates the determinants of capital goods imports in developing countries. The findings reveal that financial development, infrastructure investment, and institutions are important determinants of capital goods imports in developing countries.

The findings also indicate that financial development has greater benefits in developing countries relative to developed countries. In Africa, financial development and infrastructure investment are key determinants of capital goods imports, with infrastructure investment being critical in landlocked nations.

The overall findings in this thesis highlight the importance of capital goods imports in achieving export composition diversification, and hence economic growth. Furthermore, the findings reveal the importance of development factors that can complement capital goods imports, which can result in increased export composition diversification and economic growth. The findings may assist policymakers to (1) examine national trade structures, specifically to see how faster they have transformed over time; (2) understand the source of Africa's underperforming trade, which is highly documented in the literature; (3) have a good understanding of the linkages between capital goods imports, technological export composition, and the rest of the economy; and (4) attain the best trade and industrial policies for their economies.

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Declaration

I, Blessing Chipanda, declare that this thesis titled, "*Essays on technological trade composition and capital goods imports*" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a Doctor of Philosophy degree at the University of Pretoria.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at the University of Pretoria or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed: Blessing Chipanda

Date: December 2021

TABLE OF CONTENTS

List of Tables

Table **Page**

List of Figures

Figure **Page**

CHAPTER 1

INTRODUCTION

Classical trade theories (see e.g., Heckman, 1977; Smith, 1937) predict welfare gains from trade liberalisation, through productivity enhancement and innovation. In Rosenberg and Nathan (1982), the success of many developed economies today is related to globalisation that spread new industrial technologies. For example, the success of the British economy is linked to the industrial revolution and foreign trade, in particular, the success of its exports (see, Rosenberg and Nathan, 1982). Similarly, the East Asian Miracle is related to globalisation and the benefit of efficient utilisation of foreign industrial technologies (i.e., capital goods), which enhanced the productivity of exporting firms and their economies (World Bank, 1993). The African continent, however, for the most part has failed to take advantage of globalisation, as several studies document underperforming trade (see e.g., Abrego et al., 2020; Brenton and Isik, 2012; Francois and Manchin, 2013; Tafirenyika, 2014).

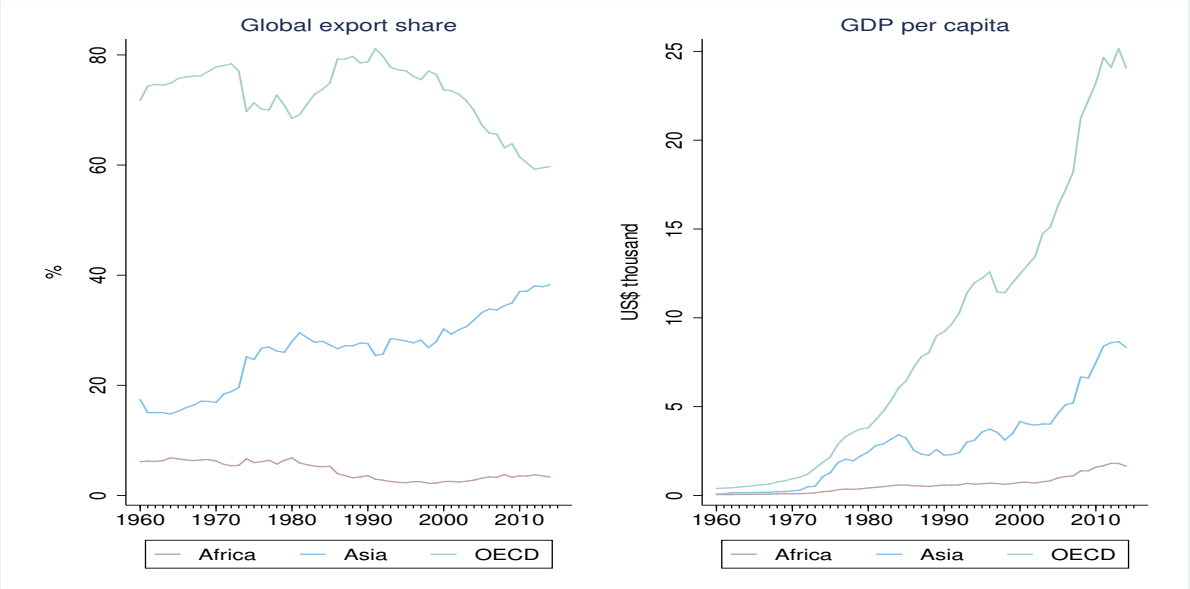
Although Africa has made significant advancements to liberalise and increase the number of signed free/preferential trade agreements, [1] its share of world trade has remained low, and the continent remains the poorest region of the world (see Figure 1.1).[2] Several studies on Africa

[1] The number of signed trade agreements include the African Continental Free Trade Area (AfCFTA), African Growth and Opportunity Act (AGOA), Economic Partnership Agreements (EPAs), Tripartite Free Trade Area (TFTA), and China trade-investment agreements with most African countries

[2] This contrasts with the trends in emerging Asian economies where increasing trade share and economic growth has been associated with trade liberalisation.

also tend to focus on aggregate trade level and mostly on exports, the role played by imports is almost completely neglected, despite the continent being far removed from the world technology frontier.[3] Imports of industrial technologies may be of major importance to African countries whose manufacturing firms are at early stages of development (see e.g., Bos and Vannoorenberghe, 2019; Mo et al., 2021; Mutreja et al., 2018).[4] Foreign technologies may also enable African countries to allocate their natural resources more efficiently which can increase their total factor productivity (TFP). Moreover, industrialisation through trade has long been identified as one of the critical pillars of much hoped growth and development (see e.g., Dufrenot et al., 2010; Ee, 2016; Elhiraika et al., 2014; Fosu and Abass, 2019; IMF, 2016; UNECA, 2015).

Figure 1.1: Historical global export share and per capita income, 1960-2014



Source: Author's calculations using Centre d'Études Prospectives et d'Informations Internationales (CEPII) and WDIs data.

In the Ricardian model, patterns of bilateral trade are determined by the differences in labour productivity ratios. Whilst in Coe and Helpman (1995); Eaton and Kortum (1999); Grossman and Helpman (1991); Mutreja et al. (2018), labour productivity asymmetry between coun-

[3] In Mutreja et al. (2018), about 80% of world capital goods production is highly concentrated in 10 developed economies.

[4] Countries such as Chile, China, India, Malaysia, and Taiwan were at stages of economic development quite similar to those in African countries today, they produced primary goods. However, by adopting capital goods from developed countries, they quickly diversified their exports away from primary goods to more manufactured goods (see Chandra, 2006).

tries can be bridged by importing industrial technologies that enhance labour productivity. In Eaton and Kortum (2001); Mo et al. (2021); Romer (1990), the transfer of industrial technologies (i.e., capital goods) from technological advanced economies is a significant source of increasing productivity and innovation in less developed countries (see e.g., Eaton and Kortum, 2001; Mo et al., 2021; Mutreja et al., 2018; Romer, 1990), and more productive firms are likely to become exporters (Bustos, 2011; Melitz, 2003). Similarly, in Rodrik (1999), the benefits of trade liberalisation are on the import side rather than the export side. Thus developing countries grow as they learn to adopt new foreign industrial technologies (see e.g., Chandra, 2006; Mutreja et al., 2018; Rodrik, 1999; Romer, 1990).

However, the adoption of foreign technologies has never been easy (see e.g., Bartel and Lichtenberg, 1987; Lall and Urata, 2003; Redding, 1999; Rodrik, 1999; Rosenberg and Nathan, 1982). Higher levels of factor endowments and technical competence are required since the technologies have to be modified to make them amenable to domestic firms (see e.g., Bas and Berthou, 2012; Chandra, 2006; Das and Drine, 2020; Rosenberg and Nathan, 1982). Therefore, the success of industrial technology transfer is not just a matter of African countries sourcing it, but also often depends on the compatibility of factor proportions required to adapt and modify the imported technologies before they can function effectively in the recipient country (see e.g., Chandra, 2006; Lall and Urata, 2003; Rosenberg and Nathan, 1982).

Moreover, the adoption of foreign technologies may also depend upon the quality of natural resources that countries are endowed with (see e.g., Chandra, 2006; Rosenberg and Nathan, 1982). African countries are well endowed with higher qualities of natural resources (i.e., high quality of copper, coal, iron ore, platinum, etc.) (see e.g., Alao, 2007; Kurecic and Seba, 2016; Ojakorotu and Olajide, 2019). However, the continent is poorly endowed with factor endowments such as infrastructure, human capital, financial development and institutions than other developing regions (see e.g., Acemoglu and Robinson, 2010*a*; Bond, 2016; Eberhard et al., 2011; UNDP, 2018). This may add to the costs associated with importing industrial technologies and exporting homogenous goods.

Africa still produce and export primary goods (see e.g., Elhiraika et al., 2014; Fosu and Abass, 2019; IMF, 2016), despite evidence that technology intensive goods (i.e., capital goods) have

the most beneficial spillover effects on growth and development (see e.g., Aboal et al., 2017; Hausmann et al., 2007). Countries that produce such goods are the most productive and their economies grow and develop faster (see e.g., Aboal et al., 2017; Hausmann et al., 2007). On the other hand, primary goods (which have the least technology intensities) tend to have the least beneficial learning and spillover effects. Countries that specialise in the production of such goods tend to have lower growth (see e.g., Aboal et al., 2017; Hausmann et al., 2007). They are limited to upstream production - down the global value chains.[5]

The purpose of this thesis is to first establish how Africa's trade is structured, i.e. what type of goods the continent imports and exports. Second, based on this context, determine if capital imports are contributing to the continent's export composition, as evidenced in the literature for countries that have managed to diversify their exports (see e.g., Castellani and Fassio, 2019; Chandra, 2006; Colantone and Crinò, 2014). Lastly, investigate the drivers of capital imports in Africa, as these factors may provide the channels that can complement the positive effects of capital imports and assist Africa to transition to technology intensive trade structures.

Answers to these questions may assist policymakers to (1) examine national trade structures, specifically to see how faster they have changed over time. This is important especially for policy and analytical purposes. This may help to understand the source of Africa's underperforming trade, which is highly documented in the literature (see e.g., Abrego et al., 2020; Bouet et al., 2008; Brenton and Isik, 2012; Francois and Manchin, 2013; Tafirenyika, 2014); (2) have a good understanding of the linkages between capital goods imports, technological export composition, and the rest of the economy; and (3) attain the best trade and industrial policies for their economies. The motivation, contributions, and review of related literature, for each of the research studies that make up the thesis, are further discussed in the following sections below.

[5]In Hausmann et al. (2007), primary goods are poor country goods, and those that continue to produce poor country goods remain poor.

1.1 Thesis outline and contribution

1.1.1 The Technological Trade Structure and Performance of African Countries, 1980-2015

Economic theory suggests that relative to technology intensive goods, primary goods prices are prone to suffer from world market volatilities and can support limited GDP growth (see e.g., Hausmann et al., 2007; Romero and McCombie, 2016; Sheu, 2014; Stiglitz and Greenwald, 2010). Chapter 2 of the thesis provides a comprehensive analysis of Africa's trade composition, with the primary purpose of assessing the changes in the technological trade composition structures over the period 1980-2015.

Using Lall (2000) classification method that separates the technology intensity and differentiates manufactured goods from primary goods, I decomposed Africa's trade (both exports and imports) into five categories: primary goods, resource-based, low technology, medium technology, and high technology manufactured goods. I then compare Africa with developed and other developing regions. I also analysed trade within Africa sub-regions, the main regions, the leading exporters, and importers. I then establish the economic variables that are correlated with the trade composition performance. This analytical approach is motivated by literature that links economic performance or development to trade composition, and that links Africa's trade performance to the key determinants of growth (see e.g., Freund and Rocha, 2011; Rodrik, 1998; Stiglitz, 2018; Tadei, 2018).

The findings of Chapter 2 reveal that Africa's merchandised export composition has remained highly concentrated in a few primary goods, which contributed to the decline of its global export share. Within its manufacturing sector, exports are stagnated and less diversified - highly concentrated resource-based goods. Few notable countries that have managed to diversify their export composition into more relatively high technology goods are more financially developed and better endowed with infrastructure and institutions than other African countries. The continent's import composition is concentrated in capital goods (medium and high technology goods). However, the share of its capital goods imports in world trade has declined. In Hentschel (1992) and Jiranyakul (2012), a decrease in capital goods imports in developing

countries can cause a decline in output and impede growth.

Chapter 2 contribution to the existing literature is threefold. First, it provides a comprehensive analysis of both export and import composition by technological sector in 54 African countries that have not yet been investigated using such a detailed technological sector classification in more recent multi-sectoral studies. Although there are different ways of classifying the trade composition, Lall (2000) classification is of interest given that it combines Pavitt (1984) resource intensity classification with the OECD (1994) R&D intensity classification. It separates the technological intensity and differentiates manufacturing from the primary sector; and resource-based from low technology manufacturing sector.

Secondly, chapter 2 contributes to the existing literature by looking at the import composition trends. Most previous analyses have only focused on exports (e.g., Edwards and Alves, 2006; Lall, 2000), whilst ignoring the potential growth-enhancing contribution of imports. Thirdly, the chapter uses a more recent and comprehensive dataset covering the period 1980-2015, which covers major events such as the Cold war, the formation of the African Union, the inception of the African Growth and Opportunity Act (AGOA), the global financial crisis, etc. The data also allows the study to analyse Africa's export and import structures down to regional and further to country-level.

Chapter 2 closely links to the works of Lall (2000) and Edwards and Alves (2006). Lall (2000) analysed the technological structure and performance of developing countries manufacturing exports using data covering the period 1985-1998. He find that the East Asian region dominates the developing countries manufactured exports, with about 70% of developing countries' total manufactured exports. The results from Chapter 2 indicate that East Asia sub-region is more integrated than Africa sub-regions in terms of intra-and-inter trade. For example, in the period 2011-15, East Asia intra-trade accounted for about 23% of its total trade, while in the Northern and Southern Africa accounted for about 2% and 13%, respectively.

Using Lall (2000) technological sector classification, Edwards and Alves (2006) analysed South Africa's export composition using data covering the period 1998-2002. They find that South Africa has managed to transform its exports from primary to more manufactured goods. These findings are in line with the chapter 2 findings. Chapter 2 reveal that South Africa,

Morocco, Egypt, and Tunisia (respectively) are African countries that have significantly transformed their export composition into more manufactured goods. South Africa dominates African countries manufactured exports, with about 40% of Africa's total manufactured exports in the period 2011-2015.

1.1.2 Effects of capital goods imports on technological export composition in developing countries

Bas and Strauss-Kahn (2014); Caselli (2018); Castellani and Fassio (2019) suggest that importing capital goods can help less developed countries to diversify their export composition. However, results in Chapter 2 indicate that Africa is struggling to diversify its export composition structure away from primary goods, despite a significant increase in its capital goods imports. Chapter 3 therefore investigates the effects of capital goods imports on technological export composition in developing countries. In particular, I want to determine if capital goods imports can assist Africa to improve its technological export composition, as suggested in the literature (see e.g., Bas and Strauss-Kahn, 2014; Caselli, 2018; Castellani and Fassio, 2019; Mo et al., 2021).

The results indicate that capital goods imports have positive and statistically significant effects on technological export composition in developing economies. In Africa, capital goods imports also have positive and significant effects on low, medium, and high technology exports. Thus, the findings suggest that trade and industrial policies aimed at eliminating barriers on capital goods imports will improve the performance of (exporting) firms in the African manufacturing sector.

The results from Chapter 3 contributes to the empirical literature on international trade and economic growth. To my knowledge, no empirical study has examined the effects of capital goods imports on technological export composition using Lall (2000) detailed technological classification. Much of the existing research focuses on aggregate manufactured exports (see e.g., Edwards et al., 2018; Sharma, 2016). The study benefits from a panel data set spanning 128 countries, including 36 developed countries, 40 African countries, and 52 non-African developing countries over the period 1980-2015, which allows me to control for unobserved country heterogeneity and year fixed effects. The dataset also allows me to determine the differential

effects of capital goods imports on technological export categories in developing regions relative to the world averages, and in Africa relative to all developing countries. Besides the more recent dataset and the use of a large sample size, the study benefits from the set of control variables that include human capital, financial development, institutions, and infrastructure which many scholars argued to be crucial in determining trade growth (see e.g., Freund and Rocha, 2011; Rodrik, 1998; Tadei, 2018).

This chapter builds on and ties to the works of Sharma (2016); Edwards et al. (2018); Castellani and Fassio (2019) and Okafor (2020). The authors investigate the relationship between imported inputs and manufactured exports. The authors find that imported inputs increase manufactured exports. Sharma (2016) used Indian manufacturing export data between 1994 to 2009, while Edwards et al. (2018) and Okafor (2020) used individual African countries manufacturing trade data; South Africa and Ghana, respectively. This chapter also connects to the existing literature by Nyantakyi and Munemo (2017); Caselli (2018) and Aisien and Abraham (2020), who show that imported inputs increase domestic productivity.

1.1.3 Determinants of capital goods imports in developing countries

The empirical evidence in chapter 3 has shown that access to foreign capital goods helps developing economies, as well as African countries to diversify their export composition. Chapter 4 therefore investigates the determinants of capital goods imports in developing countries, with a special focus on Africa using a panel data of 128 countries spanning 1980-2015. The research findings reveal that financial development, infrastructure investment, and institutions have positive and significant effects on capital goods imports in developing countries. In Africa, the results indicate that financial development and infrastructure investment are the main determinants of capital goods imports, with infrastructure being the key determinant in landlocked African countries.

The chapter contributes to the literature on capital imports and growth by specifically examining the determinants of capital goods imports and by providing broad aspects of possible factors. The study covers human capital, financial development, infrastructure investment, and institutions. These variables, as well as TFP, trade openness, and gross domestic product (GDP)

are used as control variables in determining the effects of each variable of interest (human capital, financial development, infrastructure investment, and institutions). The study also benefits from a panel dataset of 128 countries that include 36 developed and 92 developing countries. With such a dataset, I can control for both year and country fixed effects in the models. The dataset also allows me to examine the different effects of the explanatory variables across world regions.

This chapter relates to the works of Fauceglia (2014); Fauceglia (2015*b*) and Das and Drine (2020). Fauceglia (2014, 2015*b*) show evidence that financial constraints negatively influence firms' decision to import capital goods. They find that the probability to import capital goods is close to zero for financially constrained firms in developing countries. Das and Drine (2020) shows that lack of human development, poor infrastructure, and business environment as the most significant barriers preventing Sub-Saharan countries from catching up with world technologies.

CHAPTER 2

THE TECHNOLOGICAL TRADE STRUCTURE AND PERFORMANCE OF AFRICAN COUNTRIES, 1980-2015

Several studies have found that spillovers or other externalities associated with trade are sector specific. Yet trade linkages are typically analysed at the macroeconomic aggregates. This article analyses Africa's trade composition spanning 1980-2015, using a disaggregated and detailed classification by technological levels. The findings reveal that Africa's import composition is concentrated in capital goods and its export composition has remained highly concentrated in primary goods, which has contributed to the decline in Africa's share of global exports. I also find that regions within Africa have similar technological trade composition structures. A few notable countries that have managed to transform their export composition into more semi-processed and relatively high technology exports are the leading importers of capital goods, are better financially developed, and better endowed with infrastructure, human capital, and institutions than other African countries.

2.1 Introduction

Although trade structures are path dependant and hard to change, they have greater implications on economic growth and development (see e.g., Aboal et al., 2017; Caselli, 2018; Sheu,

2014). Countries that produce and export technology intensive goods (i.e., capital goods) tend to grow faster (see e.g., Aboal et al., 2017; Hausmann et al., 2007). While those that are technologically disadvantaged benefit from importing capital goods (see e.g., Castellani and Fassio, 2019; Coe and Helpman, 1995; Mo et al., 2021), as producing high technology goods require high quality inputs (see e.g., Hallak and Sivadasan, 2013; Kugler and Verhoogen, 2012). Yet several studies on Africa have analysed its trade composition at the macroeconomic aggregate level, and export-led growth dominates the literature. The role played by imports is almost completely ignored, despite Africa being far removed from the world technological frontier. In this chapter, I provide a comprehensive analysis of Africa's trade composition (both exports and imports), with the primary purpose of assessing their technological structures and performance, an indicator of their quality.

Exports generate income and create employment while imports of relatively cheaper primary and intermediate goods can positively affect output and employment (see, Caselli, 2018; Krueger, 1983). Whilst imports of capital goods that embody new industrial technologies enhance growth opportunities - boosting productivity and innovation in both primary and manufacturing sectors (see e.g., Caselli, 2018; Eaton and Kortum, 2001; Krueger, 1983; Lee, 1995). Capital goods also tend to have elastic demand and higher-income elasticities in global markets. Countries that produce such goods can export them in large quantities without significant adverse terms of trade (ToT) effects (see e.g., Hausmann et al., 2007; Lall, 2000; Romero and McCombie, 2016).

Using Lall (2000) detailed technological classification, I decompose Africa's trade (both exports and imports) into five categories. I then compare the trade trends in Africa with developed and developing regions. Trends within Africa sub-regions compared with other developing sub-regions, and the leading exporters and importers. I then establish the economic variables that are correlated with Africa's trade composition performance. This approach is motivated by literature that links economic performance or development to trade composition, and that links Africa's trade performance to the key determinants of growth.

Few studies have done such kind of data analysis. Among the few (e.g., Edwards and Alves, 2006; Lall, 2000; Romero and McCombie, 2016), one with a particular focus on the entire African

continent and focusing on both exports and imports is yet to emerge. Lall (2000) developed and utilised the technological classification to examine developing countries' export patterns over the period 1985-1998, focusing on the technological structures of manufactured exports.[1] His findings reveal that the East Asia region dominates developing economies manufactured exports, with about 70% of all developing countries' total manufactured exports.

Edwards and Alves (2006) applied Lall (2000) technological classification to analyse and evaluate the extent to which the South African export composition and levels of manufactured exports had responded to the government's macroeconomic reforms that it initiated in the 1990s. The authors observed an improvement in growth and diversification of South Africa's manufactured exports over the period 1988-2002, with its manufactured exports being highly concentrated in resource-based goods. Similarly, Romero and McCombie (2016) also applied the same classification to estimate the import and export functions in 14 developed European economies between 1984 and 2007. Their findings indicate that income elasticities of imports and exports are higher for technology intensive goods (medium and high technology goods). This suggests the importance of moving from the production of homogenous goods to relatively high technological products.

This chapter finds that Africa's export composition has remained skewed towards primary goods, more than 60% of its total exports. This pattern of trade does not bode well for the continent's sustainable economic growth, as primary goods lack both technological dynamism and economic linkages (see e.g., Hausmann et al., 2007; Herzer and Nowak-Lehnmann D, 2006; James and Aadland, 2011; Ocran and Biekpe, 2008; Sachs and Warner, 2001). In the manufacturing sector, its exports are highly concentrated in resource-based goods, which are also characterised by volatile prices. Furthermore, Africa has lost its global shares in both primary and manufactured exports, despite the continent participating more in extra-trade[2] than intra-trade. This pattern of trade significantly differs from other world regions and indicates the continent's limited integration into regional value chains.

In Africa sub-regions, similar technological export composition structures were observed. The Southern Africa region dominates the continent's total exports, however, mostly driven

[1] Lall (2000) sample of developing countries included a few Sub-Saharan countries.
[2] Trade with the rest of the world excluding the trade among African countries (intra-trade).

by an outlier - South Africa. A few notable countries such as South Africa, Morocco, Egypt, and Tunisia that have incorporated some semi-processed and relatively high technology manufactured goods into their export composition are also the leading importers of technology intensive goods. They account for the bulk of Africa's manufactured exports. They are better financially developed, better endowed with human capital, infrastructure, and institutions than other African countries (see e.g., Beck et al., 2009; Foster and Briceño-Garmendia, 2009; Ibeanu, 2015; Svirydzenka, 2016; UNDP, 2018).

On the import side, Africa's import composition is concentrated in capital goods (medium and high technology goods), mostly from China. Chinese exports to Africa significantly increased in both primary and manufactured goods, since its joining the World Trade Organisation (WTO). In Schott (2008) and Bos and Vannoorenberghe (2019), exports from China are more suitable for firms in developing countries, since they may be of lower quality than those from Europe or the United States.

Although Africa is a net importer of capital goods, its share in global imports has fallen. Primary goods imports also form a substantial share of Africa's total imports. These trends are mainly driven by agricultural products as a result of urbanisation (see e.g., Lancon and Benz, 2007; Rutsaert et al., 2013), and most African governments trade policies (e.g., Botswana, Namibia, and Libya) favour cheap imports of food (e.g., maize rice, vegetables, and fruits), rather than local production (see e.g., Rakotoarisoa et al., 2011; Rutsaert et al., 2013). The findings also reveal that regions within Africa have similar technological import composition structures.

2.2 Methodology

Following Lall (2000), I decompose Africa's annual trade data (exports and imports) into five trade categories: primary goods, resource-based manufactured (RBM) goods, low technology manufactured (LTM) goods, medium technology manufactured (MTM) goods, and high technology manufactured (HTM) goods. The classification is shown in Table 2.1 and a full list of products in each category is given in Table A.1 of Appendix A.1.

Although there are different ways of classifying the trade data, a commonly used classi-

Table 2.1: Technological trade composition classification

Classification	Examples
Primary products	Fresh fruits, meal, rice, cocoa, tea, coffee, wood, crude petroleum, gas
Manufactured products	
Resource-based manufactures (RBM)	
Agro-based products	Prepared meat, prepared fruits, beverages, wood products, vegetable oils
Other resource-based products	Ore concentrates, petroleum products, rubber products, cement, cut gems, glass
Low technology manufactures (LTM)	
Textile, garment and footwear	Textile fabrics, clothing, headgear, footwear, leather manufactures, travel goods
Other low technology	Pottery, simple metal parts/structures, furniture, jewellery, toys, plastic products
Medium technology manufactures (MTM)	
Automotive products	Passenger vehicles and parts, commercial vehicles, motorcycles and parts
Process industries	Synthetic fibres, chemical and paints, fertilizers, plastics, iron, pipes/tubes
Engineering industries	Engines, motor, industrial, machinery, pumps, switchgear, ships, watches
High technology manufactures (HTM)	
Electronics and electrical products	Office/data processing/telecommunications equipment, TVs, transistors, turbines, power-generating equipment
Other high technology	Pharmaceuticals, aerospace, optical/measuring instruments, cameras
Other transactions	Electricity, cinema film, printed matter, "special" transactions, gold, art, coins, pets

Source: Lall (2000).

fication is based on Pavitt (1984). His approach decomposes trade data into; resource-based, labour-intensive, scale-intensive, and science-based manufactured goods. Pavitt (1984) classification is argued to be difficult to use as the classifications are said to be unclear and there are said to be overlapping between sectoral categories (see e.g., Lall, 2000; OECD, 1994).

The OECD (1994) suggested a more detailed classification based on the technological activity within each category. However, Lall (2000) technological classification is of interest given that it combines Pavitt (1984) resource intensity approach with the OECD (1994) R&D intensity classification method. Lall (2000) technological classification separates the technological intensity and differentiates manufacturing from the primary sector; and resource-based from low technology manufacturing sector.

I also composed the 54 African countries into five regions: Central Africa, East Africa, North Africa, Southern Africa, and West Africa, as defined by the African Union, see list of regions in

Table A.2 of Appendix A.1. I then analysed the patterns within the established trade categories and regions with an effort to bring out the stylised facts that might be revealed. When presenting sub-regions, I also include weighted (by population) figures as the unweighted averages can be affected by the outliers, and this can lead to misleading results and interpretations. The established technological trade structures are combined with the key determinants of trade and economic growth (from the literature) and estimate the correlations using ordinary least squares (OLS) and OLS with year and country fixed effects in control for unobserved heterogeneity.

2.3 Data

The study uses trade data aggregated to country-level covering the period 1980-2015, which covers major events which have occurred such as the Cold War (1980-89), post-Cold War (1990-94), the formation of the World Trade Organisation (WTO) (1995-99), formation of the African Union (AU), the inception of African Growth and Opportunity Act (AGOA), China joining WTO (2000-04), and the global and post-financial crisis period. The trade data is from the United Nations Comtrade database, recorded at 3-digit Standard International Trade Classification (SITC) revision 2.[3]

Infrastructure investment data is from the World Development Indicators (WDIs), measured by gross fixed capital formation (at constant 2010 US$) which includes construction of roads, railways, schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Abundant literature has measures infrastructure in terms of an investment flow or stock ('public capital') (see e.g., Ayogu, 2007; Calderón and Servén, 2008; Fedderke and Bogetić, 2009; Kodongo and Ojah, 2016; Perkins et al., 2005).[4] Financial development and GDP per capita data are also from the WDIs. Financial development is measured by private credit (by banks) and other financial institutions both as a percentage of GDP. Human capital and total factor productivity (TFP) are indexes extracted from the Penn World Tables, version 9.1.

[3]Trade, infrastructure investment, and GDP values in the current United States dollar (US$) are converted to constant values using the US$ - 2010 price index.

[4]However, measuring infrastructure as a single variable, either in physical or monetary unit fails to capture the multi-dimensional nature and heterogeneity of infrastructure across time periods and countries, and does not properly distinguish between quality and bulk of infrastructure (Ayogu, 2007; Calderón and Servén, 2010; Kodongo and Ojah, 2016; Letsara et al., 2013). Constructing an infrastructure index of various infrastructure measures would be ideal.

Human capital is measured by the average years of schooling and an assumed rate of return to education. While TFP is computed using the real GDP at national prices, real capital stock at national prices, and the labour force. Institutions data is from the Center for Systemic Peace, Polity IV Project, based on *POLITY2* score scale computed by subtracting the institutional autocracy score points from the institutional democracy score points.

Combining these variables generates an unbalanced panel data set that covers the period 1980-2015. Table 2.2 reports summary statistics for the baseline sample between 1980 and 2015. The margin between the minimum and maximum values is smaller for primary exports but larger for MTM and HTM exports. These contrasts reflect in part the fact that increasingly more countries have exported primary goods, while few countries have continued to dominate the bulk of MTM and HTM exports. While the margins between minimum and maximum are smaller for all manufactured imports categories but larger for primary imports. Thus, suggesting the fact that increasingly more countries have imported manufactured goods, while some countries have continued to dominate in importing primary goods.

Table 2.2: Descriptive statistics

Variable	Mean	Std.Dev.	Min	Max
ln(Primary exports)$_t$	1.48	2.20	-5.13	7.07
ln(RBM exports)$_t$	0.21	2.49	-8.56	5.71
ln(LTM exports)$_t$	-1.80	2.65	-8.89	4.23
ln(MTM exports)$_t$	-1.48	2.52	-9.57	5.71
ln(HTM exports)$_t$	-2.63	2.28	-10.84	3.60
ln(Primary imports)	0.42	1.79	-8.09	5.33
ln(RBM imports)$_t$	1.05	1.39	-4.13	4.72
ln(LTM imports)$_t$	0.64	1.53	-4.21	4.51
ln(MTM imports)$_t$	1.55	1.69	-2.85	5.64
ln(HTM imports)$_t$	0.33	1.61	-4.55	4.90
ln(Trade openness)$_t$	4.07	0.84	1.84	5.85
ln(Infrastructure investment)$_t$	20.80	1.80	14.49	25.71
ln(Financial development)$_t$	2.55	0.96	-1.51	5.01
ln(GDP per capita)$_t$	7.05	1.00	5.10	9.93
Human capital$_t$	1.58	0.39	1.01	2.83
Institutions$_t$	-1.18	5.82	-9.00	10.00
Total factor productivity$_t$	1.03	0.27	0.40	2.64

Note: The subscript t represents the time period. All trade, GDP, and infrastructure data have been converted to constant US$ using the 2010 price index. RBM = resource based manufactures; LTM = low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures. No trade data for Botswana, Lesotho, Namibia, and Swaziland during the period 1980-1999; Eritrea and Ethiopia during the period 1980-1992. No RBM exported data for Comoros in 1982 and for Chad in 1983. No MTM and HTM exports data for Eritrea in 1993.

2.4 Trends in the Developed and Developing World

Table 2.3 and 2.4 present the export and import technological structures (respectively) for developed and developing countries. Both tables reveal the importance of medium and high technology manufactured (MTM and HTM) goods in global trade. Together, the two categories (MTM and HTM goods) make up about 50% of world total trade and over 60% of world manufactured trade in the period 1980-2015. Table 2.3 and 2.4 further reveal the dominance of developed countries in trading these technology-intensive goods (capital goods).

2.4.1 *Exports*

Table 2.3 gives market shares for developed and developing countries exports over the period 1980-2015. The figures show that developed countries' dominated the bulk of world exports. In the period 2011-15, developed countries accounted for 60.5% of the world's total exports (78.8% in the 1980s). Developed countries' exports are dominated by manufactured goods, especially technology intensive goods. Medium and high technology exports have a combined share of 56.2% of all developed countries total exports (2011-15), an increase in share by 5.7% compared with the 1980s. However, capital goods exports (medium and high technology exports) are highly concentrated in few developed countries (see Eaton and Kortum, 2001; Mutreja et al., 2018). In the period 2011-2015, about 77% of all developed countries exports were from 10 developed nations.

In developing countries, exports accounted for 21.2% of the world total exports in the 1980s, however, with the formation of the World Trade Organisation (WTO) in 1995, developing countries exports share increased significantly to 26.9% in the period 2000-04, then to 39.5% of the world total exports in the period 2011-2015. It seems that the formation of WTO spurred the exceptional growth in developing countries' exports. The complex categories (MTM and HTM goods), together accounted for 34.4% of developing countries' total exports in the period 2011-2015.

In the Africa region, the participation remained marginal, its shares in world exports have declined. Its global share accounted for just 4.0% of world total exports in the period 2011-2015,

Table 2.3: Market shares of exports (% of World total exports)

	All products	Primary	All Manufactures	RBM	LTM	MTM	HTM
			Shares of products in world exports, 1980-89 (%)				
Developed	78.8	11.2	64.9	13.9	11.2	28.9	10.9
Developing (excl. Africa)	16.7	9.7	6.8	3.4	1.6	1.1	0.7
Africa	4.5	3.2	1.1	0.8	0.1	0.1	0.1
			Shares of products in world exports, 1990-94 (%)				
Developed	80.5	8.4	68.7	12.8	11.4	30.2	14.3
Developing (excl. Africa)	16.7	6.1	10.3	2.9	3.4	2.1	1.8
Africa	2.8	1.7	0.9	0.5	0.2	0.2	0.0
			Shares of products in world exports, 1995-99 (%)				
Developed	77.7	7.1	67.4	11.7	10.6	29.2	15.9
Developing (excl. Africa)	19.9	5.5	13.8	3.1	4.4	2.9	3.5
Africa	2.4	1.3	1.0	0.5	0.3	0.2	0.0
			Shares of products in world exports, 2000-04 (%)				
Developed	73.1	6.7	63.0	9.9	9.2	27.7	16.1
Developing (excl. Africa)	24.1	6.5	16.8	2.8	5.3	3.7	5.0
Africa	2.8	1.6	1.0	0.4	0.3	0.3	0.1
			Shares of products in world exports, 2008-09 (%)				
Developed	63.8	7.5	52.6	9.1	7.2	24.1	12.2
Developing (excl. Africa)	32.1	10.0	20.9	3.8	5.9	5.8	5.5
Africa	4.1	2.8	1.1	0.5	0.2	0.4	0.1
			Shares of products in world exports, 2011-15 (%)				
Developed	60.5	7.5	49.4	9.0	6.5	23.0	11.0
Developing (excl. Africa)	35.5	10.5	23.7	4.4	6.1	6.6	6.5
Africa	4.0	2.4	1.1	0.5	0.2	0.4	0.1

Source: Authors' calculations using UN Comtrade data (SITC rev. 2). *Notes*: The shares for developing countries exclude the Africa region. Developing countries are defined as non OECD countries. "Other" transactions are not shown here and account for the difference between all products and primary plus all manufactured. RBM = Resource based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufactures and HTM = High technology manufactures.

a 0.5% decline in market share compared to the 1980s. Primary exports accounted for 2.4% of world total exports, a fall in share by about 0.8% compared to the 1980s, while manufactured exports share remained low and stagnant over the periods. The continent's performance was worse than that of other world regions. In fact, China had a bigger market share than all of Africa since the period 1995-99. China's global export share increased from 1.1% in the 1980s to 12.1% (2011-15).

The statistics suggest that the majority of African countries are failing to add value to their primary and natural resource goods. For example, countries like Ghana and Cote d'Ivoire produce about 53% of the world's cocoa, but their respective markets are stacked with chocolates imported from Switzerland and the United Kingdom (see UNCTAD, 2013). Such poor and volatile integration into the global export market poses particular concern for the developmental perspective of the continent, especially when trade is regarded as the most promising route to growth. For the continent to achieve sustained growth, countries within need to develop processing industries around their primary and resource-based goods.

2.4.2 *Imports*

The import side is also dominated by the developed world in both primary and manufactured goods, see Table 2.4. In the 1980s developed countries imported about 82.3% of world total imports on average. The share comprised 85.5% of world primary imports and 81.0% of world manufactured imports. This was mainly due to intra-trade within developed countries as developing countries' participation in global exports was very limited.

Table 2.4: Market shares of imports (% of world total imports)

	All products	Primary	All Manufactures	RBM	LTM	MTM	HTM
			Shares of products in world imports, 1980-89 (%)				
Developed	82.3	20.6	59.0	15.0	10.7	23.5	9.7
Developing (excl. Africa)	13.9	3.0	10.6	2.4	1.6	5.0	1.6
Africa	3.8	0.5	3.2	0.7	0.5	1.6	0.4
			Shares of products in world imports, 1990-94 (%)				
Developed	82.1	13.6	65.2	13.4	12.9	25.8	13.1
Developing (excl. Africa)	15.4	2.3	12.6	2.4	1.8	5.6	2.8
Africa	2.5	0.3	2.1	0.5	0.3	1.1	0.3
			Shares of products in world imports, 1995-99 (%)				
Developed	79.9	11.2	65.7	12.1	12.9	25.5	15.1
Developing (excl. Africa)	17.8	2.4	14.7	2.8	2.0	5.9	4.0
Africa	2.3	0.3	1.9	0.4	0.3	0.9	0.3
			Shares of products in world imports, 2000-04 (%)				
Developed	79.2	11.7	64.2	10.2	12.6	25.1	16.3
Developing (excl. Africa)	18.5	2.7	14.8	2.5	1.9	5.8	4.5
Africa	2.3	0.4	1.8	0.4	0.3	0.8	0.3
			Shares of products in world imports, 2008-09 (%)				
Developed	70.4	14.3	52.3	9.1	10.3	20.6	12.4
Developing (excl. Africa)	26.3	5.4	19.8	3.8	2.6	8.4	5.1
Africa	3.3	0.6	2.5	0.5	0.4	1.2	0.4
			Shares of products in world imports, 2011-15 (%)				
Developed	65.5	13.0	49.2	8.6	9.5	19.6	11.7
Developing (excl. Africa)	31.0	6.9	22.4	4.7	2.9	9.2	5.6
Africa	3.5	0.6	2.6	0.5	0.4	1.3	0.4

Source: Authors' calculations using UN Comtrade data (SITC rev. 2). *Notes*: The shares for developing countries exclude the Africa region. Developing countries are defined as non OECD countries. "Other" transactions are not shown here and account for the difference between all products and primary plus all manufactured.

Although developed economies account for the bulk of world imports, their global share has significantly declined since the late 1980s, declining to account for about 70% of world total imports in the 2008-09 global recession and further to 65.5% in the period 2011-15, as the global share of developing countries grew. In the period 2011-2015, imports of capital goods by developed countries accounted for 63.4% of their total imports and about 66.1% of world capital goods imports.

In Africa, participation has also remained marginal. Africa's import share in global trade has declined on average, from 3.8% in the 1980s to 2.3% in the last half of the 1990s, then

increased to about 3.5% of the world imports in the period 2011-2015. The continent imports mostly manufactured imports, dominated by MTM goods which accounted for 1.3% of world imports in the period 2011-2015, a decline in share from 1.6% in the 1980s. The continent's import share of HTM has remained very low and stagnant over the period 1980-2015.

2.5 Trends in Africa

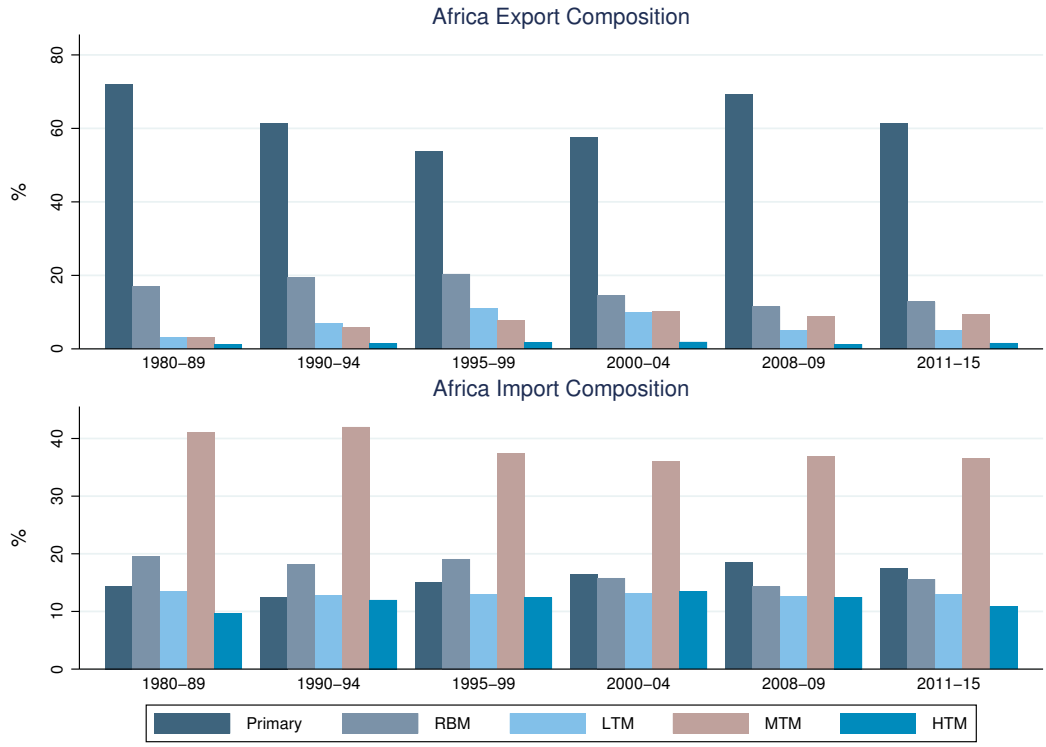
Figure 2.1 shows the trade composition in Africa for the period 1980-2015. As it can be seen, there are observable differences between the export composition and import composition trends over the period. The continent exports more homogenous goods and imports more heterogeneous goods. Despite the observable differences, I observe an overall increase in trends for both the export and import composition (see also Figure A.1 of Appendix A.2). The continent's export composition is highly concentrated in primary goods, which are characterised by very volatile prices and lack both technological dynamism and local economic linkages. Hence, the over-dependence on primary goods can only support limited growth. In Hausmann et al. (2007), primary goods are poor country goods, and those that continue to produce poor country goods remain poor.

In the 1980s, the continent's primary goods accounted for 72% of Africa's total exports. Although the share of primary goods has declined since the early 1990s, its share in total export has remained high. The share declined to 61.3% in the period 1990-94, and further down to 53.7% in the period 1995-99, but increased to 69.2% during the global financial crisis (2008-09) period.[5] The figures reflect that trade liberalisation and the participation of most African countries in the WTO seem not to have significantly influenced the continent's export composition structure. Thus the continent's participation in the global value chains (GVCs) is mostly limited to upstream production (down the value chain), providing primary inputs.

In Rodney (2010); Tadei (2018) and Stiglitz (2018), colonial rule had profound impacts on Africa's trade, African countries were structured to meet the demands of industrialising Europe

[5]The increase in the share of primary exports during the financial crisis could be explained by the increase in crude oils prices (see, Aryeetey and Ackah, 2011). Oil prices increased from $50 per barrel at the beginning of2008 to $126 in June of that year.

Figure 2.1: Africa's technological trade composition, (% of total)



Source: Author's calculations using UN Comtrade data.

by supplying primary inputs. However, the structure has remained largely unchanged in the post-colonial era, the exportation of primary goods and importation of manufactured goods.

Since the 1980s Africa's import composition has been largely concentrated in manufactured goods. Thus, the continent depends on exports of primary goods to finance imports of manufactured goods for consumption and investment purposes (see e.g., Olabisi and Sawyer, 2020). The continent's technological manufactured import composition is dominated by MTM goods, mostly engineering products (see Table A.3 of Appendix A.2). MTM goods accounted for over 38% of the continent's total imports during the period 1980-2015. HTM goods were the least imported category. Together, the complex categories (MTM and HTM) accounted for about 50% of Africa's total imports during the period 1980-2015.

Although the continent's imports are dominated by manufactured goods, primary imports accounted for a significant share of Africa's total imports since the 2000s (see Figure 2.1 and

Figure A.1 of Appendix A.2). The increase is mostly associated with a series of droughts, which led to imports of consumable goods increasingly becoming of importance in ensuring food security. Moreover, countries such a Botswana, Namibia, and Libya prefer importing food products rather than local production (see e.g., Rakotoarisoa et al., 2011; Rutsaert et al., 2013), due to several reasons i.e., the environmental climate conditions.

2.6 Africa's Main Trade Partners by Technological Categories

Overall, Africa's trade with China has significantly increased, while trade with the United States (US) remained strong, although it has declined. These two countries were Africa's largest trading partners (both exports and imports) during the period 1980-2015. For example, the region's share of total exports to China increased from 9% in the 1980s to 46% in the period 2011-15, while the share of total imports from China increased from 10% to 51%. Whilst Africa's trade with the rest of East Asia has declined, see Table A.4 of Appendix A.2.[6]

Africa's share of total exports to the US declined from 58% in the 1980s to 29% in the period 2011-15, while total imports from the US declined from 28% to 19%. Trade has been an important part of the US relationship with Africa through programs such as African Growth and Opportunity Act (AGOA). AGOA has led to a substantial increase in Africa's LTM and MTM exports to the US, while China has been very aggressive in investing and making commercial loans to most African countries. In Figure 2.2 and 2.3, I show Africa's main trade partners by technological trade categories.

2.6.1 *Main Export Partners*

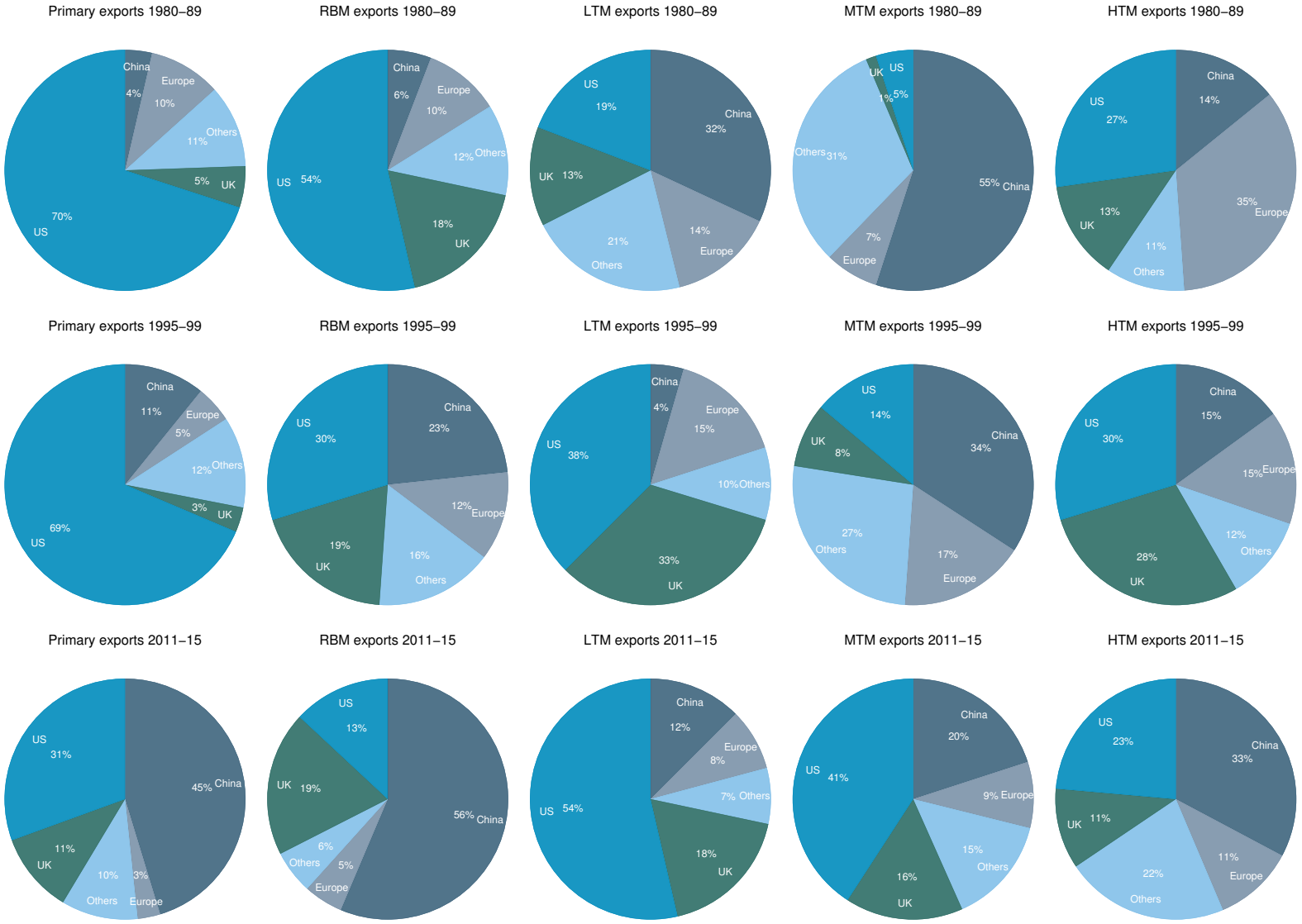
In Table A.4 of Appendix A.2, I provide a detailed analysis over six periods and separate the rest of East Asia, excluding China in the sub-region. Whilst Figure 2.2 show the continent's export partners by technological categories over the period 1980-89, 1995-99, and 2011-15. In the 1980s, Africa's primary exports were mostly destined to the US, about 70% of Africa's primary goods went to the US, however, over time, Africa's primary goods destined to the US gradually

[6]The rest of East Asia region include: Japan, Mongolia, East Korea, North Korea, and the Philippines.

decreased as those to China increased. Africa's share of primary exports to China significantly increased from 4% in the 1980s to 45% in the period 2011-15, while exports to the US and Europe declined to 31% and 3%, respectively.

The continent's RBM goods went to the US in the 1980s. However, over time RBM exports to China surpassed that which arrived in the US. The continent's RBM exports to China increased from a share of 6% in the 1980s to 56% in the period 2011-2015, while RBM to the US declined from 54% to 13%. The figures show that with the inception of AGOA in 2000, LTM and MTM exports from Africa to the US grew significantly. LTM exports from Africa to the US increased from a share of 37% in the last half of the 1990s to 53% in the period 2000-04, before declining to 50% of Africa's total LTM exports during the global financial crisis period (2008-09), see Table A.4 of Appendix A.2. MTM exports to the US increased from 14% (1995-99) to 35% of Africa's total MTM exports in the period 2000-04 and further increased to 47% during the period 2008-09.

Figure 2.2: Africa main exports destination countries/regions by technological categories (%)

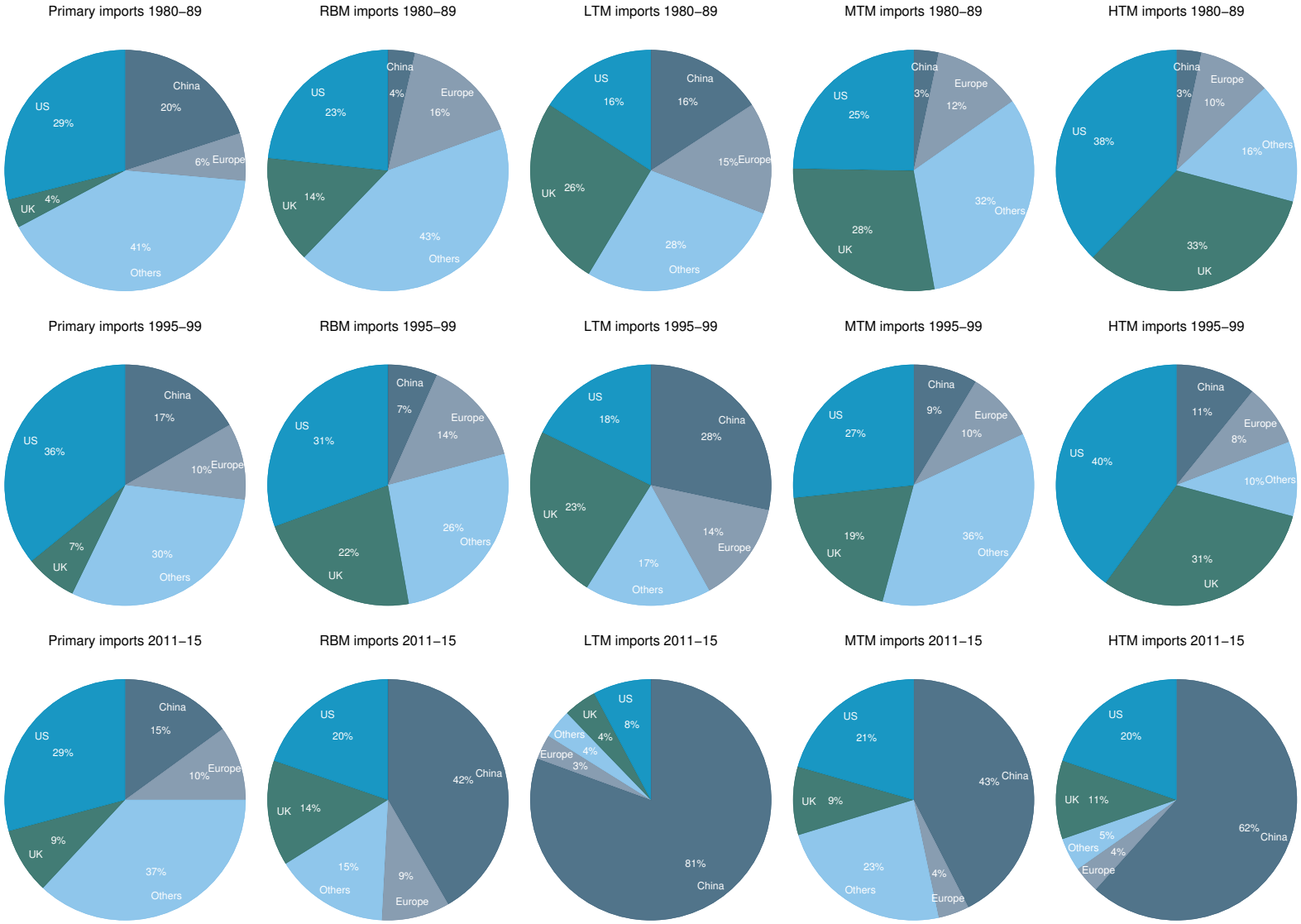


Source: Author's calculations using UN Comtrade data (SITC rev. 2). *Note*: The United Kingdom (UK) is excluded in the European Union (EU) shares. China is excluded in the East Asia group.

2.6.2 *Main Import Partners*

Figure 2.3 show Africa's main import partners by technological categories. Similar to the exports trends, China has become the main source country for the continent import composition categories, with a substantial increase in shares as it joins the WTO. Other developing countries and the US have remained the main source countries for the continent's primary imports. Although the shares of resource-based imports from other developing countries and the US declined as RBM imports from China significantly increased over the period. LTM goods from China to Africa grew from 28% in the last half of the 1990s to 47% of the continent total LTM imports in the early to 2000s then to 81% in the period 2011-15. The share of China MTM exports to Africa grew from 9% of Africa's total MTM imports in the period 1995-99 to 43% of the continent's total MTM imports in the period 2011-15. HTM imports from China accounted for 62% of Africa's total HTM imports in the period 2011-15, an increase in share from 3% in the 1980s. The US and UK were the second and third main source countries for the continent's HTM imports during the period 2011-15.

Figure 2.3: Africa main imports source countries/regions by technological categories (%)

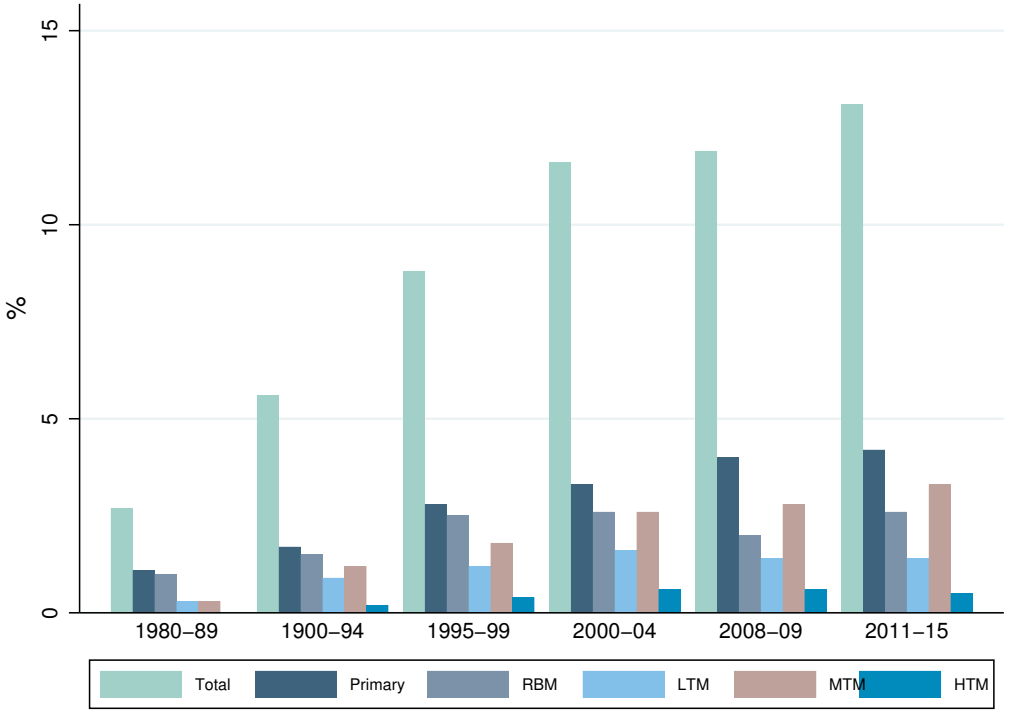


Source: Author's calculations using UN Comtrade data (SITC rev. 2). *Note*: The United Kingdom (UK) is excluded in the European Union (EU) shares. China is excluded in the East Asia group.

2.7 Africa intra-trade and extra-trade

Since 1980, Africa has witnessed an increase in intra-trade (see Figure 2.4). Between the period 1980-89 and 2011-2015, intra-Africa trade has increased significantly from 2.7% of its total exports to 13.1%. However, despite the increase, intra-Africa trade has remained significantly low compared with other world regions, far lower than the 48.7% in North America[7], 50.9% in Asia, and 67.8% in Europe during the period 2011-2015. This indicates African countries limited integration into regional value chains. However, intra-Africa trade is expected to increase with the commencing of the Africa Continental Free Trade Area (AfCFTA) (see e.g., Osuji, 2020; UNECA, 2018).[8]

Figure 2.4: Intra-trade composition in Africa, (% of total exports)



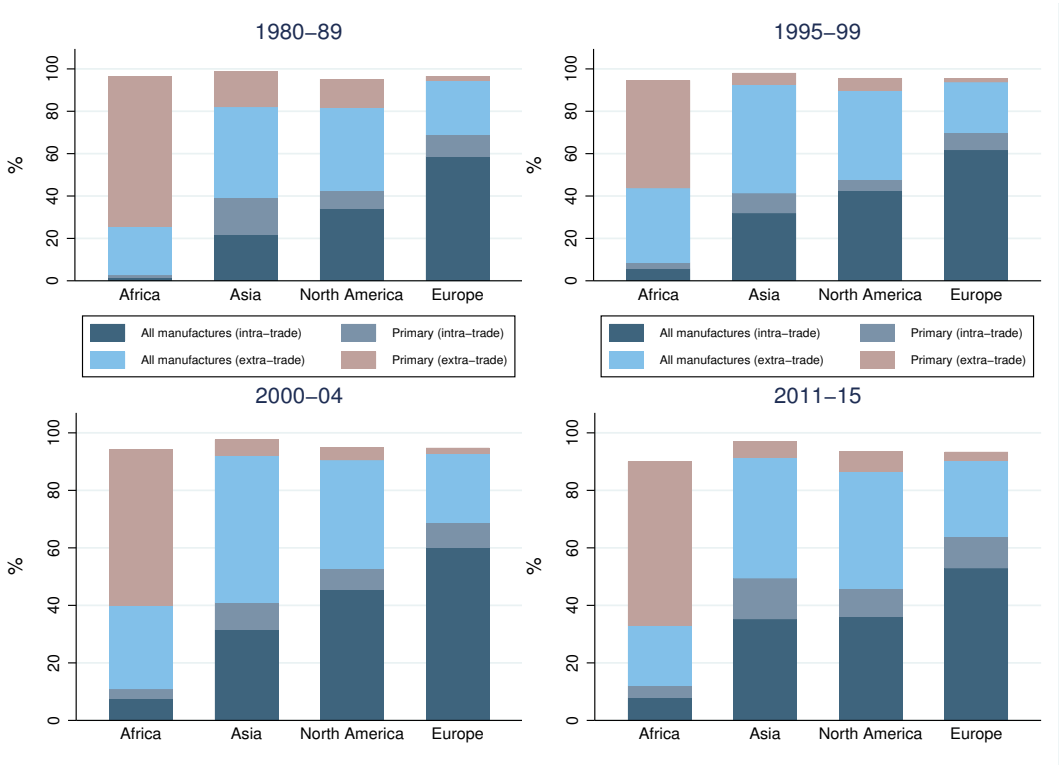
Source: Author's calculations using UN Comtrade data. Note: RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

[7]North America include: Antigua & Barbuda, Bahamas, Barbados, Belize, Canada, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Saint Kitts & Nevis, Saint Lucia, Saint Lucia, Saint Vincent & Grenadines, Trinidad & Tobago, United States

[8]The AfCFTA commits countries to remove tariffs on 90% of goods (Songwe, 2019).

Intra-trade in Africa has mainly been driven by primary goods since the 1980s. Within manufacturing, it is driven by resource-based goods, except for the period 2008-09 and 2011-15, where MTM products dominated the manufacturing sector. Intra-trade in primary goods increased from 1.1% in the 1980s to 4.2% of Africa's total exports in the period 2011-15. Resource-based goods dominated Africa's manufacturing intra-trade between the 1980s and the first half of the 1990s. Intra-trade in RBM goods accounted for about 2.6% of Africa's total exports in the period 1990-94, an increase of about 1.6% compared to the 1980s.

Figure 2.5: Intra and extra trade in Africa, (% of total exports)



Source: Author's calculations using UN Comtrade data. Note: "Other" transactions are not shown here, and account for the difference between primary and manufactured goods.

However, since the last half of the 1990s, MTM goods dominated the bulk of Africa's manufacturing intra-regional trade. Intra-trade in manufacturing grew from 1.8% of total exports in the period 1995-99 to 3.3% in the period 2011-15. Intra-regional trade in HTM goods is lower compared to other technological categories, accounting for just 0.5% of total exports in the period 2011-2015, an increase from 0.2% compared with the first half of the 1990s.

Figure 2.5 shows Africa intra and extra trade in primary and manufactured goods. Overall, manufactured goods make up a smaller share in both Africa's intra and extra-regional trade relative to other world regions (i.e., Asia, North America, and Europe). In the period 2011-2015 intra and extra trade in manufactured goods accounted for 7.9% and 20.8% (respectively) of Africa's total exports. Far lower than that of the developing region Asia, which accounted for 35.3% and 42.0%, respectively. This indicates Africa's limited integration into both regional and global value chains (GVCs).

Africa's extra-trade in primary goods is greater than in manufactured goods and is also higher than primary extra-trade in the other three regions. Thus a clear indication that Africa's participation in GVCs is in upstream production, providing primary inputs. For Africa to be more competitive in world trade depends on its ability to go up the GVCs through downstream beneficiation of its primary inputs and thereby reducing the heavy dependence on primary exports.

2.8 Trends within Africa sub-regions

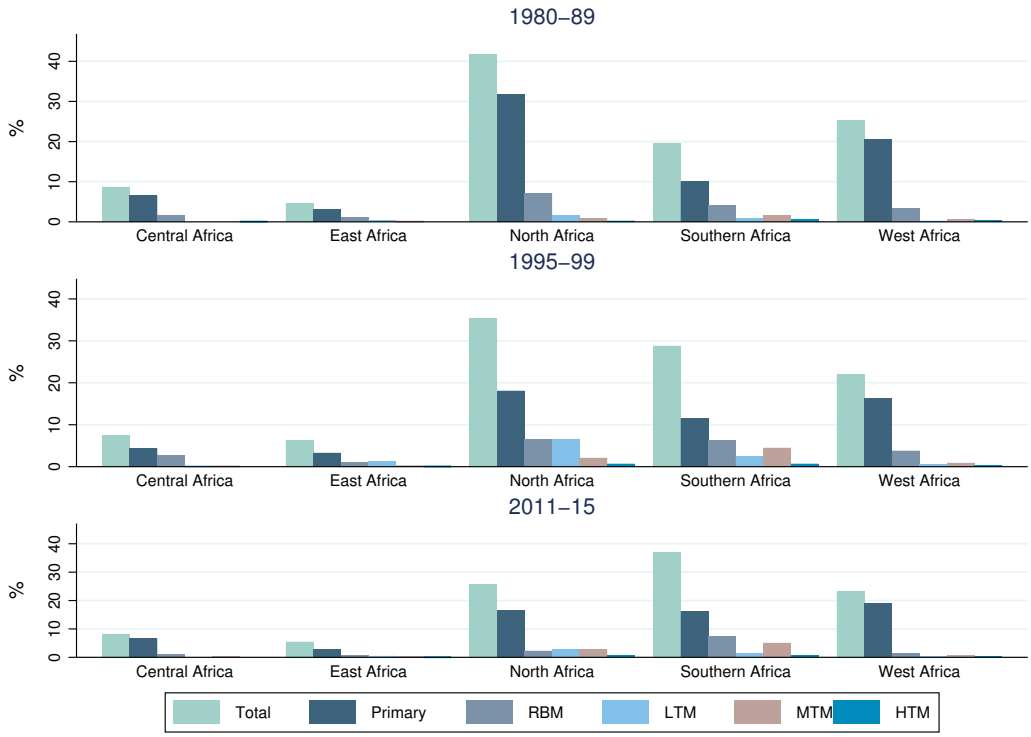
Africa sub-regions have similar trade patterns, they all export more primary goods and import mostly manufactured goods, particularly they import more industrial technologies. The sub-regions' trades are mostly dominated by outliers, and mostly in the Southern Africa region.

2.8.1 *Exports*

Figure 2.6 shows that exports in all of Africa's sub-regions are dominated by primary imports. Northern Africa dominated the continent's total exports in the 1980s and 1990s, accounting for 41.8% of the continent's exports in the 1980s and about 37.1% in the 1990s (see Table A.5 of Appendix A.2 for a more detailed distribution of Africa's exports). Since then Southern Africa surpassed the Northern region. This was mostly due to re-emerging of South Africa (the outlier in the region), as the country was mostly closed to the world market until 1994. Since then, the Northern Africa region became the second biggest exporter sub-region.

In Figure A.2 of Appendix A.2, I show the weighted average market shares (by population)

Figure 2.6: Exports regional market shares in Africa's total exports



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

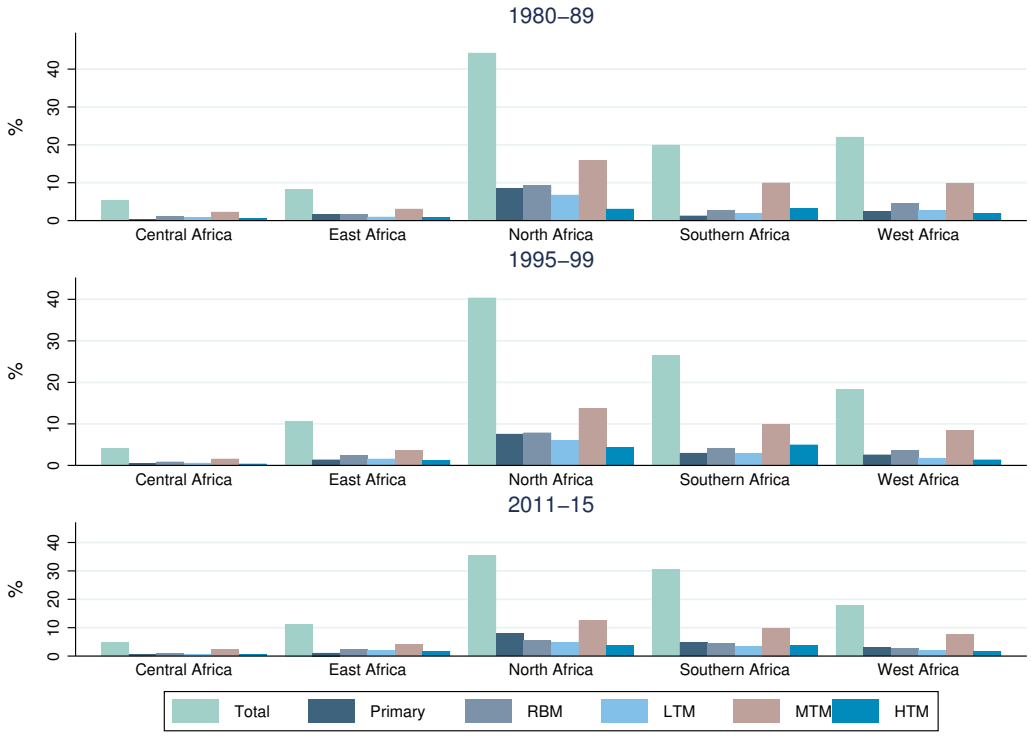
for the continent sub-regions. Southern Africa is dominated by outlier/s, as the weighted averages have a huge impact on the sub-regions market share in Africa. South Africa dominates the bulk of Southern Africa's exports. The country accounted for over 70% of Southern Africa's manufactured exports and over 35% of the continent's manufactured exports over the period in the study. South Africa manufactured exports are driven by its automotive and processing sectors (see Table A.6 of Appendix A.2 for a more detailed distribution of Africa's exports).

2.8.2 *Imports*

Figure 2.7 shows that regions within Africa have similar import composition structures, they import mostly manufactured goods, particularly medium technology goods. The Northern Africa region dominated Africa's total imports, with over 35% of Africa's total imports over the pe-

riod 1980-2015. Southern Africa was the second largest importer, accounting for about 25% of Africa's total imports.

Figure 2.7: Imports regional market shares in Africa's total imports



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

Figure A.3 of Appendix A.2 shows the weighted average (by population) import composition market shares for Africa's sub-regions. The figures show that Southern Africa's import composition is dominated by an outlier, South Africa. South Africa on its own accounted for over 50% of the sub-region total manufactured imports.

2.9 Intra and inter sub-regional trade in Africa

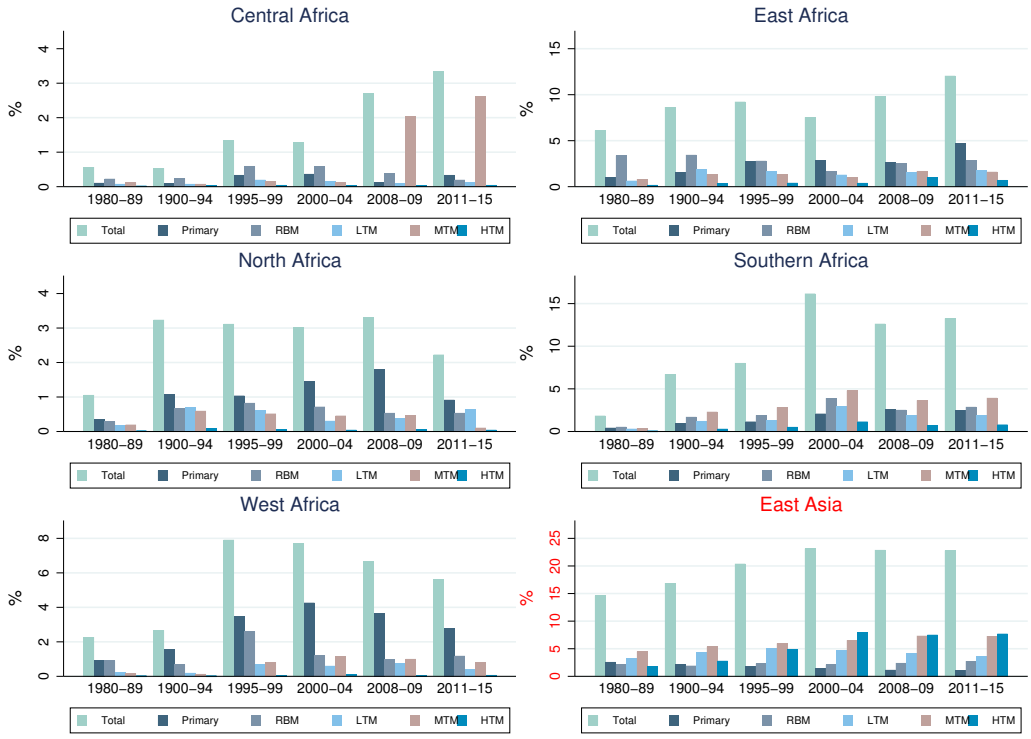
Since the 1980s, intra and inter sub-regional trade in Africa regions has marginally increased. However, despite the increase, African economies remain less integrated than other developing regions. The technological composition of both intra and inter-trade in African regions signif-

icantly differs from the East Asia region. The composition of East Asia is more of industrial technologies. The findings also show that, except in Central Africa, intra sub-regional trade is higher than inter sub-regional trade. This reflects limited integration within Africa sub-regions. However, one would expect inter sub-regional trade within Africa sub-regions to increase with the launch of the COMESA-EAC-SADC Tripartite Free Trade Area (TFTA) which was launched in mid-2015, and the AfCFTA.

2.9.1 *Intra-trade*

Figure 2.8 shows that intra-sub-regional trade in Southern Africa is greater than in other Africa sub-regions. The region has a customs union (Southern African Customs Union) and a free trade agreement (Southern African Development Community) that may have been promoted within trade.

Figure 2.8: Intra sub-regional trade composition (% of region total exports)



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

In the period 2011-15 intra-trade in the Southern Africa region accounted for 13.3% of its total exports, compared to the 22.8% in East Asia during the same period. Intra-trade is at the lowest in the Central Africa region compared to other African regions over the period 1980-2015. Southern Africa has the most diversified intra-trade, dominated by medium technology goods, while West Africa is highly dominated by primary goods.

2.9.2 *Inter-trade*

Figure 2.9 shows inter-trade[9] within the Africa sub-regions and the composition over the period 1980-2015. Inter-trade within African regions is substantially low when compared with the East Asian region, significantly increased between the period 1980-89 and the period 2011-15, from 4.1% of its total exports to 8.7%. However, its trade with other African regions is highly dominated by primary goods.

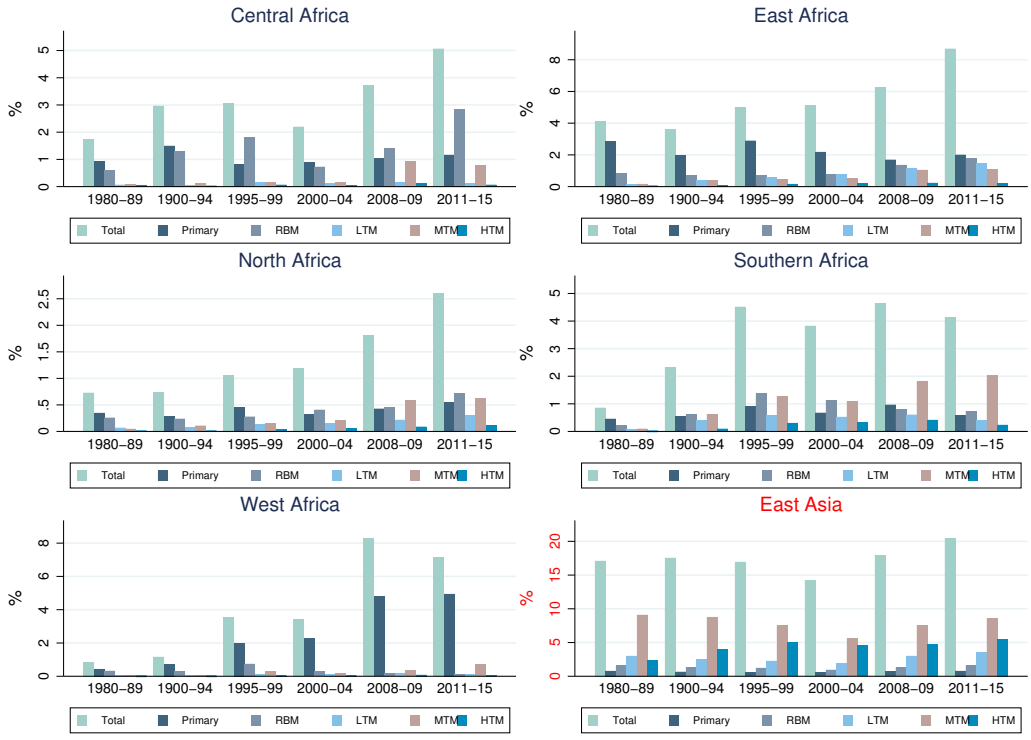
Northern Africa has the least inter-trade despite its second largest market share in Africa's total trade. The region's inter-trade has remained stagnant and low throughout the study period. In the period 2011-2015 inter-trade in Northern Africa was 2.6% of its total exports, an increase of just 1.7% compared to the 1990s.

2.10 Trends in African Countries

The bulk of Africa's trade is concentrated in a few countries (see Figure A.4 and A.5 of Appendix A.2), with South Africa becoming the dominant exporter and importer in Africa. South Africa leads in total trade (exports and imports) as well as in total manufacturing trade. The leading importers of manufactured goods are also the leading exporters in the continent. Thus, the growth performance of Africa's trade composition depends more on the performance of a few individual countries. Figure A.4 and A.5 of Appendix A.2 also show that South Africa, Egypt, Morocco, and Tunisia are the only non-oil dependent African countries that have significantly diversified their export composition into more manufactured goods.

[9]Inter-trade refers to the sub-region's trade with other sub-regions excluding intra-trade (trade within the sub-region). For example, Central Africa trade with East Africa, West Africa, and Southern Africa, excluding trade within Central Africa.

Figure 2.9: Inter sub-regional trade composition (% of region total exports)



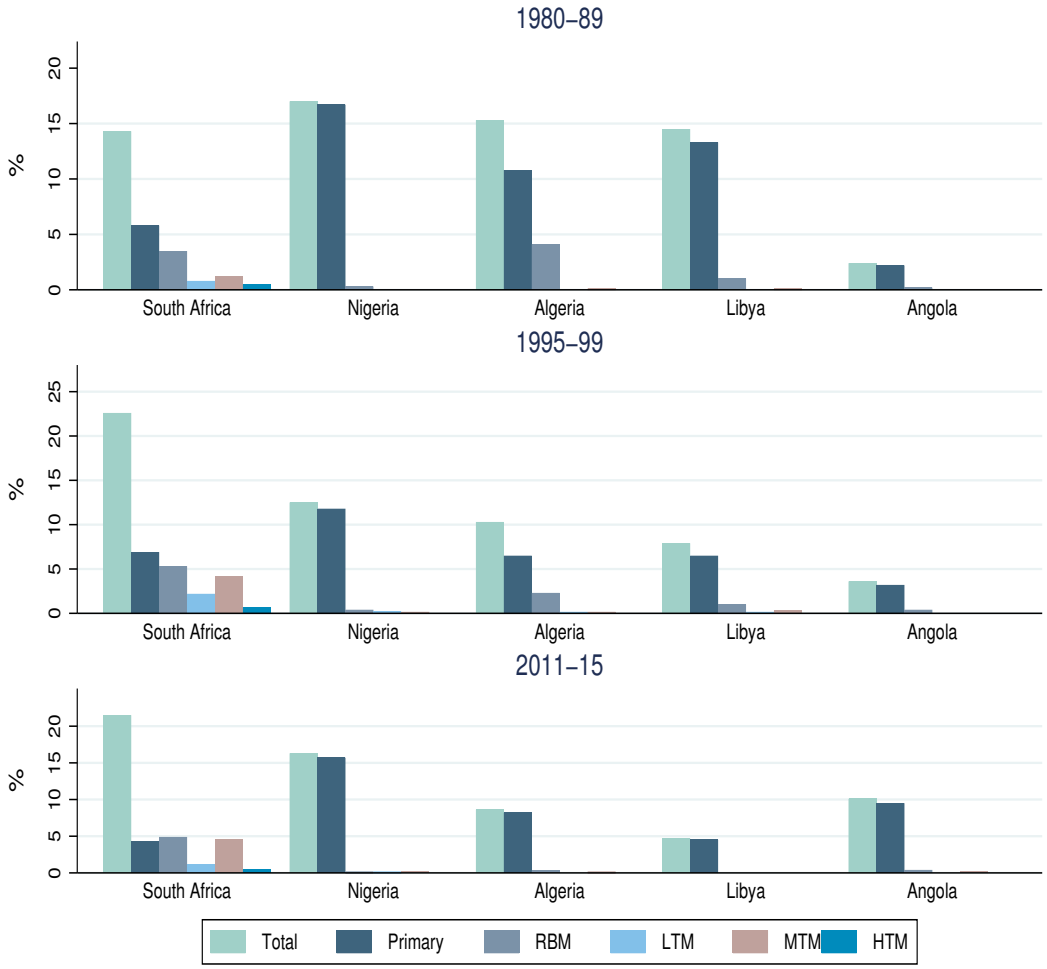
Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

2.10.1 *Exports*

Figure 2.10 shows that with the exception of South Africa, African top leading exporters export compositions are highly concentrated in primary goods. Since the 1980s, Nigeria, Algeria, Libya, and Angola's exports have been highly concentrated in primary goods, particularly crude petroleum and natural gas. South Africa is the leading exporter in Africa, its exports accounted for 21.5% of Africa's total exports in the period 2011-15, an increase from a share of 14.3% in the 1980s. South Africa also dominates the bulk of Africa's manufactured exports (see Figure 2.11). Its manufactured exports accounted for 38.8% of Africa's manufactured exports in the period 2011-2015. In the 1980s and 1990s, the country's manufactured exports were dominated by resource-based goods. Since its independence in 1994, South Africa experienced a double growth in its medium technology, which accounted for 16.1% of Africa's manufactured exports

in the period 2011-2015.

Figure 2.10: Africa top 5 exporters export composition, 1980-2015, (% of Africa total exports)

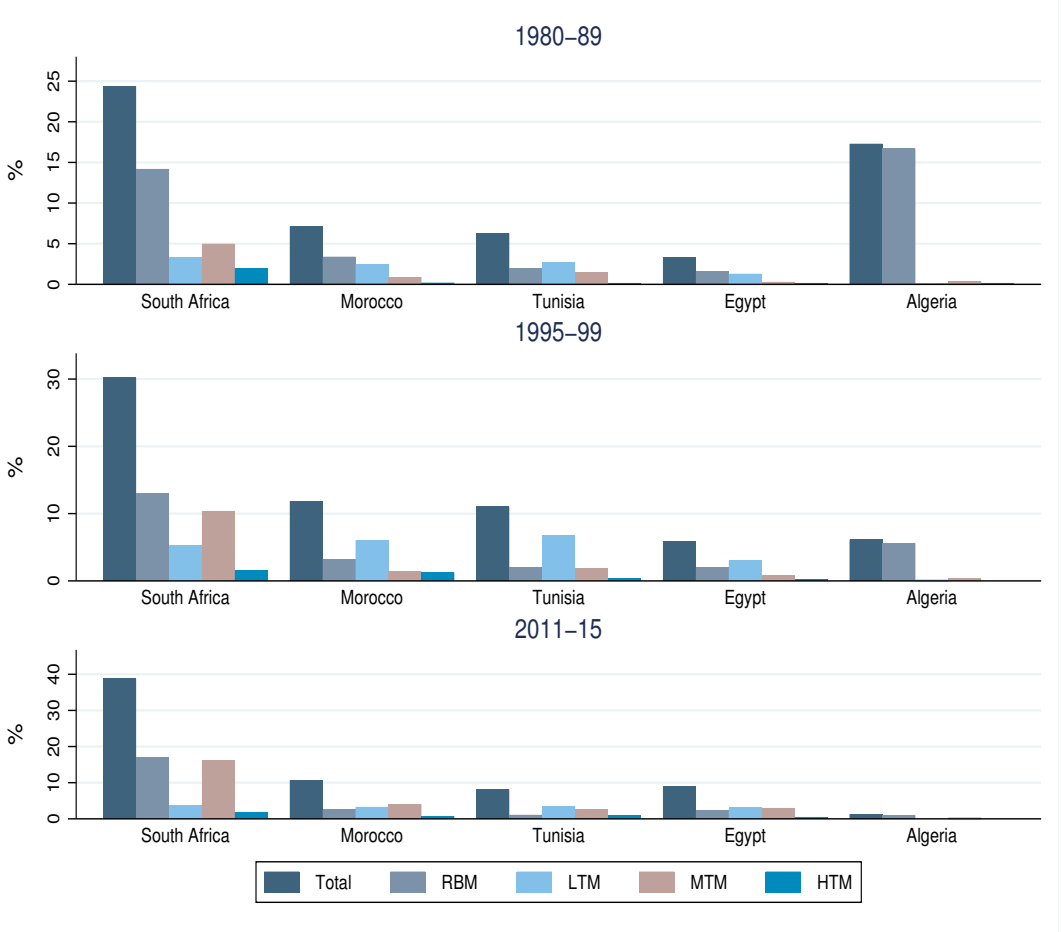


Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

Figure 2.11 also shows that African countries' manufactured export composition diversification is low, highly concentrated in resource-based goods, with the exception of a few countries. Technological export composition diversification changed marginally over the period 1980-2015. For example, Algeria is one of the five leading exports of manufactured goods over the period 1980-2015, however, resource-based goods still account for the bulk of its manufactured exports. In the 1980s, Algeria's RBM exports accounted for about 97% of its total manufactured exports.

In the period 2010-11, its RBM exports accounted for about 81% of its total manufactured exports.

Figure 2.11: Africa top 5 manufacturer exporters technological export composition, 1980-2015 (% of Africa total manufactured exports)



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

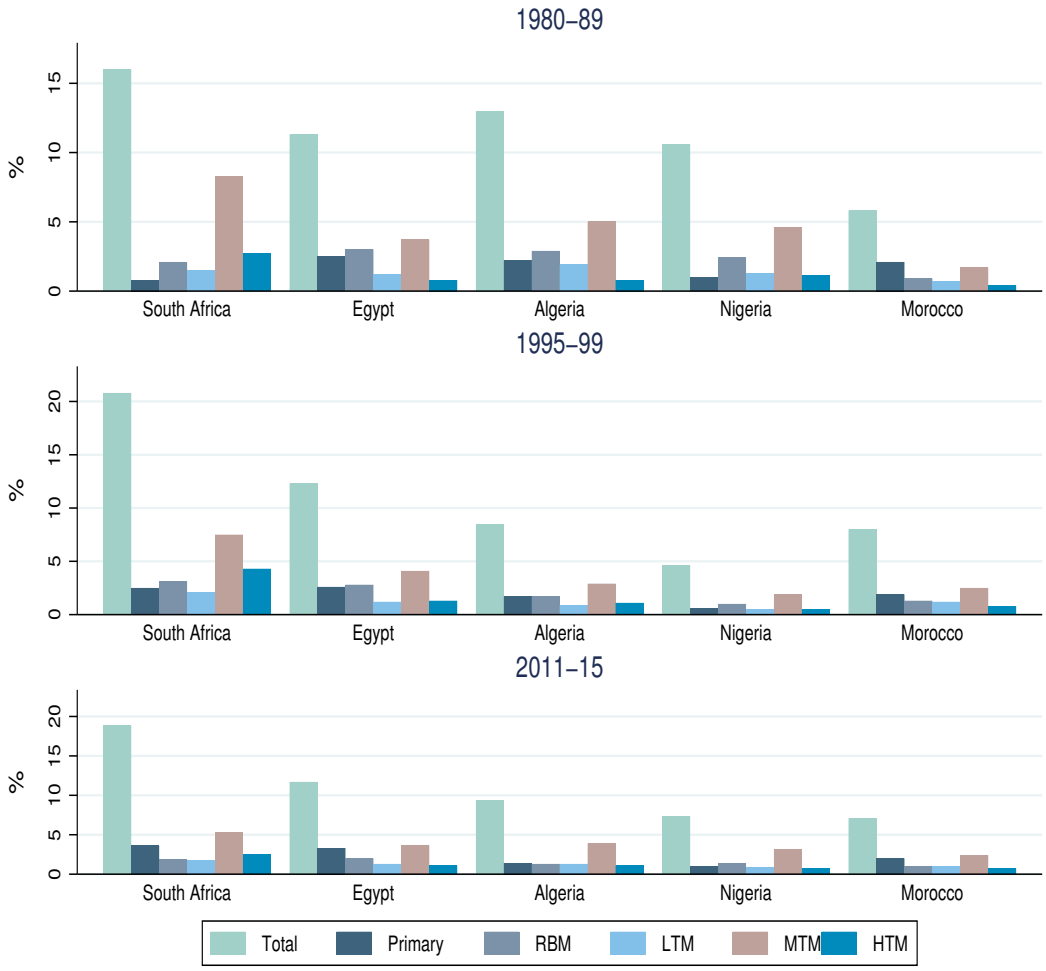
2.10.2 *Imports*

In Figure 2.12 I show the leading five countries in Africa total imports, their market shares, and import composition. The leading five importers accounted for over 50% of Africa's total imports over the period 1980-2015. Their import compositions are dominated by manufactured goods, particularly technology intensive goods. South Africa dominated Africa's total imports with an

average market share of about 18% over the period 1980-2015.

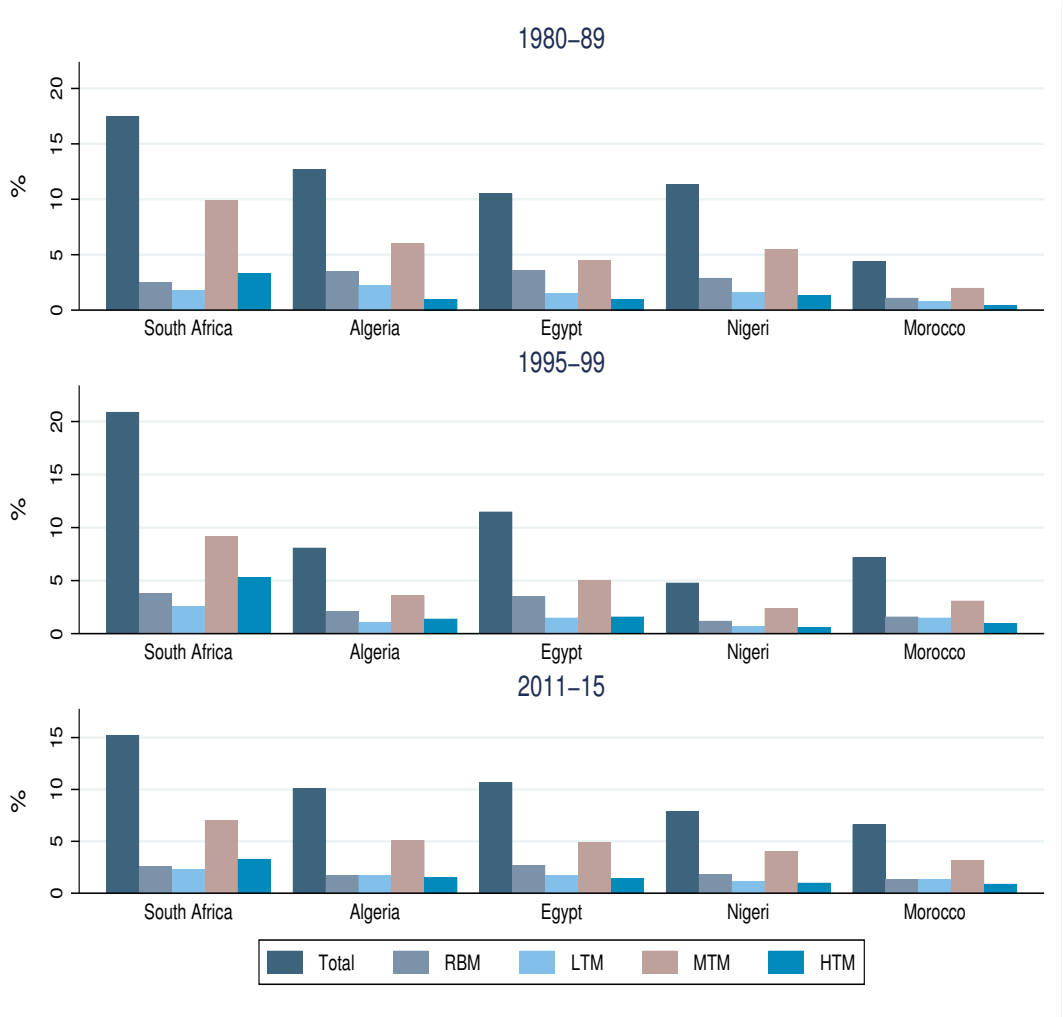
Figure 2.13 shows the technological import composition for the leading five manufactured goods importers. South Africa also dominated the continent's total manufactured imports, with a market share accounting for 18.9% of Africa's total manufactured imports in the period 2011-2015, however, a decline in share by 2.9% when compared with the last half of the 1990s. Together, the leading five manufactured importers accounted for over 50% of Africa's total manufactured imports and over 20% of the continent's medium technology imports during the period 1980-2015.

Figure 2.12: Africa top 5 importers import composition, (% of Africa total exports)



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

Figure 2.13: Africa top 5 manufacturer importers technological import composition, (% of Africa total manufactured imports)



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

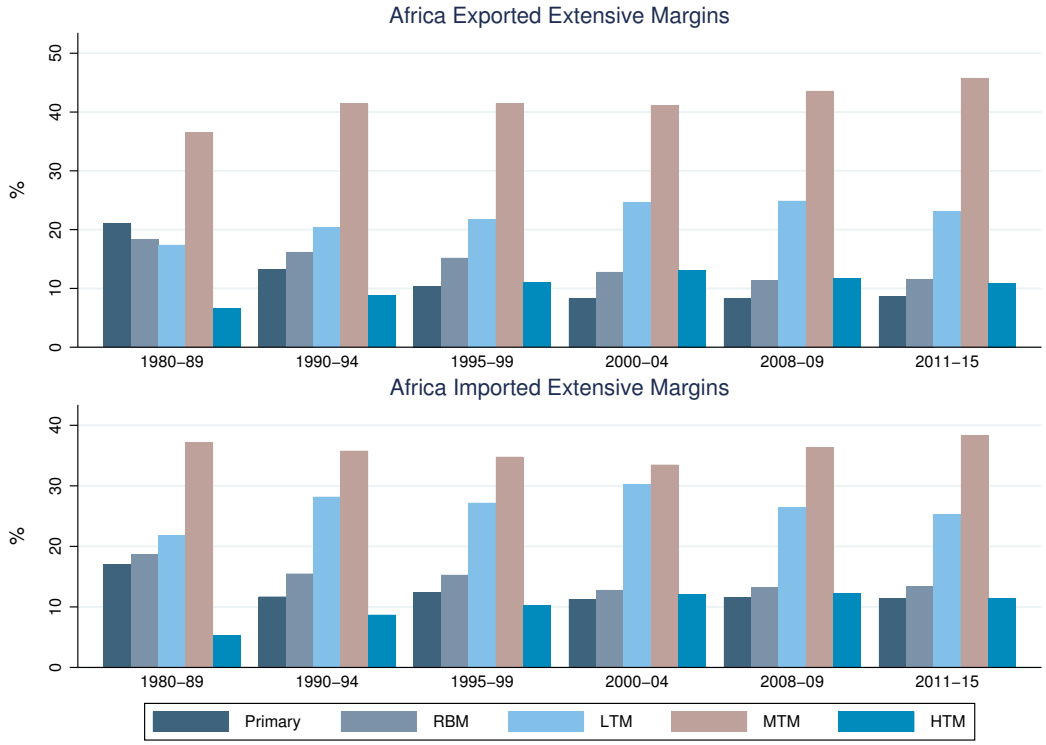
2.11 Africa Extensive Margins of Trade Composition

In the trade and growth literature, the world economy has a particular arrow pointing to the growing variety (diversification) of trade (see e.g., Coe et al., 1997; Eaton and Kortum, 1999; Rosenberg and Nathan, 1982; World Bank, 1993). In Saviotti and Frenken (2008), exporting and importing a variety of technology intensive goods stimulates faster growth (see e.g., Hausmann

and Klinger, 2006; Mo et al., 2021), while quantities only promote growth with a considerable time lag (see, Hummels and Klenow, 2005). Given the importance of trade variety in trade and economic growth literature, I analysed the trade structures extensive margins in Africa by adapting the method mapped out by Hummels and Klenow (2005).

Figure 2.14 shows the extensive margin of Africa's trade composition, while Figure A.6 of Appendix A.2 shows the extensive margins for the Asian region. Similar to the Asian region, Africa export and import more variety of manufactured goods, particularly medium technology goods. In Hummels and Klenow (2005), exporting a variety of goods is the primary avenue for trade growth and large nations export more in absolute terms than small countries.

Figure 2.14: Africa extensive margins of trade (% of total)



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

As highlighted in the previous sections, in monetary value, Africa's export composition is concentrated in primary goods, however, Figure 2.14 shows that the continent export few va-

rieties of primary goods. Moreover, Africa's primary export variety has significantly decreased during the period 1980-2015. The continent's export composition diversification is mostly distorted by oil and natural gas exporting countries such as Algeria, Angola, Chad, Equatorial Guinea, Libya, and South Sudan whose three primary products account for over 95% of their total exports (see Table A.7 of Appendix A.2). The dependence on a few varieties of primary products exposes a country to external shocks of the world demand and negative supply-side features (see e.g., Hausmann et al., 2007; Herzer and Nowak-Lehnmann D, 2006; Ocran and Biekpe, 2008).

2.12 An Overview of the Determinants of Trade in Africa

In international trade theories, determinants of trade exist on both the demand and supply side (see e.g, Grossman and Helpman, 1989; Heckscher, 1919; Helpman, 1981; Krugman, 1979; Leamer, 1980, 1984; Smith, 1937; Solow, 1956). These theories emphasised cross country differences in fixed factor endowments (i.e., infrastructure), financial development, labour productivity, exchange rates, trade costs, income per capita, and country-size.

In the Ricardian theory, international trade is determined by the differences in labour input ratios between countries. While in Heckscher-Ohlin's theory, trade between two countries is determined by the comparative advantage from differences in labour and physical capital (machinery and equipment). In Helpman (1981), patterns of trade are related to differences in factor endowments, country size, the difference in income per capita, etc.

The endogenous growth theory of Greenwood and Jovanovic (1990) and Bencivenga and Smith (1991) stresses on financial development as an important factor endowment for fostering trade. While the Marshall–Lerner (trade elasticity) theory emphasises more on the role of exchange rates as the determinant of international trade (see e.g., Bahmani et al., 2013; Bahmani-Oskooee and Niroomand, 1998; Rose, 1991). The Marshall–Lerner approach states that the devaluation of a country's currency increases the demand for exports and decreases the demand for imports, by making imports more expensive. While the appreciation of a country's currency has the opposite effects.

Various empirical studies have been conducted to investigate if these theories provide good explanations of the data, varying results have been found (see e.g., Bowen and Sveikauskas, 1992; Coe et al., 2009; Francois and Manchin, 2013; Kiendrebeogo, 2012; Maskus, 1985; Tadei et al., 2013). It would be interesting then to somehow compare the importance of these determinants in African countries' trade composition data. This may help policymakers sort through the various determinants of trade and contribute to the understanding of how these determinants create the currently observed patterns of trade.

Table 2.5 reports the correlation between trade composition and the determinants of trade (human capital, total factor productivity, financial development, infrastructure investment, and GDP per capita). The correlation results indicate a positive relationship of financial development, human capital, infrastructure investment, and GDP per capita on both the export and import composition in Africa over the period 1980-2015. Institutions also have a positive relationship with the trade composition with the exception of primary exports. While total factor productivity (TFP) is negatively correlated with the trade composition with the exception of resource-based exports.

Table 2.5: Correlation between trade composition and determinants in Africa

	ln(Fin Dev)t	Institu$t$	Human capital$t$	ln(Infra)t	TFPt	ln(GDP$_{pc}$)t
ln(Primary exports)t	0.316	-0.103	0.258	0.854	-0.018	0.500
ln(RBM exports)t	0.489	0.204	0.626	0.641	0.045	0.733
ln(LTM exports)t	0.619	0.254	0.583	0.677	-0.167	0.544
ln(MTM exports)t	0.580	0.278	0.604	0.716	-0.169	0.590
ln(HTM exports)t	0.537	0.242	0.510	0.658	-0.120	0.592
ln(Primary imports)t	0.557	0.168	0.447	0.832	-0.052	0.558
ln(RBM imports)t	0.552	0.161	0.474	0.907	-0.078	0.577
ln(LTM imports)t	0.619	0.171	0.512	0.893	-0.100	0.639
ln(MTM imports)t	0.540	0.126	0.481	0.944	-0.080	0.611
ln(HTM imports)t	0.572	0.190	0.526	0.917	-0.118	0.598

Note: ln(Fin Dev)$_t$ is the log financial development at time period t; Institu is institutions; ln(infra)$_t$ is the log infrastructure investment; ln(GDP$_{pc}$) is the log of GDP per capita at time t.

The study's descriptive analysis also reviews that Africa's leading exporters and importers are financially better developed compared to other African countries. South Africa and Morocco are the leading exporters of manufactured goods and are the most financially developed countries in Africa. South Africa is ranked 28 in global financial development rankings, while Morocco ranked second in Africa and ranked at 52 in global financial development rankings (see

Svirydzenka, 2016, global country rankings of financial development). Access to financial resources is important for trade development, the reason being that firms find it easier to finance working capital needs and investments in technology upgrading and new innovative activities. In a continent like Africa, with financial market imperfections and credit constraints, firms cannot borrow more than a multiple of their current profits, thereby affecting their ability to export or import.

Although institutions do not really change over time, in Africa, the leading exporters and importers are also endowed with better institutions. In studying institutions and economic performance, Yıldırım and Gökalp (2016) linked export performance patterns to institutional developments. Strong institutions influence a country's macroeconomic performance by affecting transaction costs, reducing uncertainty, building trust, enhancing cooperation, and directing economic activities to productive areas. Yıldırım and Gökalp (2016) found that institutional variables such as the integrity of the law system have a positive effect on the macroeconomic performance of developing countries.

The human capital theory postulates that the accumulation of human capital fosters growth and stimulates trade. In Romer (1986, 1990), educated workers are considered faster learners, as education enables workers to learn new skills and ideas. While in Hausmann et al. (2007) and Biggs et al. (1996), the most important constraint in developing countries is inadequate mechanisms for transferring new ideas and promoting learning, as skill levels can be raised through exposure to new ways of doing things and training. Weaknesses in learning mechanisms in Africa, for example, stem from the fact that public institutions are weak and lack adequate infrastructures (see e.g., Luiz, 2009; Stiglitz, 2018; Tadei, 2018).

The empirical literature (e.g., Francois and Manchin, 2013; Limao and Venables, 2001) also offers evidence on infrastructure and its impact on trade. Limao and Venables (2001) show that infrastructure is quantitatively important in determining total transport costs and hence trade. They estimate that poor infrastructure accounts for 40% of predicted transport costs for coastal countries and up to 60% for landlocked countries.

However, since trade is high in a few African countries, the correlation results in Table 2.5 should be interpreted with caution. To account for this bias, the study controls for country

Table 2.6: Correlation between trade composition and determinants in Africa (controlling for country FE & year FE)

	ln(Fin Dev)t	Institu$t$	Human capital$t$	ln(Infra)t	TFPt	ln(GDP$_{pc}$)t
ln(Primary exports)t	-0.006	-0.084	-0.045	0.300	0.238	0.358
ln(RBM exports)t	0.022	-0.096	-0.130	0.178	0.125	0.167
ln(LTM exports)t	0.042	0.027	-0.002	0.133	0.022	0.080
ln(MTM exports)t	0.066	0.068	-0.044	0.076	0.014	0.010
ln(HTM exports)t	0.211	-0.026	-0.080	0.126	-0.009	0.267
ln(Primary imports)t	0.096	-0.010	0.022	0.121	0.045	-0.036
ln(RBM imports)t	0.153	-0.058	-0.070	0.291	0.134	0.215
ln(LTM imports)t	0.377	-0.079	0.017	0.405	0.186	0.440
ln(MTM imports)t	0.218	-0.049	-0.016	0.530	0.208	0.385
ln(HTM imports)t	0.371	-0.053	-0.033	0.502	0.184	0.434

Note: The values captured are the residuals after controlling for country and year fixed effects. ln(Fin Dev)$_t$ is log financial development at time period t; Institu is institutions; TFP$_t$ is total factor productivity; ln(infra)$_t$ is the log infrastructure investment; ln(GDP$_{pc}$) is the log of GDP per capita at time t.

and year fixed effects (FE) and records the findings in Table 2.6. Immediately one can observe the importance of using a panel setting, as the positive correlations of trade composition with financial development, institutions, human capital, infrastructure investment, and income per capita becomes weaker across, even before adding control variables. While the correlation with total factor productivity becomes stronger. Together Table 2.5 and 2.6 highlight the importance of controlling for country and year fixed effects.

2.13 Discussion and Conclusion

This study has analysed Africa's trade composition (both exports and imports) covering the period 1980-2015, using a disaggregated and detailed classification by technological levels. I find that Africa's participation in global trade has remained marginal and few countries dominate the African continent's trade. The continent's import composition is concentrated in capital goods (medium and high technology goods). Its export composition is highly concentrated in primary goods, more than 60% of Africa's exports are primary goods. The continent's manufactured exports are stagnated, low, and less diversified - highly concentrated in resource-based manufactured goods.

Globally, the continent has performed poorly compared to other world regions. Africa has lost its global market shares in both primary and manufactured exports. In the period 2011-15,

Africa's total exports accounted for just 4.0% of global exports, a fall in market share from 4.5% when compared to the period 1980-89. The continent's export performance was worse than that of other world regions over the period 1980-2015. Intra-trade has remained low compared to other world regions.

I also find that regions within Africa have similar technological export composition structures. Manufactured exports are concentrated in resource-based goods in all regions. Southern Africa dominates the bulk of Africa manufactured exports with over 50% of Africa manufactured exports, however, dominated by an outlier - South Africa. Sub-regional trade has increased marginally but remains less integrated compared to other developing sub-regions of the world. Few notable countries that have managed to transform their export composition into semi-processed and relatively high technology exports are also the leading imports of capital goods. They are better financially developed and better endowed with human capital, infrastructure, and institutions than the other African countries.

If African countries could add value to their abundant and diversified natural resources, it has a high growth potential to diversify its export composition into more processed and semi-processed manufactured goods and could increase its share in global exports. Factor endowments do not have to condemn African countries to specialise only in primary and resource-based goods.

Appendix A

A.1 *Technological classification of trade and Africa sub-regions*

Table A.1: Technological classification of trade (SITC 3-digit, revision 2)

Primary products	Resource based manufactures (RBM)	**Low technology manufactures (LTM)**	**Medium technology manufactures (MTM)**
001 Live animals for food	*RBM 1: Agro-based*	*LTM 1: Textile, garment and footwear*	*MTM 1: Automotive*
011 Meat fresh child, frozen	012 Meat dried salted smoked	611 Leather	781 Passenger motor vehicle excluding buses
022 Milk and cream	014 Meat prepared preserved, nes etc	612 Leather etc. manufactures	782 Lorries, special motor vehicles nes
025 Eggs, birds,fresh,preserved	023 Butter	613 Fur skins tanned, dressed	783 Road motor vehicles nes
034 Fish,fresh,chilled, frozen	024 Cheese and curd	651 Textiles yarn	784 Motor vehicle parts, accessories nes
036 Shell fish fresh,frozen	035 Fish salted, dried smoked	652 Cotton fabrics,woven	785 Cycles, etc. motorized or not
041 Wheat, etc, unmilled	037 Fish etc. prepared, preserved nes	654 Other woven textile fabric	*MTM 2: Process*
042 Rice	046 Wheat etc. meal or flour	655 Knitted, etc. fabrics	266 Synthetic fibres to spin
043 Barley unmilled	047 Other cereals meals,flour	656 Lace, ribbons, tulle, etc	267 Other man-made fibres
044 Maize unmilled	048 Cereal etc. preparations	657 Special textile fabric, products	512 Alcohols, phenols etc
045 Cereal nuts unmilled	056 Vegetables, preserved, prepared	658 Textile articles nes	513 Carboxylic acids, etc.
054 Veg.etc. fresh, simply preserved	058 Fruit preserved, prepared	659 Floor coverings,etc	533Pigments, paints,etc.
057 Fruit, nuts, fresh, dried	061 Sugar and honey	831 Travel goods, handbags	553 Perfumery,cosmetics,etc
071 Coffee and substitutes	062 Sugar candy non-chocolate	842 Mens outwear not knitted	554 Soap, cleansing, etc. preparations
072 Cocoa	073 Chocolate and products	843 Womens outwear non-knitted	562 Fertilizers, manufactured
074 Tea and mate	098 Edible products, preparation	844 Under garments not-knitted	572 Explosives, pyrotech products
075 Spices	111 Non-alcohol beverages nes	845 Outwear knit non elastic	582 Products of condensation etc.
081 Feeding stuff for animals	112 Alcoholic beverages	846 Under garments knitted	583 Polymerization, etc. products
091 Margarine and shortening	122 Tobacco, manufactured	847 Textile clothing accessories nes.	584 Cellulose derivatives, etc.
121 Tobacco unmanufactured, refuse	233 Rubber,synthetic, reclaimed	848 Headgear, non-textile clothing	585 Plastic materials nes
211 Hides, skins, exc.furs, raw	247 Other wood rough,squared	851 Footwear	591 Pesticides disinfectants
212 Furskins, raw	248 Wood shaped sleepers	*LTM 2: Other products*	598 Miscellaneous chemical products nes
222 Seeds for "soft" fixed oils	251 Pulp and waste paper	642 Paper, etc. precut,articles of	653 Woven man-made fibre fabric
223 Seeds for other fixed oils	264 Jute, other textile based fibres	665 Glassware	671 Pig iron etc.
232 Natural rubber, gums	265 Vegetables fibre, exc.cotton,jute	666 Pottery	672 Iron, steel primary forms
244 Cork, natural, raw, waste	269 Waste of textile fabrics	673 Iron, steel shapes etc.	678 Iron, steel tubes, pipes, etc
245 Fuel wood nes,charcoal	423 Fixed vegetables, oils, soft	674 Iron, steel universal plate	786 Trailers,non motorized vehicles, nes
246 Pulpwood, chips, wood waste	424 Fixed vegetables, oil non-soft	675 Iron, steel hoop, strip	791 Railway vehicles
261 Silk	431 Processed animal vegetables, oil, etc.	676 Railway rails, etc.iron steel	882 Photo, cinema supplies
263 Cotton	621 Materials for rubber	677 Iron, steel wire (exc. Wrod)	*MTM 3: Engineering*
268 Wool (exc.tops),animal hair	625 Rubbers tyres, tubes etc .	679 Iron, steel castings unworked	711 Steam boilers and auxiliary plant
271 Fertilizers, crude	628 Rubber articles nes	691 Structures and parts nes	713 Internal combustion piston engines
273 Stone, sand and gravel	633 Cork manufacturers	692 Metal tanks, boxes, etc.	714 Engines and motors nes
274 Sulphur,iron pyrte	634 Veneers, plywood, etc	693 Wire products non-electrical	721 Agricultural machinery, excluding tractors
277 Natural abrasives nes	635 Wood manufactures nes	694 Steel, copper nails, nuts, etc.	722 Tractors non-road
278 Other crude minerals	641 Paper and paperboard	695 Tools	723 Civil, engineering equipment etc
291 Crude animal materials nes	*RBM 2: Other*	696 Cutlery	724 Textile, leather machinery
292 Crude veg. materials nes	281 Iron ore,concentrates	697 Base metal household equipment	725 Paper etc. mill machinery
322 Coal,lignite and peat	282 Iron and steel scrap	699 Base metal manufactures nes	726 Printing bookbinding machinery,parts
333 Crude petroleum	286 Uranium, thorium ore, concentrate	821 Furniture, parts thereof	727 Food machinery non-domestic
341 Gas, natural and manufactured	287 Base metal ores,concentrate,nes	893 Articles of plastic nes	728 Other machinery for specials industries
681 Silver, platinum, etc.	288 Non-ferrous metal scrap nes	894 Toys, sporting goods, etc	736 Metalworking machinery tools
682 Copper exc. Cement copper	289 Precious metal ores, waste nes	895 Office supplies nes	737 metalworking machinery nes

683 Nickel
684 Aluminium
685 Lead
686 Zinc
687 Tin

High technology manufactures (HTM)

HTM1: Electronic and electrical

716 Rotating electric plant
718 Other power generating machinery
751 Office machines
752 Automatic data processing equipment
759 Office, automatic date processing machine parts
761 Television receivers
764 Telecom equipment parts, accessories nes
771 Electric power machinery nes
774 Electro -medical, x-ray equipment
776 Transistors, valves, etc
778 Electrical machinery

HTM 2: Other

524 Radioactive, etc. material
541 Medicinal, pharmaceutical products
712 Steam engines, turbines
792 Aircraft,etc
871 Optical instruments
874 Measuring, controlling instruments
881 Photo apparatus, equipment nes
323 Briquets, coke, semi-coke
334 Petroleum products refined
335 Residual petroleum products nes
411 Animal oils and fats
511 Hydrocarbons nes, derivative
514 Nitrogen compounds
515 Organic-inorganic compounds etc
516 Other organic chemicals
522 Inorganic elements, oxides, etc.
523 Other inorganic chemicals etc.
531 Synthetic dye, natural indgo, lakes
532 Dyes nes, tanning products
551 Essential oils, perfume, etc.
592 Starch, inulin, gluten, etc.
661 Lime, cement,building products
662 Clay, refractory building products
663 Mineral manufactures nes
664 Glass
667 Pearl, precious semi-precious stone
688 Uranium thorium, alloys
689 Non-ferrous base metals nes
897 Gold, silver ware, jewellery
898 Musical instrument,pts
899 Other manufactured goods
741 Heating, cooling equipment
742 Pumps for liquids, etc
743 Pumps nes, centrifuges, etc
744 Mechanical handling equipment
745 Non electrical machinery tools nes
749 Non-electric machinery parts, nes
762 Radio broadcast receivers
763 Sound recorders phonograph
772 Switchgear, etc. parts nes
773 Electrical distributing equipment
775 Household type equipment nes
793 Ships and boats etc.
812 Plumbing, heating, lighting equipment
872 Medical instruments nes
873 Meters and counters nes
884 Optical goods nes
885 Watches and clocks
951 War firearms, ammunition

Source: SITC rev.2 product, by technological categories (Lall(2000))

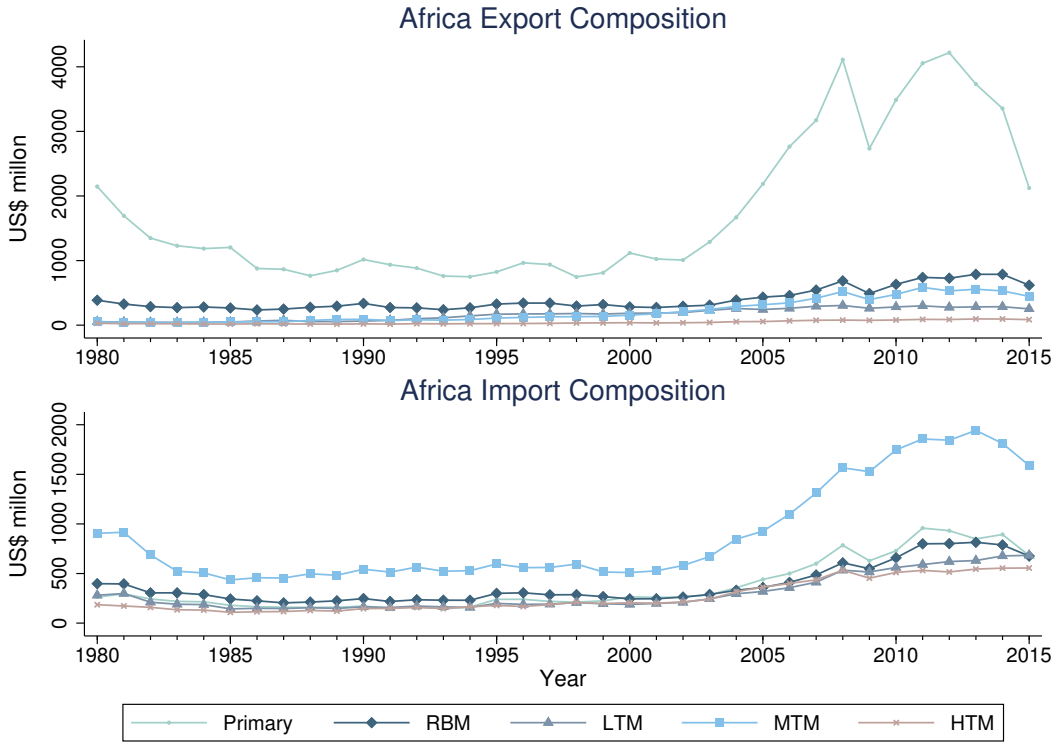
Table A.2: Africa sub-regions

ISO code	Country name	Sub-region	ISO code	Country name	Sub-region
BDI	Burundi	Central Africa	AGO	Angola	Southern Africa
CAF	Central African Republic	Central Africa	BWA	Botswana	Southern Africa
CMR	Cameroon	Central Africa	LSO	Lesotho	Southern Africa
COG	Congo	Central Africa	MOZ	Mozambique	Southern Africa
GAB	Gabon	Central Africa	MWI	Malawi	Southern Africa
GNQ	Equatorial Guinea	Central Africa	NAM	Namibia	Southern Africa
STP	Sao Tome and Principe	Central Africa	SWZ	Swaziland	Southern Africa
TCD	Chad	Central Africa	ZAF	South Africa	Southern Africa
ZAR	Democratic Republic Congo	Central Africa	ZMB	Zambia	Southern Africa
			ZWE	Zimbabwe	Southern Africa
COM	Comoros	East Africa			
DJI	Djibouti	East Africa	BEN	Benin	West Africa
ERI	Eritrea	East Africa	BFA	Burkina Faso	West Africa
ETH	Ethiopia	East Africa	CIV	Côte d'Ivoire	West Africa
KEN	Kenya	East Africa	CPV	Cabo Verde	West Africa
MDG	Madagascar	East Africa	GHA	Ghana	West Africa
MUS	Mauritius	East Africa	GIN	Guinea	West Africa
RWA	Rwanda	East Africa	GMB	Gambia	West Africa
SOM	Somalia	East Africa	GNB	Guinea-Bissau	West Africa
SSD	South Sudan	East Africa	LBR	Liberia	West Africa
SUD	Sudan	East Africa	MLI	Mali	West Africa
SYC	Seychelles	East Africa	NER	Niger	West Africa
TZA	Tanzania	East Africa	NGA	Nigeria	West Africa
UGA	Uganda	East Africa	SEN	Senegal	West Africa
			SLE	Sierra Leone	West Africa
DZA	Algeria	North Africa	TGO	Togo	West Africa
EGY	Egypt	North Africa			
LBY	Libya	North Africa			
MAR	Morocco	North Africa			
MRT	Mauritania	North Africa			
TUN	Tunisia	North Africa			

Source: African Union database.

A.2 *Additional Results*

Figure A.1: Trends in our key trade variables for Africa to and from the world, 1980-2015.



The data is in US$ values. The key variables are primary goods trade, resource based manufactured (RBM), low technology manufactured (LTM), medium technology manufactured (MTM) and high technology manufactured (HTM) goods. Source: Author's calculations using UN Comtrade data (SITC rev. 2).

Table A.3: Africa manufactured trade by sub-categories

Manufactured trade by technological sub-categories												
	Exports						Imports					
	1980-89	1990-94	1995-99	2000-04	2008-09	2011-15	1980-89	1990-94	1995-99	2000-04	2008-09	2011-15
All manufactures	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
RBM	69.2	57.9	49.7	39.8	41.8	44.9	23.4	21.5	23.3	20.1	18.4	20.6
Agro-based	17.6	17.0	15.9	15.3	12.6	12.5	13.2	13.2	14.1	12.6	11.3	13.0
Other RBM	51.6	40.8	33.8	24.5	29.3	32.3	10.2	8.2	9.3	7.6	7.1	7.6
LTM	12.8	20.7	26.7	27.2	20.1	17.1	16.0	15.1	15.8	16.7	16.7	17.0
Textile	9.4	15.1	20.5	19.6	12.8	10.8	4.9	5.7	6.3	6.8	4.9	5.5
Other LTM	3.4	5.6	6.1	7.6	7.4	6.3	11.1	9.4	9.6	9.8	11.8	11.5
MTM	13.1	17.2	19.1	27.7	32.6	32.5	49.1	49.4	45.7	46.0	49.2	48.0
Automotive	0.5	1.3	2.1	6.2	6.2	7.0	11.7	9.5	8.3	9.5	11.9	11.7
Process	8.4	9.9	9.9	10.7	13.0	11.8	10.7	11.2	11.6	11.4	12.2	12.4
Engineering	4.1	5.9	7.1	10.8	13.4	13.6	26.7	28.7	25.7	25.0	25.1	23.9
HTM	5.0	4.3	4.5	5.3	5.5	5.6	11.5	14.1	15.2	17.3	15.7	14.4
Electronic	0.7	1.7	2.7	3.5	3.2	3.0	6.9	7.5	9.2	10.2	9.1	8.4
Other HTM	4.3	2.6	1.8	1.8	2.2	2.6	4.6	6.6	6.0	7.0	6.6	5.9

Table A.4: Africa's trade partners by technological categories, 1980-2015

		Export Partners						Imports Partners					
		Europe	UK	East Asia	China	US	Others	Europe	UK	East Asia	China	US	Others
	Primary	9.8%	5.4%	8.2%	3.6%	70.1%	2.9%	6.4%	3.9%	4.4%	20.1%	29.0%	36.2%
	RBM	10.3%	17.9%	8.4%	5.8%	53.8%	3.9%	15.8%	14.4%	11.5%	3.7%	23.3%	31.3%
1980-89	LTM	14.3%	13.4%	13.4%	31.9%	19.2%	7.8%	15.1%	25.6%	18.1%	15.7%	15.7%	9.7%
	MTM	7.3%	1.4%	27.5%	54.9%	5.0%	3.9%	11.8%	28.1%	28.0%	3.4%	24.6%	4.1%
	HTM	34.6%	13.4%	4.0%	14.2%	27.2%	6.6%	9.8%	33.1%	13.6%	3.2%	37.8%	2.5%
	Primary	8.2%	5.8%	8.5%	6.8%	67.8%	2.9%	8.3%	4.1%	2.8%	25.8%	34.6%	24.3%
	RBM	13.3%	21.9%	11.9%	9.3%	38.7%	5.0%	13.5%	16.7%	9.3%	5.8%	28.1%	26.6%
1990-94	LTM	15.7%	21.9%	12.0%	12.7%	29.7%	8.0%	15.2%	24.9%	13.7%	20.9%	16.9%	8.4%
	MTM	16.4%	3.7%	28.6%	38.1%	5.8%	7.3%	9.3%	15.7%	50.1%	4.5%	17.2%	3.2%
	HTM	30.2%	22.9%	8.3%	6.8%	21.5%	10.4%	10.0%	27.2%	10.4%	5.5%	44.4%	2.5%
	Primary	5.0%	3.3%	10.1%	10.8%	68.8%	2.0%	10.0%	6.9%	2.8%	16.7%	36.0%	27.5%
	RBM	12.1%	19.3%	11.5%	23.3%	29.7%	4.2%	14.1%	22.0%	8.6%	6.8%	30.7%	17.9%
1995-99	LTM	15.5%	32.6%	6.1%	4.4%	37.4%	3.9%	13.6%	23.3%	11.2%	28.3%	17.8%	5.8%
	MTM	16.7%	8.4%	17.2%	34.6%	13.8%	9.3%	9.5%	19.1%	33.4%	8.6%	26.6%	2.7%
	HTM	15.2%	28.6%	4.8%	14.8%	29.9%	6.8%	8.4%	30.7%	8.1%	10.6%	40.0%	2.2%
	Primary	3.3%	3.2%	6.3%	34.2%	51.5%	1.6%	9.5%	7.6%	3.6%	14.8%	35.1%	29.5%
	RBM	6.3%	50.4%	3.7%	28.5%	9.0%	2.1%	12.0%	25.0%	8.6%	13.0%	27.4%	14.1%
2000-04	LTM	7.6%	30.1%	2.7%	4.5%	53.0%	2.2%	10.5%	18.2%	5.8%	47.3%	14.2%	4.1%
	MTM	15.5%	17.3%	13.4%	12.4%	35.3%	6.1%	9.0%	17.6%	31.8%	13.3%	25.7%	2.7%
	HTM	10.0%	18.5%	8.2%	26.2%	29.8%	7.3%	6.9%	24.3%	6.1%	21.0%	39.9%	1.8%
	Primary	2.4%	3.6%	4.2%	29.6%	59.3%	1.0%	12.1%	6.1%	4.2%	9.8%	31.5%	36.3%
	RBM	6.5%	14.4%	4.2%	59.8%	13.3%	1.9%	9.6%	15.6%	8.4%	32.3%	25.0%	9.0%
2008-09	LTM	8.1%	24.2%	7.7%	7.7%	48.9%	3.4%	6.6%	7.1%	3.3%	67.1%	13.1%	2.8%
	MTM	10.6%	9.2%	12.0%	12.4%	46.9%	8.9%	5.7%	10.5%	23.1%	34.5%	22.7%	3.4%
	HTM	9.5%	16.7%	5.1%	35.7%	24.0%	9.0%	5.2%	14.4%	4.4%	49.4%	24.8%	1.8%
	Primary	3.1%	10.7%	8.5%	45.2%	30.6%	1.9%	10.1%	8.9%	4.6%	15.0%	29.2%	32.2%
	RBM	5.4%	19.4%	3.7%	56.3%	13.1%	2.1%	8.9%	14.2%	6.6%	41.8%	19.6%	8.9%
2011-15	LTM	8.4%	18.1%	3.1%	12.4%	53.6%	4.2%	3.3%	4.4%	2.3%	80.6%	7.7%	1.8%
	MTM	8.9%	15.6%	7.8%	19.9%	40.9%	6.9%	4.3%	9.2%	20.3%	42.5%	20.6%	3.1%
	HTM	11.0%	10.9%	13.2%	32.7%	23.5%	8.7%	3.6%	10.6%	2.9%	61.5%	19.7%	1.6%

Source: Author's calculations using UN Comtrade data (SITC rev. 2)
Notes:UK = United Kingdom; US = United States

Table A.5: Regions market shares in Africa total exports.

	All products	Primary	All Manufactures	RBM	LTM	MTM	HTM
Shares of products in Africa total exports, 1980-89 (%)							
Central Africa	8.7	6.5	1.9	1.7	0.0	0.0	0.1
East Africa	4.7	3.1	1.5	1.0	0.4	0.1	0.0
North Africa	41.8	31.7	9.8	7.1	1.6	0.9	0.2
Southern Africa	19.6	10.0	7.0	4.1	0.9	1.5	0.5
West Africa	25.3	20.6	4.5	3.3	0.2	0.6	0.4
Shares of products in Africa total exports, 1990-94 (%)							
Central Africa	8.3	5.5	2.7	2.5	0.0	0.0	0.1
East Africa	5.0	2.7	2.3	1.0	1.0	0.2	0.1
North Africa	38.7	23.4	13.8	7.4	3.9	1.9	0.6
Southern Africa	25.9	12.7	10.3	5.1	1.8	2.9	0.4
West Africa	22.2	17.0	4.8	3.5	0.3	0.8	0.3
Shares of products in Africa total exports, 1995-99 (%)							
Central Africa	7.4	4.4	2.9	2.7	0.1	0.1	0.0
East Africa	6.3	3.3	2.8	1.1	1.3	0.2	0.1
North Africa	35.4	18.1	15.9	6.5	6.6	2.1	0.7
Southern Africa	28.8	11.5	13.9	6.2	2.5	4.5	0.7
West Africa	22.1	16.3	5.5	3.8	0.5	0.9	0.3
Shares of products in Africa total exports, 2000-04 (%)							
Central Africa	6.8	5.0	1.8	1.6	0.0	0.1	0.0
East Africa	6.0	3.4	2.2	0.8	1.1	0.2	0.1
North Africa	31.7	19.9	11.2	2.4	5.4	2.5	0.7
Southern Africa	34.4	12.4	18.2	7.9	3.0	6.3	0.9
West Africa	21.0	17.0	3.3	1.8	0.3	1.0	0.1
Shares of products in Africa total exports, 2008-09 (%)							
Central Africa	8.0	6.3	1.6	1.2	0.0	0.4	0.0
East Africa	5.3	3.4	1.6	0.6	0.5	0.2	0.1
North Africa	33.0	23.8	8.9	2.4	3.2	2.7	0.5
Southern Africa	33.5	16.9	13.6	6.3	1.5	5.1	0.7
West Africa	20.1	17.1	2.1	1.1	0.3	0.6	0.1
Shares of products in Africa total exports, 2011-15 (%)							
Central Africa	8.2	6.6	1.5	1.0	0.0	0.4	0.0
East Africa	5.5	2.9	1.7	0.8	0.5	0.2	0.1
North Africa	25.7	16.5	8.7	2.3	2.8	2.9	0.6
Southern Africa	37.1	16.2	14.4	7.4	1.3	5.1	0.7
West Africa	23.4	19.0	2.3	1.3	0.2	0.7	0.2

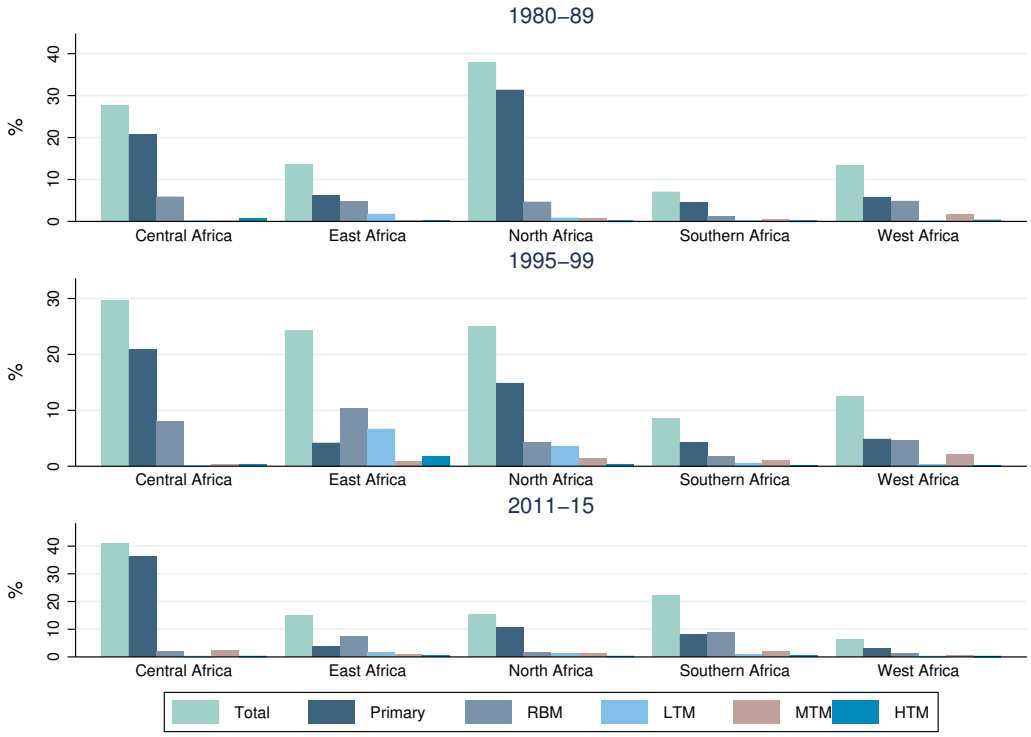
Author's calculations using UN Comtrade data (SITC rev. 2)
Notes: Figures are weighted by countries' population sizes
"Other" transaction are not shown here, and account for the difference between all products and primary plus all manufactured.
RBM = Resource based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufactures and HTM = High technology manufactures.

Table A.6: Regions market shares in Africa total imports.

	All products	Primary	All Manufactures	RBM	LTM	MTM	HTM
			Shares of products in Africa total imports, 1980-89 (%)				
Central Africa	5.3	0.4	4.8	1.1	0.9	2.3	0.6
East Africa	8.3	1.6	6.6	1.7	1.0	3.1	0.8
North Africa	44.3	8.6	35.1	9.3	6.8	15.9	3.1
Southern Africa	20.0	1.3	18.0	2.8	2.0	10.0	3.2
West Africa	22.1	2.5	19.0	4.6	2.7	9.8	1.9
			Shares of products in Africa total imports, 1990-94 (%)				
Central Africa	4.2	0.4	3.7	0.8	0.6	1.7	0.6
East Africa	8.7	1.0	7.4	1.8	1.3	3.3	1.1
North Africa	42.1	7.6	33.8	8.5	6.0	14.8	4.5
Southern Africa	24.2	1.7	21.8	3.9	2.7	11.2	4.1
West Africa	20.7	1.8	18.2	3.3	2.2	11.1	1.7
			Shares of products in Africa total imports, 1995-99 (%)				
Central Africa	4.1	0.5	3.6	0.9	0.6	1.6	0.4
East Africa	10.7	1.4	9.0	2.4	1.6	3.7	1.3
North Africa	40.4	7.6	32.0	7.9	6.0	13.8	4.3
Southern Africa	26.5	3.0	22.1	4.2	2.9	9.9	5.0
West Africa	18.3	2.6	15.3	3.7	1.8	8.4	1.4
			Shares of products in Africa total imports, 2000-04 (%)				
Central Africa	3.7	0.5	3.1	0.8	0.5	1.4	0.5
East Africa	10.3	1.4	8.6	1.9	1.7	3.5	1.5
North Africa	35.9	6.9	27.9	5.4	5.5	12.5	4.6
Southern Africa	31.8	4.7	24.1	4.7	3.6	10.4	5.3
West Africa	18.2	2.9	14.7	3.0	1.8	8.2	1.6
			Shares of products in Africa total imports, 2008-09 (%)				
Central Africa	4.7	1.0	3.6	0.7	0.5	1.9	0.5
East Africa	11.4	1.3	9.8	1.9	1.7	3.9	2.3
North Africa	37.1	7.4	28.9	5.2	5.3	14.5	3.9
Southern Africa	29.2	5.2	21.0	4.0	3.3	9.9	3.8
West Africa	17.7	2.6	14.2	2.4	2.1	8.0	1.8
			Shares of products in Africa total imports, 2011-15 (%)				
Central Africa	4.9	0.7	4.1	0.8	0.6	2.2	0.5
East Africa	11.3	1.1	9.8	2.2	2.0	4.2	1.5
North Africa	35.4	7.9	26.6	5.4	4.9	12.5	3.8
Southern Africa	30.5	4.8	21.3	4.5	3.3	9.9	3.6
West Africa	17.9	2.9	14.0	2.8	2.1	7.6	1.5

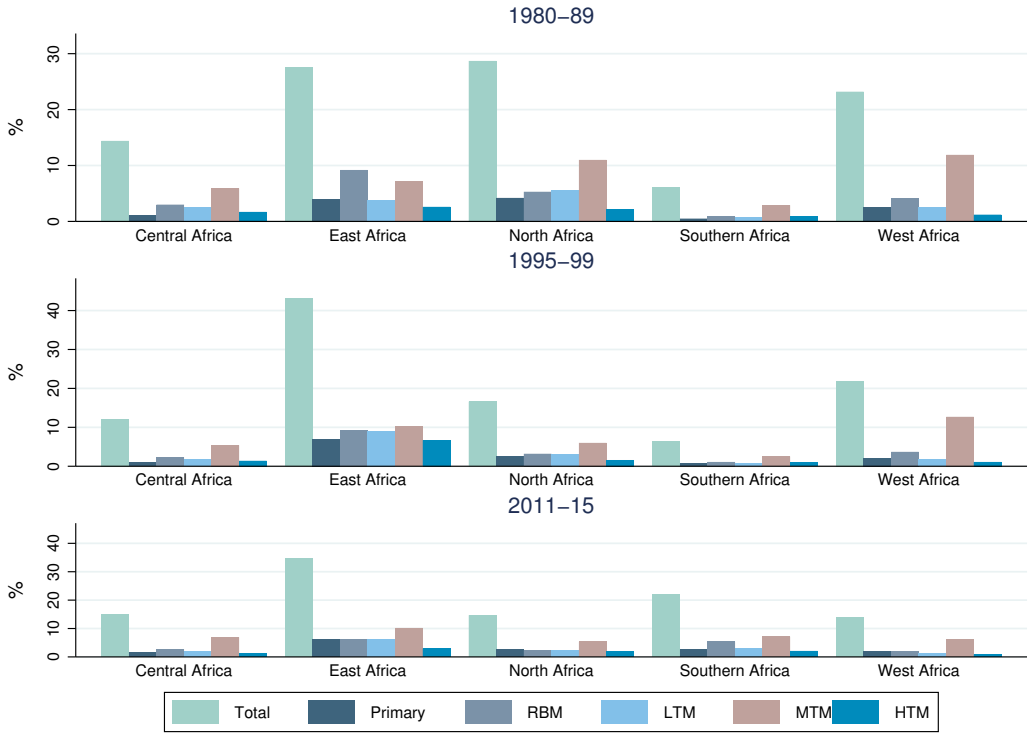
Author's calculations using UN Comtrade data (SITC rev. 2)
Notes: Figures are weighted by countries' population sizes. "Other" transaction are not shown here, and account for the difference between all products and primary plus all manufactured. RBM = Resource based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufactures and HTM = High technology manufactures.

Figure A.2: Regional market shares in Africa's total exports (weighted averages)



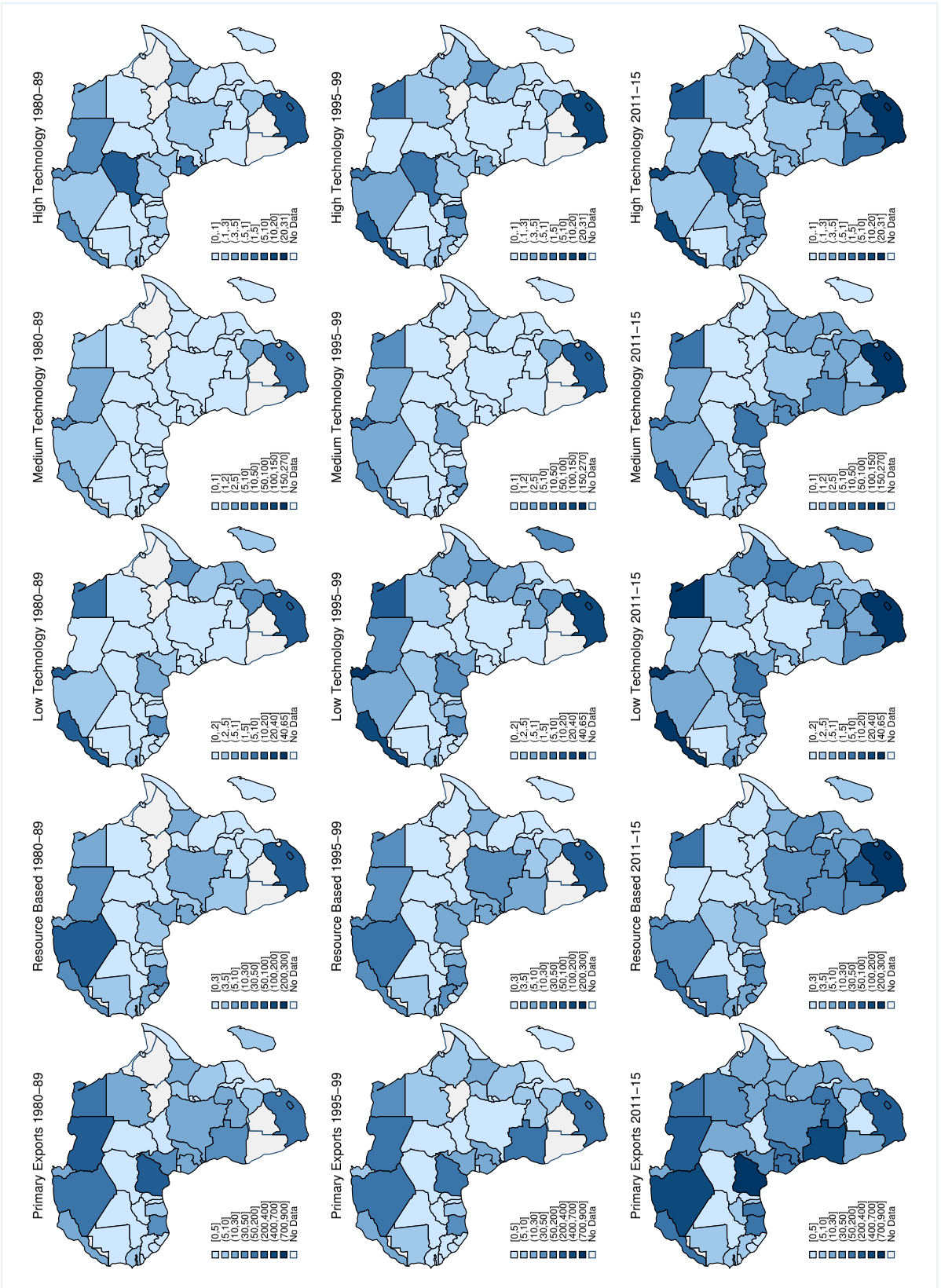
Source: Author's calculations using UN Comtrade data.
Note: Weighted averages by countries' population sizes.
RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

Figure A.3: Regional market shares in Africa's total imports (weighted averages)



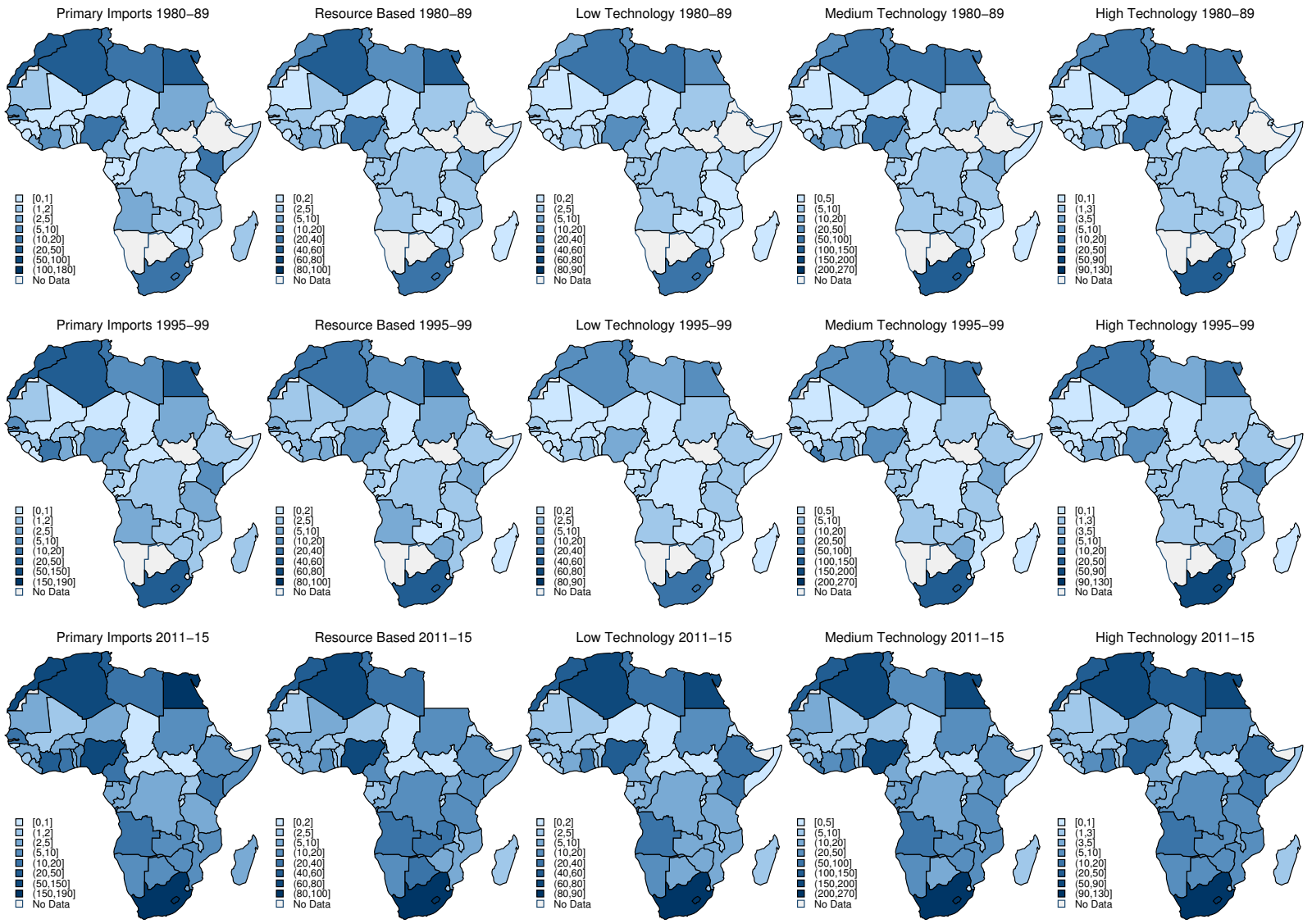
Source: Author's calculations using UN Comtrade data.
Note: Weighted averages by countries' population sizes.
RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

Figure A.4: Africa's technological export composition by country, (real US$ million)



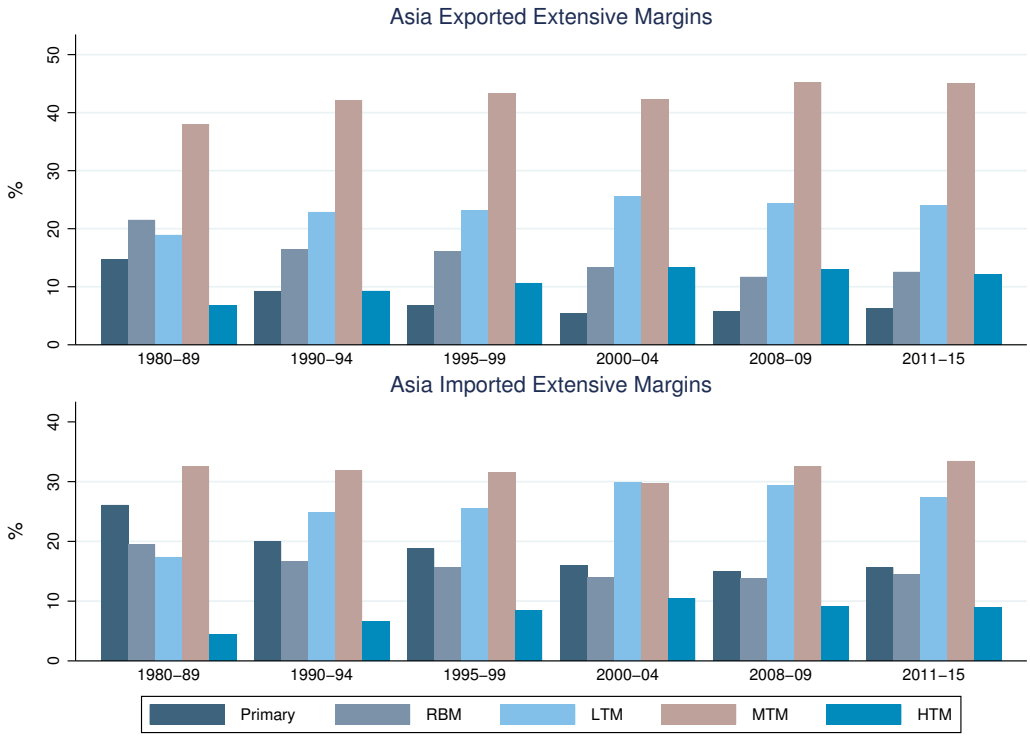
Source: Author's calculations using UN Comtrade data (SITC rev. 2).

Figure A.5: Africa's technological import composition by country (real US$ million).



Source: Author's calculations using UN Comtrade data (SITC rev. 2).

Figure A.6: Asia extensive margins of trade (% of total)



Source: Author's calculations using UN Comtrade data. *Note:* RBM = resource-based manufactures; LTM = Low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

Table A.7: Africa sample: Three largest exports as a share of total merchandised exports for each country, 2010-2015.

Country	1st export product	% share	2nd export product	% share	3rd export product	% share	% share of top 3 exports
South Sudan	Crude petroleum	99.7	Seeds for other fixed oils	0.1	Seeds for soft fixed oils	0.1	99.8
Libya	Crude petroleum	86.5	Gas, natural and manufactured	9.4	Gold	2.0	97.8
Chad	Crude petroleum	92.9	Gold	2.0	Cotton	1.6	96.5
Algeria	Crude petroleum	52.0	Gas, natural and manufactured	42.9	Residual petroleum products	1.5	96.4
Angola	Crude petroleum	92.0	Pearl, precious stones	2.4	Natural abrasives	1.7	96.1
Equatorial Guinea	Crude petroleum	71.3	Gas, natural and manufactured	21.6	Alcohols, phenols	2.8	95.8
Nigeria	Crude petroleum	81.6	Gas, natural and manufactured	11.4	Cocoa	1.2	94.2
Eritrea	Gold	48.5	Base metal ores	43.0	Silver, platinum	1.5	92.9
Mali	Gold	79.4	Cotton	11.0	Fertilizers, manufactured	2.3	92.7
Gabon	Crude petroleum	79.5	Base metal ores	7.7	Ships and boats	5.2	92.3
Congo	Crude petroleum	74.6	Copper	8.5	Ships and boats	6.8	89.9
Botswana	Pearl, precious stones	77.9	Base metal ores	9.1	Meat fresh child, frozen	1.4	88.4
Sudan	Crude petroleum	61.7	Gold	21.9	Live animals for food	4.7	88.3
Burkina Faso	Gold	62.0	Cotton	22.5	Seeds for soft fixed oils	2.8	87.3
Comoros	Spices	67.8	Ships and boats	15.6	Special transactions	3.6	87.0
Guinea-Bissau	Fruit, nuts, fresh , dried	69.4	Fish, fresh, chilled, frozen	9.2	Crude petroleum	7.3	85.9
Somalia	Live animals for food	70.1	Animals, live	7.3	Seeds for soft fixed oils	6.5	83.9
Sierra Leone	Iron ore	54.4	Base metal ores	15.0	Pearl, precious stones	12.9	82.3
Seychelles	Fish, prepared, preserved	53.2	Fish, fresh, chilled, frozen	24.1	Lime, cement	4.1	81.4
Zambia	Copper	77.7	Sugar and honey	1.7	Maize unmilled	1.4	80.8
Burundi	Gold	50.6	Coffee and substitutes	22.3	Tea and mate	7.0	79.9
Ghana	Gold	30.5	Cocoa	26.5	Crude petroleum	21.0	78.0
Dem. Rep. Congo	Copper	42.4	Base metal ores	23.9	Crude petroleum	11.2	77.5
Liberia	Ships and boats	32.5	Natural rubber, gums	20.7	Iron ore	20.4	73.6
Guinea	Base metal ores	34.5	Gold	21.0	Crude petroleum	16.5	72.0
Rwanda	Base metal ores	47.3	Coffee and substitutes	12.5	Tea and mate	12.1	71.9
Niger	Radioactive	41.9	Tobacco, manufactured	16.9	Uranium, thorium ore	10.6	69.3
Sao Tome & Principe	Cocoa	60.0	Ships and boats	3.8	Transistors, valves	2.8	66.5
Mauritania	Iron ore	40.7	Fish, fresh, chilled, frozen	14.1	Base metal ores	11.2	66.0
Cameroon	Crude petroleum	41.3	Cocoa	12.3	Wood shaped sleepers	8.9	62.5
Gambia	wood, rough	22.8	Woven man-made fibre fabric	20.7	Fruit, nuts, fresh , dried	17.7	61.2
Côte d'Ivoire	Cocoa	43.0	Crude petroleum	9.1	Natural rubber, gums	7.9	60.0
Central African Rep.	wood, rough	27.5	Pearl, precious stones	20.2	Cotton	12.0	59.6
Lesotho	Pearl, precious stones	32.2	Outwear knit non elastic	15.6	Mens outwear not knitted	11.7	59.5
Ethiopia	Coffee and substitutes	24.8	Vegetables, fresh, preserved	19.3	Seeds for soft fixed oils	13.7	57.8
Benin	Gold	26.2	Cotton	15.6	Fruit, nuts, fresh , dried	15.0	56.8
Cabo Verde	Fish, fresh, chilled, frozen	21.8	Trailers, non motorized vehicles	17.5	Fish, prepared, preserved	17.4	56.7
Swaziland	Essential oils, perfumes	22.5	Sugar and honey	18.6	Chemical products	10.0	51.1

Source: Authors' calculations using UN Comtrade data (SITC rev. 2).

CHAPTER 3

EFFECTS OF CAPITAL GOODS IMPORTS ON TECHNOLOGICAL EXPORT COMPOSITION IN DEVELOPING COUNTRIES

In recent decades, imports of capital goods in developing countries have increased. While the literature has mainly focused on how importing capital technologies may affect growth, less attention has been paid to how capital goods imports may affect the export composition. This article studies the effects of capital goods imports on technological export composition using panel data of 128 countries spanning 1980-2015. The findings reveal that capital goods imports have a positive effect on the technological export composition in developing countries. The findings also show that the positive effect of capital goods imports on technological export composition is larger in developing countries relative to developed economies. In Africa, capital goods imports also have a positive effect on the technological export composition. However, the positive effect of capital goods imports on high technology exports is smaller in Africa relative to other developing countries.

3.1 Introduction

Most African countries are heavily dependent on primary goods as their main source of export income (see Chapter 2). However, several studies argue that countries that produce capital goods (i.e., technology intensive goods) tend to experience higher and more stable economic growth

than those that mostly produce primary goods (see e.g., Aboal et al., 2017; Hausmann et al., 2007; Sheu, 2014). Capital goods are embodied with technologies that improve manufacturing firms' productivity and more productive firms are more likely to become exporters (see e.g., Damijan and Kostevc, 2015; Melitz, 2003). Most productive firms can overcome the fixed costs to export (Melitz, 2003). Moreover, their innovative activities can drive productivity and output growth in the importing countries if circumstances and conditions permit (see e.g., Caselli, 2018; Lee, 1995; Mo et al., 2021).[1]

The works of Castellani and Fassio (2019); Colantone and Crinò (2014); Fan et al. (2015) suggest that importing capital goods from technologically advanced economies increases productivity and innovation in less developed countries to the extent that it can enable their ability to export similar goods. However, evidence suggests that Africa's export composition remains highly concentrated in primary goods despite being a net importer of capital goods (see Chapter 2). This raises a question: Do developing regions like Africa experience export composition diversification or growth as a consequence of importing capital goods?

This chapter investigates the effect of capital goods imports on developing countries' technological export composition, specifically whether African countries' technological export composition improves as they import more capital goods. I focus on Africa given that most countries on the continent have failed to diversify their export composition away from primary goods, although capital goods imports have risen over the last three decades (see Chapter 2). Africa is also consistently ranked at the bottom among developing regions in export performance[2] due to poor institutions as well as deficient financial, human, and public capital (Freund and Rocha, 2011; Rodrik, 1998; Stiglitz, 2018; Tadei, 2018).

Using a sample of 128 countries, I disaggregate exports into technology based composition (low, medium, and high technology) following Lall (2000) technological trade classification. This disaggregation will allow me to analyse the effects of capital goods imports on the technological export composition (categories) of each country. I define capital goods imports as the sum of

[1]Higher levels of factor endowments and technical competence are needed since the embodied technologies have to be modified to make them amenable to local firms (see e.g., Lall and Urata, 2003; Rodrik, 1996; Rosenberg and Nathan, 1982).

[2]Its exports share in world export remained low and highly concentrated in primary goods, which many see as poor country products.

medium and high technology goods.

The findings reveal that capital goods imports have positive effects on low, medium, and high technology exports in developing countries. The research findings give support to recent empirical studies (e.g., Bas and Strauss-Kahn, 2014; Castellani and Fassio, 2019; Chevassus-Lozza et al., 2013; Colantone and Crinò, 2014) that provide evidence that imported technology facilitate firm entry into export markets and improve firm performance in those markets in terms of higher export quality and broader export scope. Moreover, the findings also show the heterogeneous effect of capital goods imports on technological export composition between developing and developed countries. In developing countries, the positive effect of capital goods imports on technological export composition is larger. This is in line with Coe and Helpman (1995) findings that imported capital stocks have larger positive effects in developing countries than in developed economies.

In Africa, capital goods imports also have positive effects on low, medium, and high technology exports. However, the positive effect of capital goods imports on Africa's high technology exports is smaller relative to other developing countries. This result could be explained by the fact that the bulk of Africa's capital goods imports is from China (see Chapter 2) which are considered lower quality than from developed countries (see, Bos and Vannoorenberghe, 2019; Schott, 2008). Similarly, Feng et al. (2016) shows that imported capital goods from OECD rather than non-OECD countries generated larger firm export improvements.

3.2 Review of Literature

3.2.1. *Theoretical Motivation*

Early models of trade focused on technology differences (Ricardian) or endowment difference (Heckscher-Ohlin) to explain the reason for the pattern of bilateral trade. One crucial gap missing from earlier models was the ability of countries to adopt foreign technologies or industrial inputs to bridge these gaps. Since the production of intensive technology goods is highly concentrated in few developed economies (see, Eaton and Kortum, 2001; Keller, 2004; Mutreja et al., 2018), importing capital goods is one of the channels for diffusion of technology (Rivera-Batiz

and Romer, 1991; Romer, 1986, 1990). Importers can improve their technology by incorporating imported capital inputs into their production processes - leading to higher productivity, new product creation, improved quality of final goods, and output growth (see e.g., Aisien and Abraham, 2020; Caselli, 2018; Mo et al., 2021).

Since foreign capital goods are embodied with new technologies that improve domestic firms' productivity and innovation, they can facilitate firms' entry into export markets and firm performance in those markets (Bustos, 2011; Damijan and Kostevc, 2015; Melitz, 2003), in terms of higher total exports, export quality, and broader export composition (see e.g., Bas and Strauss-Kahn, 2014, 2015; Chevassus-Lozza et al., 2013; Feng et al., 2016).

The benefit of foreign capital goods can either be direct or indirect, which in both cases enhance firm productivity. This in turn expands the sectoral composition of production and increases export composition (see e.g., Bas and Strauss-Kahn, 2014; Damijan et al., 2014; Mutreja et al., 2018). Direct benefits arise from the adoption of high-quality capital technologies in the production process which enhances domestic firms' productivity, increasing the quality and quantity of production (see e.g., Bas and Strauss-Kahn, 2014; Caselli, 2018; Mo et al., 2021). Moreover, the increase in productivity allows more domestic firms to reach the export productivity cut-off (see e.g., Amin and Islam, 2014; Goldberg et al., 2010; Melitz, 2003; Sharma, 2016), enabling them to overcome export fixed costs (indirect benefit) (see e.g., Damijan and Kostevc, 2015; Melitz, 2003).

Indirect benefits may also emanate from skill complementary technologies (human capital) embodied in capital goods imports (see e.g., Burstein et al., 2013; Parro, 2013; Raveh and Reshef, 2016). Embodied skill technology increases the capacity of domestic firms to carry out technological innovation and the ability to adapt and efficiently implement the imported technology. This also leads to an increase in productivity and a change in the sectoral composition of production - driving the export composition of a country (see e.g., Amin and Islam, 2014; Castellani and Fassio, 2019; Edwards et al., 2018; Goldberg et al., 2010; Veeramani, 2014).

Most developing countries invest relatively less in intensive technology R&D Keller (2004), rely on a small group of developed countries for capital goods and techniques (methods and learning) to improve productivity in their production and possibly contribute to economic growth

(Eaton and Kortum, 2001; Keller, 2004; Mutreja et al., 2018). Poor regions like Africa rely even more on foreign sources for productivity growth than rich countries do (see e.g., Coe and Helpman, 1995; Keller, 1998). However, Liu and Qiu (2016) argues that foreign capital goods may also reduce domestic innovation as foreign technologies become cheaper. It is therefore important to empirically investigate the effects of capital goods imports on technological export composition in developing economies, as most are highly dependent on them for production and learning by doing.

3.2.2. *Empirical Literature*

This chapter builds on a growing literature empirically documenting the impact of technology diffusion on productivity and exports (see e.g., Coe et al., 1997; Goldberg et al., 2010; Keller, 2004; Mo et al., 2021). These studies provide empirical support for the hypothesis that technology diffusion from a small group of innovators drives firm productivity, new product creation, improved quality of final goods, and export growth. This study contributes to the literature by empirically examining how capital imports affect technological export composition (low technology, medium technology, and high technology manufacturing exports). The study is closely related to the recent works of Bas and Strauss-Kahn (2014); Castellani and Fassio (2019); Edwards et al. (2018); Feng et al. (2016); Okafor (2020); Pierola et al. (2018); Sharma (2016).

Feng et al. (2016) empirically examines the connection between imports of intermediate inputs and export outcomes using Chinese manufacturing data spanning 2002-2006. The results show that firms that increased intermediate imports increased the volume of their exports and export scope. Similarly, Pierola et al. (2018) investigates the relationship between imports of intermediate inputs and firm export performance using Peru firm-level data covering the period 2000-2012. They find that greater use of imported intermediate inputs correlated with higher exports, faster export growth, and higher quality of exports (measured by relative unit prices).

Bas and Strauss-Kahn (2014) investigates the role of imported inputs in enhancing productivity and export scope using France's manufacturing trade data at the product (HS6) level over the period 1996–2005. Their findings from the semi-parametric estimation show evidence that imported inputs may enhance productivity and thereby exports, both through greater comple-

mentarity of inputs and advanced technology transfer. They also find that quality and low-priced imported inputs help firms to overcome export fixed costs, thereby boosting expected export revenues. Similarly, Castellani and Fassio (2019) studies the determinants of the propensity to export new products using a sample of Swedish manufacturing data over the period 2001-2012. Their findings from the binomial regression model show that imported inputs are a key determinant of firms' propensity to add new products to their export composition.

Using the Indian industrial dataset from 1994 to 2009, Sharma (2016) analyses the role of imported inputs on productivity and export growth. The Ordinary Least Squares (OLS) and System Generalised Method of Moments (Sys-GMM) results show that imported inputs are crucial determinants of total factor productivity, which lead to substantial growth in exports. Additionally, they find that the effects of imports vary greatly across industries, with chemical, machinery, and transport equipment exports being highly dependent on imported intermediate goods.

Similarly, using South African manufacturing data covering the period 2009–2013, Edwards et al. (2018) studies the relationship between intermediate imports and export performance in South Africa's manufacturing sector. Their findings from the OLS regressions show that imported inputs increase the export performance of the South African manufacturing sector, both at the intensive and extensive margins, especially if the imported inputs are sourced from technologically advanced economies. Okafor (2020) examines whether the use of imported inputs has a moderating impact on the productivity effects on export market destinations, using data from Ghana manufacturing data covering the period of 1991-2002. They find that the use of imported inputs in the production process helps firms that export outside Africa to enhance productivity compared to non-exporting firms. They also find that firms that export outside Africa but do not use imported inputs in the production process have lower productivity compared to firms that use imported inputs.

The research is also connected to the recent empirical literature on imports and domestic productivity. Caselli (2018) investigates whether imported inputs matter for productivity using Mexican manufacturing data over the period 1994-2003. They find evidence of self-selection into importing and learning-by-importing. However, their findings revealed that not all imports

matter for productivity. Manufacturing firms that import capital goods (i.e., machinery and equipment) tend to experience an increase in productivity, while the same does not happen for manufacturing firms that import intermediate goods (i.e., materials). Moreover, Caselli (2018) also finds evidence of productivity gains following the entry into export markets and complementarities between importing intermediate inputs, capital goods, and exporting. Nyantakyi and Munemo (2017) investigates the effects of capital goods imports on domestic firms' productivity using data from Ghana, Kenya, and Tanzania. They show that an increase in capital goods imports increases domestic firm productivity and the effects are larger for domestic firms that have more absorptive capabilities. Similarly, Aisien and Abraham (2020) examined the impact of capital goods imports on manufacturing output in Nigeria using annual data over the period 1981–2017. They find that capital goods imports have positive effects on the manufacturing output in Nigeria.

From here, one can draw that foreign capital goods enhance domestic productivity, innovation, and hence export growth. However, foreign capital goods may conflict with domestic capability development (see e.g., Chandra, 2006; Sheridan, 2014). Importing countries need to be relatively developed in terms of factor endowments (i.e. income, human capital, and physical infrastructure) in order to reap the full benefits from foreign capital goods since the foreign technologies have to be modified to make them amendable to domestic firms (see e.g., Lall and Urata, 2003; Rosenberg and Nathan, 1982; Sheridan, 2014). African countries are underdeveloped in terms of financial development, human capital, physical infrastructure, and institutions relative to other developing countries (see e.g., Acemoglu and Robinson, 2010*b*; Stiglitz, 2002). Therefore, without local capabilities to adopt foreign capital goods, African countries are likely to remain exporting primary goods.

3.3 Empirical Strategy and Data

3.3.1. *Empirical Model*

The empirical methodology implemented in this research builds on the approach in Rodrik (1999) that includes openness and diffusion of technology. The following specifications are used

to investigate the effects of capital goods imports on technological export composition;

$$ln(X^{\varphi})_{it} = \beta_0 + \beta_1 ln(capital\ imports)_{it-1} + \theta V_{it-1} + \delta_i + \gamma_t + \varepsilon_{it} \tag{3.1}$$

$$\begin{aligned} ln(X^{\varphi})_{it} =& \beta_0 + \beta_1 ln(capital\ imports)_{it-1} + \beta_2 ln(capital\ imports)_{it-1} * 1(non-OECD) \\ &+ \theta V_{it-1} + \delta_i + \gamma_t + \varepsilon_{it} \end{aligned} \tag{3.2}$$

$$\begin{aligned} ln(X^{\varphi})_{it} =& \beta_0 + \beta_1 ln(capital\ imports)_{it-1} + \beta_2 ln(capital\ imports)_{it-1} * 1(Africa) \\ &+ \theta V_{it-1} + \delta_i + \gamma_t + \varepsilon_{it} \end{aligned} \tag{3.3}$$

where $(X)_{it}$ is the natural logarithm of export each category φ (i.e., $\varphi = 1,...,5$) defined as: 1) primary exports, 2) resource-based manufactured exports, 3) low technology, 4) medium technology and 5) high technology manufactured exports in country i and year t. The variable $ln(capital\ imports)$ is the natural logarithm of capital goods imports in country i and year $t-1$, while V_{it-1} is a vector of controls variables discussed in the next paragraph below.

In the literature, Africa's trade patterns can be explained by lower levels of financial development, infrastructure, human capital, poor institutions, and lower levels of income (see e.g., Acemoglu and Robinson, 2010*b*; Nunn, 2007; Rodrik, 1998; Stiglitz, 2018). Exporters and importers incur fixed costs that require external finance. As such, financial constraints can be a key barrier to international trade (see e.g., Bas and Berthou, 2012; Beck, 2002; Manova, 2013). The provision of infrastructure such as schools, hospitals, roads, railways, airports, offices facilitates trade (see e.g., Kodongo and Ojah, 2016; Mbaku, 2013).

Human capital is the knowledge, skills, and other attributes embodied in individuals that are relevant to economic activities (Gallié and Legros, 2012). High stocks of human capital enhance productivity and the rate at which the new technologies are diffused in an economy (see e.g., Acemoglu and Zilibotti, 2001; Gallié and Legros, 2012; Nelson and Phelps, 1966). Whilst bad (weak) institutions can constrain productive activities and goods (strong) when they induce productive behaviours (see e.g., Acemoglu, 2003; North, 1990).

In addition to these control variables, country and year fixed effects are included in the models designated by δ_i and γ_t, respectively, and ε_{it} is the error term. To model the specific effects for developing or African countries, I interact capital goods imports in equation (3.2) and (3.3), respectively, with a binary variable equal to one if a developing (non-OECD) country or

an African country and zero otherwise. This specification allows for further investigation of the heterogeneous outcomes specific to developing countries and more importantly to the African continent.

3.3.2. *Endogeneity Problem*

One of the main challenges in investigating the effects of capital goods imports on technological export composition is the potential for reverse causality and omitted variables. Access to previously unavailable capital goods imports enhance productivity that can improve the export scope, whereas exporting can increase firms' revenues that can increase the demand for advanced capital goods.

To mitigate the endogeneity problem, first, the models use lagged values of the control variables. The lagged values allow a delay in the responsiveness of technological export composition to changes in capital goods imports.[3] Second, I control for a range of characteristics that may drive both capital goods imports and the technological export composition. Finally, the study applies fixed effects (FE) regression models.

3.3.3. *Data and Summary Statistics*

To investigate the link between capital goods imports and technological export composition, I use annual panel data of 128 countries covering the period 1980-2015. The sample includes 36 OECD and 92 non-OECD countries (including 40 African countries). A list of countries used in the analysis can be found in Table B.1 of Appendix B.1. Countries were selected based on the data availability. Similarly to Bedard and Cho (2010); Korkmaz et al. (2017); Krammer (2015); Luci-Greulich and Thévenon (2014), I define developed countries as OECD countries and developing countries as non-OECD countries.

Trade data is from the United Nations Comtrade database, classified to Standard International Trade Classification (SITC) revision 2 at three-digit product categories. The nominal trade values are converted to constant (2010) US$. Following Lall (2000), I construct the technological trade composition: primary goods, resource-based manufactured (RBM), low technology

[3] I also attempted to use three and five years lag. The conclusion does not change, the primary results still hold.

manufactured (LTM), medium technology manufactured (MTM), and high technology manufactured (HTM) goods (see Table A.1 of Appendix A.1). I define complex categories (MTM and HTM goods) as capital goods. Complex goods are technology-intensive goods, which have the most beneficial effects (see, Caselli, 2018; Hausmann et al., 2007; Lall, 2000; Mo et al., 2021).

Table 3.1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Developed countries				
$\ln(\text{Total exports})_t$	13.44	1.41	8.31	16.38
$\ln(\text{Primary exports})_t$	11.23	1.43	6.54	14.27
$\ln(\text{RBM exports})_t$	11.72	1.25	7.53	14.38
$\ln(\text{LTM exports})_t$	11.39	1.44	5.70	14.25
$\ln(\text{MTM exports})_t$	12.01	1.85	6.39	15.72
$\ln(\text{HTM exports})_t$	11.07	2.14	4.23	14.99
$\ln(\text{Capital imports})_{t-1}$	12.76	1.37	7.43	16.16
$\ln(\text{Financial development})_{t-1}$	4.12	0.68	1.84	5.36
$\ln(\text{Infrastructure investment})_{t-1}$	20.43	1.52	16.28	24.26
$\ln(\text{GDP})_{t-1}$	21.94	1.51	17.95	25.80
$\text{Human capital}_{t-1}$	3.00	0.46	1.47	3.73
$\text{Institutions}_{t-1}$	8.74	3.20	-8.00	10.00
Developing countries (incl. Africa)				
$\ln(\text{Total exports})_t$	10.47	1.94	3.60	16.71
$\ln(\text{Primary exports})_t$	9.34	2.11	-0.03	14.86
$\ln(\text{RBM exports})_t$	8.54	2.04	0.50	14.08
$\ln(\text{LTM exports})_t$	7.48	2.75	-0.02	15.51
$\ln(\text{MTM exports})_t$	7.18	2.75	-1.29	15.35
$\ln(\text{HTM exports})_t$	5.98	2.85	-1.53	15.61
$\ln(\text{Capital imports})_{t-1}$	9.83	1.80	4.27	15.66
$\ln(\text{Financial development})_{t-1}$	2.98	0.98	-1.51	5.56
$\ln(\text{Infrastructure})_{t-1}$	17.50	1.89	10.15	24.47
$\ln(\text{GDP})_{t-1}$	19.02	1.74	14.47	25.30
$\text{Human capital}_{t-1}$	1.94	0.57	1.01	3.52
$\text{Institutions}_{t-1}$	0.55	6.68	-10.00	10.00

Note: Subscript t represent time period. RBM = resource based manufactures; LTM = low technology manufactures; MTM = Medium technology manufacturing; HTM = High technology manufactures.

Financial development and infrastructure data are from the World Development Indicators (WDIs). I proxy financial development using private credit (by banks) and other financial institutions as a percentage of GDP. Infrastructure investment is measured by gross fixed capital formation, which includes land improvements, industrial plants, roads, railways,schools, offices, hospitals, machinery, and equipment purchases, etc.

Human capital data is an index from the Penn World Tables, version 9.1. Human capital is based on the average years of schooling and an assumed rate of return to education. Institutional data is from the Center for Systemic Peace, Polity IV Project based on *POLITY2* score scale computed by subtracting the institutional autocracy score points from the institutional democracy score points. The institutional democracy score is computed based on three essential

interdependent elements.

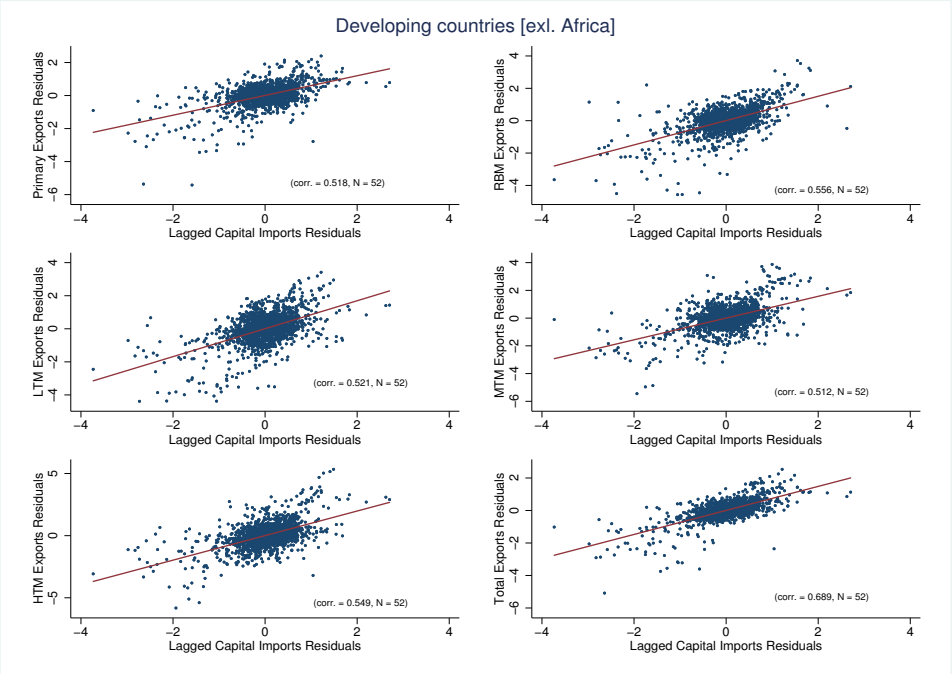
Combining these variables generates an unbalanced panel data set that spans the years 1980–2015. Table 3.1 reports summary statistics for our baseline sample. The data indicate that the values of all variables are higher in developed (OECD) countries relative to developing (non-OECD) countries on averages. This implies that on averages, developed countries are better endowed with financial development, infrastructure, and stronger institutions than developing countries. However, in terms of capital goods imports, the mean difference between developed and developing countries is small, an average difference of 2.93.

3.4 Results

3.4.1. *Descriptive results*

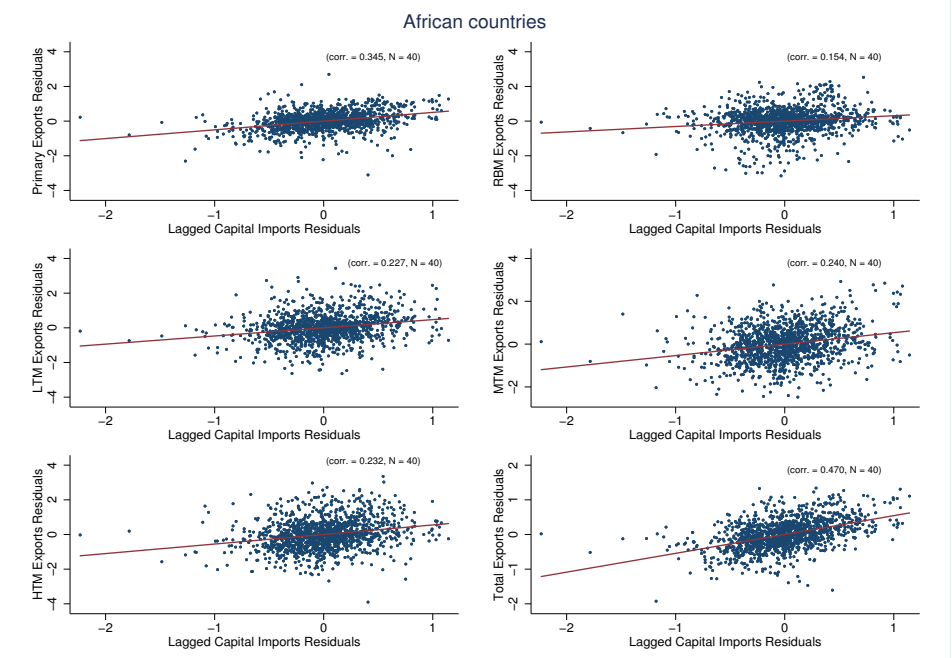
The study reports descriptive results in Figure 3.1 and 3.2. To account for the unobserved country and time heterogeneity, I control for country and year fixed effects and then plot the residuals of both export composition and lagged capital imports. I observed a positive relationship between capital goods imports and export composition structures (LTM, MTM, and HTM). However, the positive relationship is noticeably weaker for Africa (Figure 3.2).

Figure 3.1: Developing countries' export composition & capital goods imports, 1980-2015



Source: Author's calculations using United Nations Comtrade data.

Figure 3.2: Africa's export composition & capital goods imports, 1980-2015



Source: Author's calculations using United Nations Comtrade data.

3.4.2. *Empirical Results*

The study presents the empirical results as follows. Firstly, the study presents the results that compare the effects of capital goods imports on export composition for the full sample of countries, equation (3.1). Secondly, the study disaggregates the sample for developing countries, equation (3.2). Thirdly, the research further disaggregates the results for Africa, equation (3.2).

3.4.2.1. *Effects of capital goods imports on technological export composition in the World*

The baseline results of equation (3.1) are given in columns (1)-(6) of Table 3.2. Column (1) is total exports and column (2)-(6) is the disaggregation. The study focuses on the technological categories - low, medium, and high technology manufactured exports (columns (4)-(6)). The findings indicate that capital goods imports have positive and significant effects on low technology, medium technology, and high technology manufactured exports. The results show that a 1% increase in capital goods imports would yield a 0.34%, 0.49%, and 0.61% increase in low, medium, and high technology manufactured exports (respectively). Thus, an increase in capital goods imports increases the world's technological export composition on average.

Table 3.2: Effects of capital imports on technological export composition in the world.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital import)$_{t-1}$	0.426***	0.373***	0.273***	0.340***	0.490***	0.610***
	(0.023)	(0.043)	(0.037)	(0.046)	(0.053)	(0.050)
ln(Financial development)$_{t-1}$	0.023	0.002	0.123***	0.036	-0.041	0.179***
	(0.015)	(0.022)	(0.028)	(0.030)	(0.034)	(0.032)
ln(Infrastructure investment)$_{t-1}$	-0.039	-0.103**	0.187***	0.188**	0.031	0.051
	(0.028)	(0.044)	(0.055)	(0.079)	(0.076)	(0.065)
ln(GDP)$_{t-1}$	0.335***	0.208***	-0.115	-0.361***	-0.056	0.021
	(0.038)	(0.052)	(0.078)	(0.092)	(0.094)	(0.082)
Human capital$_{t-1}$	0.189***	0.104	-0.377***	0.224	0.092	0.219
	(0.065)	(0.091)	(0.120)	(0.149)	(0.145)	(0.158)
Institutions$_{t-1}$	0.006***	-0.001	0.009**	0.029***	0.023***	0.010**
	(0.002)	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)
Observations	3,671	3,671	3,671	3,671	3,671	3,671
R-squared	0.984	0.964	0.951	0.961	0.965	0.964
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The results are based on the full sample, that includes OECD and non-OECD countries.

Although capital goods imports can have two opposing effects on local firms' innovation (see Liu and Qiu, 2016), the research finds that the net common effect is positive for the world. These

findings are consistent with the works of Bas and Strauss-Kahn (2014, 2015); Castellani and Fassio (2019); Feng et al. (2016). These studies provided empirical evidence that increases in the use of imported capital goods facilitate firm export performance by increasing total exports, export scope, and improved export quality.

3.4.2.2. *Effects of capital goods imports on technological export composition in developing countries*

Having determined the effects of capital goods imports in the world, I examine the effect in developing countries using the interaction approach, equation (3.2). The results in columns (4)-(6) of Table 3.3 also reveal that imported capital goods have a positive effect on the technological export composition (low, medium, and high technology exports) in developing countries. For example, the findings indicate that a 1% increase in capital goods imports will result to a 0.62% increase in high technology exports in developing countries.[4] These findings are consistent with the works of Colantone and Crinò (2014) and Castellani and Fassio (2019). The authors argue that the importation of capital goods by developing countries can increase productivity and innovation activities to the extent that can enable their abilities to export such goods.

Table 3.3: Effects of capital goods imports on technological export composition in developing countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.417***	0.405***	0.186***	0.055	0.063	0.538***
	(0.026)	(0.040)	(0.042)	(0.055)	(0.059)	(0.059)
ln(Capital imports)$_{t-1} * I^{non-OECD}$	0.011	-0.037	0.099***	0.326***	0.488***	0.082**
	(0.017)	(0.025)	(0.028)	(0.035)	(0.039)	(0.042)
ln(Financial development)$_{t-1}$	0.024	0.000	0.129***	0.054*	-0.014	0.183***
	(0.015)	(0.022)	(0.028)	(0.030)	(0.033)	(0.032)
ln(Infrastructure investment)$_{t-1}$	-0.040	-0.099**	0.176***	0.151*	-0.024	0.042
	(0.028)	(0.044)	(0.055)	(0.077)	(0.075)	(0.066)
ln(GDP)$_{t-1}$	0.338***	0.201***	-0.095	-0.296***	0.041	0.038
	(0.039)	(0.052)	(0.078)	(0.090)	(0.093)	(0.083)
Human capital$_{t-1}$	0.185***	0.118	-0.414***	0.102	-0.091	0.188
	(0.067)	(0.095)	(0.122)	(0.150)	(0.143)	(0.161)
Institutions$_{t-1}$	0.006***	-0.001	0.008**	0.026***	0.019***	0.010**
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Observations	3,671	3,671	3,671	3,671	3,671	3,671
R-squared	0.984	0.964	0.951	0.962	0.967	0.964
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size include OECD and non-OECD countries.

[4]This is calculated by adding coefficient of $\beta_1 + \beta_2$, which is $0.538 + 0.082 = 0.62$.

Table 3.3 also shows heterogeneous effect of imported capital goods for developing and developed countries. Columns (4)-(5) suggest that the positive effect of capital goods imports on LTM and MTM exports is only due to the effect of capital goods imports in developing countries. While column (6) indicates that imported capital goods have a larger positive effect on HTM exports in developing countries relative to developed economies average ($\beta_1 + \beta_2 > \beta_1$). The results closely connect with the literature of Coe and Helpman (1995), that foreign capital stocks have larger positive effects in developing countries relative to developed economies. Developed nations are less dependent on foreign capital goods than developing countries (Coe and Helpman, 1995; Keller, 2004).

3.4.2.3. *Effects of capital goods imports on Africa's technological export composition*

To determine the impact and differential effect of capital goods imports in Africa, I reduce the sample size only to account for developing (non-OECD) countries. I expect that importing capital goods will have a differential effect on Africa's technological export composition relative to other developing countries. As mentioned earlier, higher levels of factor endowments are required in the transition process (see e.g., Chandra, 2006; Lall, 2000; Rosenberg and Nathan, 1982). Africa is consistently rated lower than most developing regions in terms of economic development (see e.g., Acemoglu and Robinson, 2010*b*; Bond, 2016; Eberhard et al., 2011; Ee, 2016; Freund and Rocha, 2011; UNDP, 2018).

Table 3.4, columns (4)-(6) also show that capital goods imports have positive effects on Africa's low, medium, and high technology manufactured exports. The results indicate that an increase in capital goods imports by 1% will result to a 0.42%, 0.61%, and 0.49% increase in low, medium, and high technology exports in Africa. The results are closely related to Nyantakyi and Munemo (2017). They find that capital goods imports have positive effects on domestic firms' productivity using firm-level data from Ghana, Tanzania, and Kenya.

The findings indeed show that capital goods imports have a differential effect on Africa's technological export composition relative to other developing countries. Columns (4)-(5) of Table 3.4 indicate that the positive effects of capital goods imports on low and medium technology exports are larger in Africa relative to other developing countries averages ($\beta_1 + \beta_2 > \beta_1$), while

Table 3.4: Effects of capital goods imports on technological export composition in Africa.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
$\ln(\text{Capital imports})_{t-1}$	0.435***	0.416***	0.251***	0.260***	0.404***	0.625***
	(0.026)	(0.053)	(0.044)	(0.053)	(0.059)	(0.057)
$\ln(\text{Capital imports})_{t-1} * I^{Africa}$	-0.049**	-0.101***	-0.057	0.159***	0.201***	-0.139**
	(0.024)	(0.038)	(0.047)	(0.049)	(0.054)	(0.054)
$\ln(\text{Financial development})_{t-1}$	0.041**	-0.005	0.178***	0.140***	0.070*	0.259***
	(0.017)	(0.026)	(0.034)	(0.035)	(0.039)	(0.037)
$\ln(\text{Infrastructure investment})_{t-1}$	-0.031	-0.061	0.171***	0.121	-0.095	0.044
	(0.030)	(0.046)	(0.059)	(0.080)	(0.076)	(0.069)
$\ln(\text{GDP})_{t-1}$	0.303***	0.169***	-0.171**	-0.209**	0.043	0.002
	(0.042)	(0.057)	(0.084)	(0.092)	(0.097)	(0.089)
$\text{Human capital}_{t-1}$	0.149*	0.140	-0.584***	-0.122	-0.607***	-0.229
	(0.081)	(0.120)	(0.149)	(0.186)	(0.168)	(0.195)
$\text{Institutions}_{t-1}$	0.004*	0.002	0.000	0.014***	0.000	0.003
	(0.002)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)
Observations	2,590	2,590	2,590	2,590	2,590	2,590
R-squared	0.972	0.954	0.917	0.943	0.940	0.932
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only developing countries.

column (6) indicates that the positive effect of capital goods imports on high technology exports is smaller in Africa ($\beta_1 + \beta_2 < \beta_1$).

The differential effect of capital goods imports for Africa's high technology exports can be explained by the fact that the bulk of its capital goods imports is from China (see Chapter 2), which are regarded to be of lower quality than from developed countries (Bos and Vannoorenberghe, 2019; Schott, 2008). Similarly, in studying the connection between Chinese imported capital inputs and its exports, Feng et al. (2016) find that capital inputs from OECD rather than non-OECD generated larger export improvements.

Although imported capital goods from China are considered lower quality than from OECD countries, they are an important technology transfer channel in a less developing region like Africa. Munemo (2013) provides empirical support that imports of capital goods from China are considered of higher quality than domestic manufacturing inputs in Sub-Saharan African countries, embody technology and knowledge leading to higher firm productivity, and improve quality of final goods.

3.5 Robustness Checks

Next, I consider a number of sensitivity checks to ensure that the findings to this point are in fact robust. Firstly, I explore a different economic technique of estimation (no interactions). Secondly, I include additional control variables. Thirdly, I consider using the varieties of capital goods imports - extensive margins of capital goods imports.

3.5.1. *Alternative econometric technique: No capital goods imports interactions*

In this section, an interaction estimation technique was used to determine the effects of capital goods imports in developing countries and specifically in Africa. As a robustness check, I estimate the effects of capital goods imports in developing countries as well as in Africa without interacting capital goods imports with the binary variable. I reduced the sample size to only account for developing countries or African countries.

Columns (4)-(6) of Table 3.5 confirm that capital goods imports have positive and significant effects on low, medium, and high technology exports in developing countries. While the results in Table 3.6 columns (4)-(6) confirm the positive effect of capital goods imports on Africa's technological export composition. For example, evidence in column (4) of Table 3.5 and 3.6 shows that if capital goods imports increase by 1%, LTM exports in developing and African countries would increase by 0.32% and 0.28%, respectively. Whilst in column (5) of the two tables, MTM exports will increase by 0.47% and 0.46% respectively in developing and African countries due to a 1% rise in capital goods imports.

3.5.2. *Robustness checks with respect to additional control variables*

In the literature, exporting firms gain from importing capital goods through productivity enhancement (see e.g., Bas and Strauss-Kahn, 2014; Castellani and Fassio, 2019; Fan et al., 2015). The increase in productivity enables manufacturing firms to reach export productivity cut-off as they can overcome export fixed costs (Goldberg et al., 2010; Melitz, 2003; Sharma, 2016). This facilitates more firm to enter export markets and increase their international competitiveness (see

Table 3.5: Effects of capital goods imports on technological export composition in developing countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.417***	0.381***	0.231***	0.316***	0.474***	0.577***
	(0.026)	(0.049)	(0.043)	(0.051)	(0.058)	(0.056)
ln(Financial development)$_{t-1}$	0.043**	0.001	0.181***	0.132***	0.060	0.266***
	(0.017)	(0.026)	(0.034)	(0.035)	(0.039)	(0.038)
ln(Infrastructure investment)$_{t-1}$	-0.034	-0.068	0.167***	0.132*	-0.082	0.035
	(0.030)	(0.046)	(0.059)	(0.080)	(0.075)	(0.070)
ln(GDP)$_{t-1}$	0.312***	0.188***	-0.161*	-0.238**	0.006	0.027
	(0.042)	(0.057)	(0.085)	(0.094)	(0.097)	(0.090)
Human capital$_{t-1}$	0.172**	0.188	-0.556***	-0.197	-0.702***	-0.164
	(0.081)	(0.115)	(0.147)	(0.181)	(0.168)	(0.193)
Institutions$_{t-1}$	0.004	0.001	-0.000	0.015***	0.002	0.001
	(0.002)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)
Observations	2,590	2,590	2,590	2,590	2,590	2,590
R-squared	0.972	0.953	0.917	0.943	0.940	0.932
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only the developing countries.

Table 3.6: Effects of capital goods imports on technological export composition in African countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.360***	0.332***	0.040	0.284***	0.456***	0.321***
	(0.043)	(0.059)	(0.071)	(0.085)	(0.104)	(0.093)
ln(Financial development)$_{t-1}$	-0.029	-0.130***	0.267***	0.163***	0.035	0.306***
	(0.024)	(0.034)	(0.061)	(0.058)	(0.066)	(0.058)
ln(Infrastructure investment)$_{t-1}$	0.015	0.059	0.334***	0.093	-0.032	0.063
	(0.039)	(0.050)	(0.076)	(0.108)	(0.107)	(0.097)
ln(GDP)$_{t-1}$	0.421***	0.315***	-0.113	0.042	0.121	0.121
	(0.059)	(0.072)	(0.115)	(0.114)	(0.137)	(0.116)
Human capital$_{t-1}$	-0.067	0.057	-0.792***	-0.162	-0.761**	-0.587
	(0.133)	(0.175)	(0.282)	(0.325)	(0.305)	(0.385)
Institutions$_{t-1}$	0.003	0.005	-0.008	0.006	0.002	-0.010
	(0.004)	(0.005)	(0.007)	(0.006)	(0.007)	(0.007)
Observations	1,151	1,151	1,151	1,151	1,151	1,151
R-squared	0.957	0.944	0.869	0.925	0.894	0.860
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to only account for the African countries

e.g., Bustos, 2011; Melitz, 2003). Using a sample of developing countries, I opt to include total factor productivity (TFP)[5], the sum of regional trade agreements (RTAs)[6], and a binary variable equal to one for GATT/WTO member country and zero otherwise. The inclusion of number of RTAs could indicate a country's open border policy. In Crawford and Fiorentino (2005), RTAs with larger partners is a way by which developing countries can gain security for their access to larger markets. While country GATT/WTO entry gives access to more market opportunities (see e.g., Feng et al., 2016; Laird, 1999), as barrier to trade are reduced.

Table 3.7: Effects of capital goods imports on technological export composition in developing countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.422***	0.332***	0.249***	0.173***	0.232***	0.515***
	(0.028)	(0.044)	(0.043)	(0.060)	(0.062)	(0.068)
ln(Capital imports)$_{t-1} * I^{non-OECD}$	-0.007	-0.049	0.084***	0.175***	0.326***	0.161***
	(0.021)	(0.030)	(0.032)	(0.042)	(0.044)	(0.050)
ln(Financial development)$_{t-1}$	-0.049***	-0.080***	0.025	-0.059**	-0.086**	0.089**
	(0.015)	(0.023)	(0.028)	(0.030)	(0.034)	(0.036)
ln(Infrastructure investment)$_{t-1}$	-0.068**	-0.100*	0.137**	0.037	-0.147*	0.003
	(0.029)	(0.053)	(0.058)	(0.084)	(0.080)	(0.073)
ln(GDP)$_{t-1}$	0.360***	0.231***	-0.126	-0.149	0.178*	0.082
	(0.041)	(0.065)	(0.079)	(0.103)	(0.104)	(0.097)
Human capital$_{t-1}$	0.194***	0.017	-0.459***	0.062	-0.029	-0.148
	(0.069)	(0.104)	(0.123)	(0.161)	(0.152)	(0.175)
Institutions$_{t-1}$	0.003	-0.005	0.015***	0.033***	0.030***	0.015***
	(0.002)	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)
Total factor productivity$_{t-1}$	0.117**	0.247***	0.150**	-0.241**	-0.458***	-0.293**
	(0.054)	(0.080)	(0.076)	(0.110)	(0.108)	(0.124)
GATT/WTO membership$_t$	0.099***	0.114***	-0.098**	0.556***	0.105*	0.283***
	(0.026)	(0.041)	(0.047)	(0.054)	(0.054)	(0.063)
RTAs$_t$	0.001*	0.001	-0.002***	0.002*	-0.001	0.007***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	3,046	3,046	3,046	3,046	3,046	3,046
R-squared	0.987	0.968	0.957	0.967	0.972	0.969
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size include OECD and non-OECD countries.

Table 3.7 shows that controlling for TFP, RTAs and GATT/WTO entry does not alter the positive effect of capital goods imports on technological export composition in developing countries. However, the results indicate that domestic firms TFP have a negative effect on technological export composition in developing countries. Thus suggesting the substitution effect between domestic TFP and the embodied TFP in capital goods imports. While GATT/WTO entry and

[5]I obtain TFP data from the Penn World Tables, version 9.1, computed using real GDP at national prices, real capital stock at national prices, and the labour force.

[6]The data was collected from Centre d'Études Prospectives et d'Informations Internationales (CEPII)

RTAs have positive effects. In Carrere (2006), RTAs significantly increase trade among members, however, at the expense of other trade partners. Also in Africa, the inclusion of TFP, RTAs and a GATT/WTO dummy variable does not alter the positive effect of capital goods imports in Africa's technological export composition, see Table 3.8. Results in column (6) also show that capital goods imports have smaller positive effects in Africa relative to other developing countries.

Table 3.8: Effects of capital goods imports on Africa's technological export composition.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
$\ln(\text{Capital imports})_{t-1}$	0.418***	0.332***	0.296***	0.216***	0.449***	0.676***
	(0.027)	(0.063)	(0.048)	(0.061)	(0.067)	(0.064)
$\ln(\text{Capital imports})_{t-1} * I^{Africa}$	-0.019	-0.135***	-0.006	0.244***	0.171***	-0.104*
	(0.029)	(0.043)	(0.053)	(0.055)	(0.062)	(0.063)
$\ln(\text{Financial development})_{t-1}$	-0.041**	-0.083***	0.057	-0.011	-0.047	0.167***
	(0.019)	(0.028)	(0.036)	(0.038)	(0.043)	(0.045)
$\ln(\text{Infrastructure investment})_{t-1}$	-0.064**	-0.067	0.142**	0.013	-0.215**	-0.001
	(0.031)	(0.058)	(0.062)	(0.092)	(0.084)	(0.078)
$\ln(\text{GDP})_{t-1}$	0.305***	0.197***	-0.277***	-0.079	0.118	0.015
	(0.046)	(0.074)	(0.089)	(0.112)	(0.115)	(0.109)
$\text{Human capital}_{t-1}$	0.197**	0.019	-0.637***	-0.029	-0.542***	-0.582***
	(0.087)	(0.136)	(0.156)	(0.210)	(0.185)	(0.219)
$\text{Institutions}_{t-1}$	-0.000	-0.003	0.002	0.019***	0.008	0.004
	(0.003)	(0.004)	(0.005)	(0.006)	(0.006)	(0.006)
$\text{Total factor productivity}_{t-1}$	0.148**	0.219**	0.277***	-0.092	-0.241**	-0.228
	(0.060)	(0.090)	(0.088)	(0.123)	(0.121)	(0.140)
$\text{GATT/WTO membership}_t$	0.110***	0.121***	-0.137**	0.573***	0.054	0.247***
	(0.029)	(0.042)	(0.054)	(0.061)	(0.057)	(0.068)
RTAs_t	0.001	0.000	-0.001	0.002	-0.002	0.007***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Observations	1,967	1,967	1,967	1,967	1,967	1,967
R-squared	0.978	0.959	0.929	0.948	0.950	0.943
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only developing countries.

3.5.3. *Robustness checks with respect to varieties of capital goods imports*

Recent literature (e.g., Halpern et al., 2015; Mo et al., 2021) finds evidence that international sourcing of more varieties (diverse) and better qualities of capital goods improves the productivity of importing firms. Following this, I opt to use varieties of capital goods imports - the extensive margin of capital goods imports. Following the methodology of Hummels and Klenow (2005), I estimate the extensive margin of capital goods imports in Africa, and estimate the effects of importing a variety of capital goods on technological export composition, using only a

sample of African countries.

Table 3.9: Effects of importing a variety of capital goods on Africa's technological export composition.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports: variety)$_{t-1}$	0.285***	0.167***	0.202**	0.287***	0.431***	0.332***
	(0.048)	(0.064)	(0.082)	(0.103)	(0.115)	(0.121)
ln(Financial development)$_{t-1}$	-0.119***	-0.280***	-0.140*	-0.036	-0.081	0.221***
	(0.033)	(0.051)	(0.074)	(0.071)	(0.096)	(0.082)
ln(Infrastructure investment)$_{t-1}$	-0.002	0.008	0.290***	0.008	-0.131	-0.024
	(0.044)	(0.062)	(0.081)	(0.131)	(0.126)	(0.109)
ln(GDP)$_{t-1}$	0.486***	0.505***	-0.164	0.110	0.206	0.341**
	(0.072)	(0.096)	(0.120)	(0.165)	(0.184)	(0.156)
Human capital$_{t-1}$	-0.484***	-0.748***	-1.452***	-0.395	-0.649	-1.379***
	(0.148)	(0.223)	(0.291)	(0.443)	(0.396)	(0.486)
Institutions$_{t-1}$	-0.007*	-0.010	-0.036***	0.013	0.021*	-0.011
	(0.005)	(0.007)	(0.011)	(0.010)	(0.011)	(0.012)
Total factor productivity$_{t-1}$	0.267***	0.488***	0.393***	-0.025	-0.179	-0.628***
	(0.089)	(0.123)	(0.137)	(0.193)	(0.205)	(0.221)
GATT/WTO membership$_t$	0.043	-0.299***	-0.429*	-0.082	-0.426***	0.786***
	(0.076)	(0.094)	(0.232)	(0.119)	(0.144)	(0.203)
RTAs$_t$	0.009***	0.012***	0.002	0.004	0.007*	0.010**
	(0.001)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Observations	818	818	818	818	818	818
R-squared	0.969	0.956	0.895	0.941	0.913	0.892
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only African countries. The values of capital goods imports are the extensive margins values.

Table 3.9 reports the findings. Columns (4)-(6) reveal that importing more varieties of capital goods will positively affect Africa's export composition. In Halpern et al. (2015), importing more varieties of capital goods improves the productivity of importers, which increases export composition (Bas and Strauss-Kahn, 2014). The results indicate that a 1% increase in varieties of capital goods imports will cause a 0.29%, 0.43%, and 0.33% increase in LTM, MTM, and HTM exports in Africa, respectively. However, column (6) indicates that GATT/WTO entry has a negative effect on medium technology export in Africa. Under the WTO, developing countries will benefit from improvements in market access opportunities, however, they are also required to make a larger contribution through tariff reductions and bindings that might negatively affect their domestic manufacturing firm (Laird, 1999). Furthermore, in Chapter 2, the analysis shows that world trade is highly concentrated in medium technology goods, indicating high level of competition in the sector. Whilst export subsidies are generally phased out under WTO (Laird, 1999).

3.6 Conclusion

Using a sample dataset of 128 countries over the period 1980-2015, the study investigates the effects of capital goods imports on the technological export composition. I find that capital goods imports have a positive effect on technological export composition (low, medium, and high technology exports). I also find that this positive effect is heterogeneous for developed and developing countries, and also in the African continent.

The results show that capital goods imports have a larger positive effect on technological export composition in developing countries relative to developed countries. In Africa, the positive effect is smaller in high technology manufactured exports relative to the average for other developing countries, while greater in low and medium technology manufactured exports.

The research findings suggest that capital goods imports are essential in accelerating Africa's export composition growth and diversification - promoting growth in both primary and manufactured export categories (i.e., resource-based, low, medium, and high technology manufacturers). It is therefore important for Africa to implement trade liberalisation policies that attract the importation of new and technologically advanced industrial goods that encourage the transition from exports of primary goods to more processed and relatively high technology products.

Appendix B

B.1 *List of countries*

Table B.1: List of countries in the study.

OECD Countries		non-OECD (excl. Africa)		African countries	
Australia	Latvia	Albania	Kuwait	Algeria	Mali
Austria	Lithuania	Argentina	Kyrgyzstan	Angola	Mauritania
Belgium	Luxembourg	Armenia	Laos	Benin	Mauritius
Canada	Mexico	Bahrain	Malaysia	Botswana	Morocco
Chile	Netherlands	Bangladesh	Moldova	Burkina Faso	Mozambique
Colombia	New Zealand	Belize	Mongolia	Burundi	Namibia
Czechia	Norway	Bolivia	Myanmar	Cameroon	Niger
Denmark	Poland	Brazil	Nepal	Central African Rep.	Nigeria
Estonia	Portugal	Bulgaria	Nicaragua	Congo	Rwanda
Finland	Slovakia	Cambodia	Pakistan	Côte d'Ivoire	Senegal
France	Slovenia	China	Panama	Dem. Rep. Congo	Sierra Leone
Germany	South Korea	Costa Rica	Paraguay	Egypt	South Africa
Greece	Spain	Croatia	Peru	Gabon	Sudan
Hungary	Sweden	Cyprus	Philippines	Gambia	Swaziland
Ireland	Switzerland	Dominican Rep.	Russia	Ghana	Tanzania
Israel	Turkey	Ecuador	Saudi Arabia	Kenya	Togo
Italy	UK	El Salvador	Singapore	Lesotho	Tunisia
Japan	USA	Guatemala	Sri Lanka	Liberia	Uganda
		Haiti	Syria	Madagascar	Zambia
		Honduras	Tajikistan	Malawi	Zimbabwe
		India	Thailand		
		Iran	Ukraine		
		Iraq	UAE		
		Jamaica	Uruguay		
		Jordan	Venezuela		
		Kazakhstan	Vietnam		

B.2 Additional Results: Coastal vs landlocked developing countries

International trade literature argues that landlocked countries trade less than coastal countries (see e.g., Arvis et al., 2010; Hummels, 2007; Radelet and Sachs, 1998). The literature associate being landlocked with increased import costs and reduced export revenues. In Radelet and Sachs (1998) exporting is extremely difficult in landlocked countries, especially landlocked developing countries due to the higher cost of capital and intermediate inputs. High transport costs heavily affects landlocked developing countries (see e.g., Arvis et al., 2010; Hummels, 2007), as they have to adjust their export prices to global prices (see e.g., Amjadi et al., 1995). Transport infrastructure of landlocked developing countries is argued to be worse than that of coastal developing countries (see e.g., Arvis et al., 2010).

In the study, there are 29 landlocked countries, the majority of them are in developing coun-

tries, while only 6 of the 36 developed (OECD) countries are landlocked. To examine the impact of capital goods imports in coastal and landlocked developing countries specifically, I reduce the sample sizes to account for only coastal or landlocked developing countries. Table B.2 and B.3 reports the results.

Table B.2: Effects of capital goods imports on technological export composition in coastal developing countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.442***	0.213***	0.263***	0.262***	0.544***	0.827***
	(0.026)	(0.036)	(0.053)	(0.072)	(0.065)	(0.071)
ln(Financial development)$_{t-1}$	0.008	-0.030	0.124***	0.027	-0.035	0.143***
	(0.019)	(0.025)	(0.035)	(0.043)	(0.047)	(0.048)
ln(Infrastructure investment)$_{t-1}$	-0.050	-0.079	0.168***	-0.075	-0.245**	0.010
	(0.031)	(0.067)	(0.062)	(0.108)	(0.096)	(0.093)
ln(GDP)$_{t-1}$	0.191***	0.130*	-0.223**	0.152	0.115	-0.072
	(0.048)	(0.073)	(0.089)	(0.126)	(0.125)	(0.121)
Human capital$_{t-1}$	0.143*	0.182	-0.189	-0.357	-0.628***	-0.936***
	(0.086)	(0.120)	(0.141)	(0.242)	(0.199)	(0.230)
Institutions$_{t-1}$	0.001	-0.004	0.004	0.026***	0.007	-0.007
	(0.003)	(0.003)	(0.006)	(0.007)	(0.006)	(0.006)
Total factor productivity$_{t-1}$	0.155**	0.187**	0.237***	-0.328**	-0.296**	-0.133
	(0.067)	(0.085)	(0.091)	(0.137)	(0.131)	(0.154)
GATT/WTO membership$_t$	0.132***	0.153***	-0.050	0.652***	0.068	0.268***
	(0.029)	(0.040)	(0.056)	(0.072)	(0.061)	(0.076)
RTAs$_t$	0.000	-0.002*	-0.002	0.002	-0.002	0.008***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Observations	1,525	1,525	1,525	1,525	1,525	1,525
R-squared	0.979	0.971	0.928	0.936	0.946	0.945
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only coastal developing countries.

The results show that capital goods imports have a positive effect on technological export composition in coastal developing countries, as well as in landlocked developing economies. Columns (4)-(5) of Table B.3 also indicate that there is no heterogeneous effects of capital goods imports in low and medium technology exports between coastal and landlocked developing countries. Whilst column (6) capital goods imports have differential effect on high technology exports in landlocked relative to coastal developing countries. The positive effect of capital goods imports are smaller in landlocked developing countries.

Table B.3: Effects of capital goods imports in landlocked developing countries relative to all developing countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.425***	0.211***	0.256***	0.308***	0.534***	0.729***
	(0.027)	(0.042)	(0.048)	(0.059)	(0.062)	(0.065)
ln(Capital imports)$_{t-1} * I^{Landlocked}$	-0.037	0.217***	0.106**	-0.037	-0.083	-0.244***
	(0.033)	(0.073)	(0.053)	(0.060)	(0.068)	(0.071)
ln(Financial development)$_{t-1}$	-0.038**	-0.101***	0.048	-0.008	-0.041	0.187***
	(0.019)	(0.029)	(0.036)	(0.038)	(0.044)	(0.046)
ln(Infrastructure investment)$_{t-1}$	-0.062**	-0.093	0.132**	0.030	-0.197**	0.014
	(0.032)	(0.061)	(0.063)	(0.092)	(0.084)	(0.083)
ln(GDP)$_{t-1}$	0.298***	0.285***	-0.245***	-0.134	0.062	-0.038
	(0.047)	(0.074)	(0.089)	(0.117)	(0.115)	(0.113)
Human capital$_{t-1}$	0.194**	0.115	-0.609***	-0.114	-0.616***	-0.611***
	(0.087)	(0.126)	(0.154)	(0.204)	(0.182)	(0.217)
Institutions$_{t-1}$	-0.001	-0.006	0.002	0.023***	0.010*	0.004
	(0.003)	(0.004)	(0.005)	(0.006)	(0.006)	(0.006)
Total factor productivity$_{t-1}$	0.155***	0.189**	0.260***	-0.096	-0.235*	-0.184
	(0.060)	(0.087)	(0.087)	(0.123)	(0.120)	(0.141)
GATT/WTO membership$_t$	0.119***	0.138***	-0.146***	0.507***	0.014	0.300***
	(0.029)	(0.042)	(0.054)	(0.060)	(0.057)	(0.070)
RTAs$_t$	0.001	0.001	-0.001	0.002	-0.002	0.006***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Observations	1,967	1,967	1,967	1,967	1,967	1,967
R-squared	0.978	0.959	0.929	0.947	0.950	0.943
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Note: The sample size was reduced to account for only the developing countries.

B.3 Additional Results: Coastal vs landlocked African countries

In coastal African countries, the results in columns (5)-(6) of Table B.4 indicate that capital goods imports have positive and significant effect on medium and high technology exports. The columns reveal that a 1% increase in capital goods imports will increase medium and high technology exports by 0.35% and 0.50% (respectively). The effect on low technology is negative but insignificant.

As for landlocked African countries, Table B.5 show a positive effect of capital goods imports on technological export composition in landlocked African countries. The results also indicate no differential effect of capital goods imports on medium and high technology in coastal and landlocked African countries, and suggest that the positive effect on low technology exports in Africa is essentially being driven by landlocked African countries.

Table B.4: Effects of capital goods imports on technological export composition in coastal African countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.245***	0.164**	-0.169*	-0.028	0.351**	0.503***
	(0.055)	(0.079)	(0.094)	(0.179)	(0.163)	(0.183)
ln(Financial development)$_{t-1}$	-0.017	-0.088**	-0.071	0.116	-0.084	0.238**
	(0.035)	(0.041)	(0.067)	(0.084)	(0.113)	(0.100)
ln(Infrastructure investment)$_{t-1}$	0.037	0.032	0.440***	-0.093	-0.113	-0.085
	(0.041)	(0.070)	(0.060)	(0.156)	(0.168)	(0.126)
ln(GDP)$_{t-1}$	0.304***	0.330***	0.093	0.272	0.242	0.387**
	(0.066)	(0.082)	(0.102)	(0.183)	(0.200)	(0.162)
Human capital$_{t-1}$	-0.607***	-0.096	-0.869***	-1.058**	-0.256	-2.451***
	(0.147)	(0.187)	(0.253)	(0.507)	(0.456)	(0.518)
Institutions$_{t-1}$	-0.006	-0.012**	-0.039***	0.014	-0.003	-0.010
	(0.005)	(0.005)	(0.009)	(0.011)	(0.012)	(0.014)
Total factor productivity$_{t-1}$	0.156*	0.386***	0.079	-0.196	-0.314	-0.799***
	(0.086)	(0.121)	(0.127)	(0.223)	(0.242)	(0.247)
GATT/WTO membership$_t$	0.076	-0.312***	-0.183	0.041	-0.402***	0.659***
	(0.088)	(0.098)	(0.174)	(0.157)	(0.150)	(0.216)
RTAs$_t$	0.007***	0.004**	0.006*	0.007*	0.007*	0.018***
	(0.001)	(0.002)	(0.003)	(0.004)	(0.004)	(0.005)
Observations	580	580	580	580	580	580
R-squared	0.973	0.974	0.895	0.938	0.908	0.887
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only coastal African countries.

Table B.5: Effects of capital goods imports in landlocked developing countries relative to all developing countries.

	Dependent Variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Total)	ln(Primary)	ln(RBM)	ln(LTM)	ln(MTM)	ln(HTM)
ln(Capital imports)$_{t-1}$	0.288***	0.238***	0.017	0.181	0.427***	0.372***
	(0.054)	(0.070)	(0.095)	(0.121)	(0.127)	(0.136)
ln(Capital imports)$_{t-1} * I^{Landlocked}$	-0.007	-0.139	0.363***	0.207*	0.008	-0.079
	(0.065)	(0.087)	(0.133)	(0.122)	(0.125)	(0.145)
ln(Financial development)$_{t-1}$	-0.119***	-0.285***	-0.127*	-0.029	-0.080	0.218***
	(0.033)	(0.051)	(0.075)	(0.072)	(0.096)	(0.082)
ln(Infrastructure investment)$_{t-1}$	-0.002	0.014	0.276***	-0.001	-0.131	-0.021
	(0.044)	(0.060)	(0.085)	(0.127)	(0.126)	(0.110)
ln(GDP)$_{t-1}$	0.484***	0.461***	-0.051	0.174	0.208	0.316*
	(0.075)	(0.097)	(0.122)	(0.171)	(0.189)	(0.165)
Human capital$_{t-1}$	-0.487***	-0.800***	-1.316***	-0.317	-0.646	-1.409***
	(0.146)	(0.224)	(0.296)	(0.440)	(0.397)	(0.486)
Institutions$_{t-1}$	-0.008*	-0.011	-0.033***	0.015	0.021*	-0.012
	(0.005)	(0.007)	(0.011)	(0.010)	(0.011)	(0.012)
Total factor productivity$_{t-1}$	0.268***	0.512***	0.330**	-0.060	-0.180	-0.615***
	(0.088)	(0.122)	(0.135)	(0.194)	(0.209)	(0.222)
GATT/WTO membership$_t$	0.042	-0.317***	-0.382	-0.055	-0.425***	0.776***
	(0.076)	(0.090)	(0.243)	(0.125)	(0.145)	(0.203)
RTAs$_t$	0.009***	0.012***	0.004	0.005	0.007*	0.009**
	(0.001)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
Observations	818	818	818	818	818	818
R-squared	0.969	0.956	0.896	0.942	0.913	0.892
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 . *Note*: The sample size was reduced to account for only African countries.

CHAPTER 4

DETERMINANTS OF CAPITAL GOODS IMPORTS IN DEVELOPING COUNTRIES

Since research and development (R&D) in capital goods is highly concentrated in few developed economies, international technology diffusion plays an important role in shaping technology advancement in most developing countries. This article investigates the determinants of capital goods imports in developing countries using a panel dataset spanning 1980-2015. The findings reveal that financial development, infrastructure investment, and institutions are important determinants of capital goods imports in developing countries. The findings also indicate that financial development has a larger positive effect in developing countries relative to developed economies. In Africa, financial development and infrastructure investment are key determinants of capital goods imports, with infrastructure investment being critical in landlocked nations.

4.1 Introduction

Since the production of capital goods is highly concentrated in a few developed economies (see, Eaton and Kortum, 2001; Mutreja et al., 2018), globalisation plays a major role in shaping technology advancement in less developed countries (see e.g., Coe and Helpman, 1995; Keller, 2004; Mutreja et al., 2018). Developing countries are reliant on the importation of capital goods for

domestic productivity growth, and a decrease in these types of imports can cause a decline in output and impede growth (see e.g., Hentschel, 1992; Jiranyakul, 2012; Keller, 2004). Additionally, in Chapter 3, I find that capital goods imports positively affect the technological export composition in developing countries. It is thus highly relevant to examine the factors that affect imports of capital goods in developing countries, particularly in Africa.

Africa's share of capital goods imports relative to the world has declined on average since the 1980s (see Chapter 2). This begs the question: what factors affect the importation of capital goods in African countries? Apart from African countries' sizes and geographic factors, it is argued that the patterns of trade in Africa are linked to colonial rule. The colonial rule is blamed for failing to leave a legacy of institutions, infrastructure, human and financial capital which could have enabled the continent to develop (see e.g., Acemoglu and Robinson, 2010*b*; Brown, 2007; Nunn, 2007; Stiglitz, 2018; Tadei, 2018). Africa is characterised by poor institutions, as well as low levels of human capital, financial markets, and infrastructure compared to other developing regions (see e.g., Foster and Briceño-Garmendia, 2009; Svirydzenka, 2016; Tadei, 2018; UNDP, 2018). Given the importance placed on these variables in the literature to explain development outcomes in Africa, I examine their effects on capital goods importation in the region.

The study uses a panel dataset of 128 countries that include 91 developing economies. Using Lall (2000) technological trade classification, I define capital goods as the sum of medium and high technology manufactured goods i.e., machinery and equipment, pharmaceutical, electrical, engineering, aircraft, railway, and automotive products. Apart from financial development, infrastructure, human capital, and institutions the study model also includes controls such as total factor productivity and GDP.

The findings indicate that financial development, infrastructure investment, and institutions have positive and significant effects on capital goods imports in developing countries. These findings are in line with works of Bas and Berthou (2012); Fauceglia (2014, 2015*a*). Their studies reveal that access to finance and physical resources enhances the decision to capital inputs by manufacturing firms in developing nations. The effect of human capital is insignificant, however, it is positive and significant for landlocked developing countries. In Eaton and Kortum

(2001), barriers to capital goods imports are higher in countries with lower levels of human capital. Capital goods imports such as computers and machinery embody skill-biased technology that needs to be complemented with certain types of skills (Burstein et al., 2013; Raveh and Reshef, 2016). However, Mukoyama et al. (2003) argues that as the quality of capital goods improve, they become more user friendly so that any person can handle them.

The findings also reveal that financial development and infrastructure investment have larger positive effects on capital goods imports in developing countries relative to developed countries, while institutions have smaller benefits in developing countries relative to developed economies. In Africa, financial development and infrastructure investment are key determinants of capital goods imports. The findings also indicate that infrastructure investment has a larger positive effect in landlocked African countries relative to coastal African countries. Whilst there is no heterogeneous effect of financial development between landlocked and coastal African countries. The overall study findings are consistent with the literature arguing that the benefits of importing capital goods are not automatic and that certain factor endowments to accompany the importation of capital goods are needed (see e.g., Acemoglu and Robinson, 2010*b*; Eaton and Kortum, 1999; Rodrik, 1999; Rosenberg and Nathan, 1982; Stiglitz, 2018; Tadei, 2018).

4.2 Review of Literature

4.2.1. *Theoretical Motivation*

Although technology diffusion is one major channel by which developing countries can catch up with developed economies (see e.g., Coe et al., 1997; Keller, 2004; Rodrik, 1999), in terms of productivity and sustainable growth, a common feature of foreign capital goods is that they are difficult to handle (see e.g, Chandra, 2006; Rodrik, 1999; Rosenberg and Nathan, 1982). Higher levels of factor endowments and technical competence are required to adopt the technology, as these foreign technologies need to be modified to make them amendable to domestic firms (see e.g., Bartel and Lichtenberg, 1987; Chandra, 2006; Lall, 2000; Nelson and Phelps, 1966; Rodrik, 1999; Rosenberg and Nathan, 1982).

In Rodrik (1999) theory, the importation of capital goods from advanced nations can help de-

veloping economies overcome some of their obstacles to stable growth. However, he argues that the potential productivity growth benefits of the technology embodied in foreign capital goods can only be fully enjoyed when complementary policies and institutions are in place domestically. That is, for an economy to be successful, it has to combine a certain degree of openness with factor endowments that are conducive to investment.

In Nelson and Phelps (1966) model, education enhances the adoption of new technologies. They argue that the level of technology a country can adopt is higher when the level of education is also higher. Similarly, Eaton and Kortum (2001) emphasise that a country's level of human capital may provide some indication of its ability to exploit foreign technology. Their model shows that barriers to capital goods imports are lower in countries with higher levels of human capital, suggesting that the benefits of imported capital goods can increase with the level of human capital.

However, in Mukoyama et al. (2003) theorem, as the technology matures (or the quality gets better), they become more user friendly so that anyone can handle them, they become more reliable. The increase in reliability makes the adoption easier for less-skilled workers. While in Chari and Hopenhayn (1991) theory, the adoption of new capital goods depends on the existing old capital inputs specifically for that same technology. In their model, new and old capital goods are complementary in production.

In Rosenberg and Nathan (1982) and Chandra (2006), the adoption of capital goods imports may also depend upon the quality of natural resources a country has. Most African countries are well endowed with higher qualities of natural resources, such as high quality of copper,iron ore, platinum, and many others (see e.g., Alao, 2007; Kurecic and Seba, 2016; Ojakorotu and Olajide, 2019). However, Africa is poorly endowed with factor endowment such as financial markets, human capital, infrastructure, and institutions than other developing regions Acemoglu and Robinson (2010*a*); Bond (2016); Eberhard et al. (2011); UNDP (2018). Little is known about how these factor endowments may add to the costs associated with importing capital goods by African countries.

4.2.2. *Empirical Literature*

This study is related to various strands of the literature. It is closely related to the empirical international technology diffusion literature. Although numerous studies show correlation between capital goods imports and growth exist (see e.g., Coe and Helpman, 1995; Eaton and Kortum, 1999; Lee, 1995; Romer, 1990), few examine the determinants of capital goods imports, especially for developing regions like Africa. Much of the existing literature focuses on aggregate imports (e.g., Aziz and Horsewood, 2008; Çakmak and Çakmak, 2016; Olabisi and Sawyer, 2020), but not all imports matter for productivity and growth (see e.g., Caselli, 2018; Romero and McCombie, 2016). Few studies distinguish capital goods from intermediate.

Firms that import capital goods tend to experience an increase in productivity, while firms that import intermediate goods (i.e., materials) do not (Caselli, 2018). Capital goods are embodied with intensive R&D technologies (Caselli, 2018; Hausmann et al., 2007; Lall, 2000; Romero and McCombie, 2016; Sheu, 2014). As such, analysing the determinants of imports at the aggregate level can lead to aggregation bias.

Fewer studies focused on the extent to which infrastructure, human capital, financial development, institutions, and productivity are important. Most of the existing literature emphasise on the relative prices (i.e., exchange rate) and GDP growth as the main determinants (see e.g., Al-Hazaimeh et al., 2011; Aziz and Horsewood, 2008; Çakmak and Çakmak, 2016; Olabisi and Sawyer, 2020). They show positive effects of the exchange rate and GDP on capital goods imports. This study is closely related to the works of Caselli and Coleman (2001); Bas and Berthou (2012); Fauceglia (2014); and Fauceglia (2015*b*).

Caselli and Coleman (2001) empirically investigates the determinants of imports of computers across 155 countries over the period 1970-1990, using both random effects (RE) and fixed effects (FE) estimation techniques. They show that human capital and good property rights protection are significant determinants of computer imports. Using the Indian manufacturing dataset covering the period 1997-2006, Bas and Berthou (2012) analyses whether financial constraints prevent Indian manufacturing firms from importing capital goods. The linear probability estimation results provide evidence that Indian manufacturing firms with lower leverage and higher liquidity are more likely to import their capital goods from technologically advanced

nations.

Fauceglia (2014) studies whether credit constraints are an important barrier for importing capital goods in developing countries using a sample of 13 developing countries over the period 2002-2005. The bivariate probit, instrumental variables (IV) probit, and the two-stage least squares (2SLS) results show that the probability to import capital goods reduces to almost zero for credit constrained firms in developing countries.

Fauceglia (2015*b*) examines the interaction between firms' wealth and country's credit markets institutions on capital goods imports using data for seven developing countries over the period 2003-2007. His findings from the Generalised Method of Moments (GMM) estimators show that credit constraints have a negative impact on the decision to import capital goods. Additionally, his results also indicate that institutions such as creditor rights, efficient debt enforcement, and accounting standards improve access to external finance and reduce credit constraints with regard to importing capital goods.

This study is also linked to studies that investigate the factors that determine the adoption and implementation of new technologies. Danquah (2012) investigates the factors that determine the capacity to absorb and implement new technology using a sample of 19 Sub-Saharan African countries over the period 1960-2002. He finds that human capital and domestic innovation are important factors that determine the capacity to absorb and implement new technologies in Sub-Saharan African countries. Similarly, Danquah and Amankwah-Amoah (2017) examines the effects of human capital on innovation and technology adoption using a sample of 45 sub-Saharan African countries over the period 1960-2010. They find that human capital exerts a positive and significant impact on the adoption of technology.

Costantini and Liberati (2014) investigates whether country specific structural features support the impulse of technology transfer on development in developing countries. They find evidence that well-functioning institutions improve the capacity to transform imported technology into domestic development opportunities. Similarly, Krammer (2015) examines the moderating effects of institutional quality on technological spillovers and domestic productivity in developed and emerging economies. Their results provide evidence that good institutions have positive and comparable direct effects on productivity across the board. However, they find that institutions

moderate the relationship differently for emerging economies; governance, intellectual property rights (IPRs), and economic freedom exhibit negative moderation, while the ease of doing business moderates positively for both groups of countries.

4.3 Empirical Model

Both theoretical and empirical literature consider the importation of capital goods a critical mechanism of technological diffusion by which most developing countries can enhance productivity, output and export growth. Therefore, investigating the determinants of capital goods imports is of importance in understanding a major component of productivity and sustainable growth in developing countries.

4.3.1. *Model Specification*

Building on the model in Caselli and Coleman (2001) and Eaton and Kortum (2001), the following specifications are used to examine the determinants of capital goods imports;

$$\begin{aligned} ln(capital\ M)_{it} = {} & \beta_0 + \beta_1 ln(FD)_{it-1} + \beta_2 ln(INFRA)_{it-1} + \beta_3 HC_{it-1} + \beta_4 INST_{it-1} \\ & + \beta_5 TFP_{it-1} + \beta_6 ln(GDP)_{it-1} + \delta_i + \gamma_t + \varepsilon_{it} \end{aligned} \tag{4.1}$$

$$\begin{aligned} ln(capital\ M)_{it} = {} & \beta_0 + \beta_1 ln(FD)_{it-1} + \beta_2 ln(FD)_{it-1} * 1(non-OECD) + \beta_3 ln(INFRA)_{it-1} \\ & + \beta_4 ln(INFRA)_{it-1} * 1(non-OECD) + \beta_5 HC_{it-1} + \beta_6 HC_{it-1} \\ & * 1(non-OECD) + \beta_7 INST_{it-1} + \beta_8 INST_{it-1} * 1(non-OECD) + \beta_9 TFP_{it-1} \\ & + \beta_{10} ln(GDP)_{it-1} + \delta_i + \gamma_t + \varepsilon_{it} \end{aligned} \tag{4.2}$$

$$\begin{aligned} ln(capital\ M)_{it} = {} & \beta_0 + \beta_1 ln(FD)_{it-1} + \beta_2 ln(FD)_{it-1} * 1(Africa) + \beta_3 ln(INFRA)_{it-1} + \\ & \beta_4 ln(INFRA)_{it-1} * 1(Africa) + \beta_5 HC_{it-1} + \beta_6 HC_{it-1} * 1(Africa) \\ & + \beta_7 INST_{it-1} + \beta_8 INST_{it-1} * 1(Africa) + \beta_9 TFP_{it-1} + \beta_{10} ln(GDP)_{it-1} \\ & + \delta_i + \gamma_t + \varepsilon_{it} \end{aligned} \tag{4.3}$$

where $ln(Capital\ M)_{it}$ is the natural logarithm of capital goods imports in country i and year t. FD is financial development, $INFRA$ is infrastructure, HC is human capital, and $INST$ is institutions, TFP is total factor productivity, and GDP is the gross domestic product. δ_i and γ_t indicate country and year fixed effects, respectively.[1] The variable ε_{it} is the error term. The variables of interest are financial development, infrastructure, human capital and institutions. To model the specific effects for developing or African countries, I interact variables of interest in equation (4.2) and (4.3) respectively, with a binary variable equal to one if a developing or an African country and zero otherwise. The specification allows for further investigation of the differential effects to developing and African countries.

4.3.2. *Endogenous Problem*

The endogenous problem may stem from the unobserved explanatory variables related to observables. For instance, capital goods imports are embodied skill-complementary technologies which can affect the supply of human capital (see e.g., Krusell et al., 2000; Parro, 2013; Raveh and Reshef, 2016). They may also be explanatory variables directly related to capital goods imports in the error term (ε_{it}).

To mitigate the endogenous problem, I lagged the control variables and applied fixed effects (FE) regression models. Due to the lack of conventional instrumental variables (IV) for the capital imports, I used an alternative estimation technique proposed by Lewbel (2012). This estimation technique makes use of a heteroscedastic covariance restriction to construct an internal IV that can be used to obtain IV estimates for capital goods imports.

Lewbel (2012) estimation strategy provides an estimator for linear regression models that contain an endogenous regressor when there are no outside exogenous instruments available. The estimation method works by exploiting model heteroscedasticity to construct an IV instrument using the available regressors. Due to the reverse causality between capital goods imports, human capital and total factor productivity (TFP), I used the human capital and TFP variables to obtain IV estimates for capital goods imports. This estimation technique has been useful in models in which endogeneity is a problem and either no exogenous IVs available or when the

[1] The introduction of country fixed effects is important to control for unobservable country characteristics that do not vary over time.

available IVs are weak (see e.g., Baum and Lewbel, 2019; Le Moglie et al., 2015; Lewbel, 2018; Mishra and Smyth, 2015).

4.3.3. *Data and Summary Statistics*

This study relies on panel data of 128 countries chosen in line with data availability, see Table B.1 of Appendix B.1 for the list of countries. The imports data is from the United Nations Comtrade database recorded at 3-digit Standard International Trade Classification (SITC) revision 2. Using Lall (2000) technological classification, capital goods are a sum of medium and high technology manufactured goods.

Data on financial development and infrastructure investment is sourced from the World Development Indicators (WDIs) of the World Bank. Financial development is measured by private credit (by banks) and other financial institutions both as a percentage of GDP. Infrastructure investment is measured by gross fixed capital formation - includes industrial plants, roads, railways, schools, offices, hospitals, private residential dwellings, commercial and industrial buildings, machinery, and equipment. Human capital and total factor productivity are indexes sourced from the Penn World Tables, version 9.1. Human capital is measured by the average years of schooling and an assumed rate of return to education. Total factor productivity is computed using the real GDP at national prices, real capital stock at national prices, and the labour force. Institutional data is sourced from the Center for Systemic Peace, Polity IV Project based on *POLITY2* score scale computed by subtracting the institutional autocracy score points from the institutional democracy score points.

Following Bedard and Cho (2010); Korkmaz et al. (2017); Krammer (2015); Luci-Greulich and Thévenon (2014), I define OECD member countries as developed economies and non-OECD as developing countries. Table 4.1 reports our summary descriptive statistics for our data variables. The descriptive statistics show that on average, developed nations import more capital goods than developing economies, however, the gap between the two is small. On average, developed countries are also more open than developing economies. The developed economies are better endowed with financial development, infrastructure investment, human capital, and institutions than developing countries on average. Total factor productivity is higher in developing

Table 4.1: Summary statistics of key variables.

Variable	Mean	Std. Dev.	Min	Max
Based on on 36 developed economies				
ln(Capital imports)$_t$	12.77	1.37	7.43	16.18
ln(Financial development)$_{t-1}$	4.12	0.68	1.84	5.36
ln(Infrastructure investment)$_{t-1}$	20.43	1.52	16.28	24.26
Human capital$_{t-1}$	3.00	0.46	1.47	3.73
Institutions$_{t-1}$	8.74	3.20	-8.00	10.00
Total factor productivity$_{t-1}$	0.96	0.11	0.54	1.40
ln(GDP)$_{t-1}$	21.93	1.50	18.05	25.83
Based on 92 developing economies				
ln(Capital imports)$_t$	9.85	1.80	4.27	15.66
ln(Financial development)$_{t-1}$	2.98	0.98	-1.51	5.56
ln(Infrastructure investment)$_{t-1}$	17.50	1.89	10.15	24.47
Human capital$_{t-1}$	1.94	0.57	1.01	3.52
Institutions$_{t-1}$	0.55	6.68	-10.00	10.00
Total factor productivity$_{t-1}$	1.02	0.27	0.29	2.93
ln(GDP)$_{t-1}$	18.99	1.74	14.95	25.29

countries than in developed economies on average.

4.4 Results

4.4.1. *Determinants of capital imports in developed and developing countries*

The baseline estimates of equation (4.1) are given in columns (1)-(4) of Table 4.2. The coefficient estimates based on the full sample size are displayed in column (1). They show that financial development, infrastructure investment, human capital, and institutions have positive and significant effects on capital goods imports in the world. The effect of total factor productivity is positive but insignificant. These findings are consistent with the literature of Bencivenga and Smith (1991); Greenwood and Jovanovic (1990); Helpman (1981) that argues that differences in factor endowments such as country income level, financial development, infrastructure investment, and human capital determine trade between countries.

Column (2) shows that infrastructure investment, human capital, and institutions have positive and significant effects on capital goods imports in developed (OECD) countries. The effect of total factor productivity is negative but insignificant. The human capital results are consistent with the findings of Caselli and Coleman (2001) and Burstein et al. (2013). Caselli and Coleman (2001) finds that capital goods imports such as computers are positively correlated with human capital. Burstein et al. (2013) shows that imported capital inputs such as computers and industrial machinery embody skill-biased technology that is complementary with human

capital. Eaton and Kortum (2001) also shows that barriers to capital goods imports are lower in countries with higher levels of human capital. Thus suggesting that the benefits of imported machinery and equipment may increase with the level of human capital.

Table 4.2: Determinants of capital goods imports across regions

	Dependent Variable: ln(Capital imports)$_t$			
	(1)	(2)	(3)	(4)
	(World)	(Developed)	(Developing)	(Africa)
ln(Financial development)$_{t-1}$	0.048***	-0.118***	0.104***	0.060**
	(0.016)	(0.022)	(0.019)	(0.026)
ln(Infrastructure)$_{t-1}$	0.379***	0.335***	0.357***	0.298***
	(0.037)	(0.059)	(0.040)	(0.049)
Human capital$_{t-1}$	0.128**	0.261***	0.025	-0.144
	(0.064)	(0.092)	(0.076)	(0.113)
Institutions$_{t-1}$	0.007***	0.022***	0.003	-0.008**
	(0.002)	(0.005)	(0.003)	(0.004)
Total factor productivity$_{t-1}$	0.080	-0.072	0.074	0.021
	(0.054)	(0.109)	(0.060)	(0.088)
ln(GDP)$_{t-1}$	0.274***	0.301***	0.273***	0.244***
	(0.049)	(0.083)	(0.053)	(0.064)
Observations	3,081	1,079	2,002	853
R-squared	0.983	0.981	0.971	0.966
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Moreover, the findings indicate that financial development has a negative effect on capital goods imports in developed countries. The results show that in developed countries, a 1% increase in financial development will cause a 0.12% decrease in capital goods imports. The negative effect of financial development on capital goods imports in developed countries is consistent with Gorodnichenko and Schnitzer (2013) survey of firms in Eastern European countries which shows that an increase in financial resources increases investment in innovation by domestic firms. This suggests that financial development can discourage capital goods imports in developed countries while encouraging more intensive R&D activities.

Column (3) reports that in developing countries, financial development and infrastructure investment have positive and significant effects on capital goods imports. Thus, the development of financial markets institutions and trade (transport) infrastructure (i.e., ports, railways, roads, borders, commercial and industrial buildings) encourages the importation of capital goods in developing countries.

These findings are consistent with the previous literature of Bas and Berthou (2012); Dulleck et al. (2008); Fauceglia (2014, 2015*b*); Mastromarco and Ghosh (2009). The authors find that ac-

cess to financial and physical resources positively influences the decision to import capital goods by domestic firms in developing countries. Bas and Berthou (2012) and Fauceglia (2014, 2015*a*) argue that importing capital goods is costly and requires external finance. Importers incur fixed costs, for example, the cost of gathering information about the foreign market, establishing linkages with foreign suppliers, and learning the new technologies. Therefore, financial constraints can be a key barrier to firms' imports of capital goods in developing economies, thereby limiting their opportunities to benefit from technological spillovers embodied in capital goods imports.

The effects of human capital and institutions on capital goods imports are also positive but not significant. In Fauceglia (2014, 2015*b*), institutions such as creditors rights and efficient debt enforcement have indirect positive effects on capital goods imports, for example, through improving access to external finance and reducing credit constraints.

Finally, column (4) indicates that financial development and infrastructure investment have positive and significant effects on capital goods imports in Africa. The results reveal that a 1% increase in financial development would cause a 0.06% increase in capital goods, while a 1% rise in infrastructure investment would lead to 0.30% increase in capital goods imports in Africa. Whilst institutions have a negative effect on capital goods imports in Africa. The impact of human capital is negative but insignificant.

The positive and significant effects of financial development and infrastructure investment on capital goods imports results in African countries are consistent with the empirical works of Das and Drine (2020); Menyah et al. (2014); Wolde-Rufael (2009). In Wolde-Rufael (2009) and Menyah et al. (2014), financial development helps poor African countries to catch up with the rest of the world, as it enables them to facilitate growth by enabling capital accumulation and technological innovation. While Das and Drine (2020) finds that poor infrastructure is one of the most significant barriers to technology catching up in Africa.

4.4.2. *Determinants in developing countries relative to developed countries*

To determine the differential effects of determinants of capital goods imports in developing countries relative to developed countries, I estimate equation (4.2). The findings based on the full sample size of developed and developing countries, which are displayed in Table 4.3, columns (1)-

(4) show the heterogeneous effects of financial development, infrastructure investment, human capital, and institutions in developed and developing countries.

Table 4.3: Determinants of capital goods imports in developing countries

	Dependent Variable: ln(Capital imports)$_t$			
	(1)	(2)	(3)	(4)
ln(Financial development)$_{t-1}$	-0.087***	0.054***	0.048***	0.047***
	(0.020)	(0.016)	(0.016)	(0.016)
ln(Infrastructure)$_{t-1}$	0.367***	0.303***	0.380***	0.376***
	(0.037)	(0.040)	(0.037)	(0.037)
Human capital$_{t-1}$	0.075	0.110*	0.134	0.104
	(0.063)	(0.064)	(0.084)	(0.065)
Institutions$_{t-1}$	0.005**	0.006***	0.007***	0.024***
	(0.003)	(0.003)	(0.003)	(0.005)
Total factor productivity$_{t-1}$	0.108**	0.088	0.079	0.068
	(0.055)	(0.054)	(0.055)	(0.054)
ln(GDP)$_{t-1}$	0.275***	0.288***	0.274***	0.268***
	(0.049)	(0.049)	(0.049)	(0.048)
ln(Financial development)$_{t-1} * I^{non-OECD}$	0.183***			
	(0.025)			
ln(Infrastructure investment)$_{t-1} * I^{non-OECD}$		0.079***		
		(0.023)		
Human capital$_{t-1} * I^{non-OECD}$			-0.006	
			(0.059)	
Institutions$_{t-1} * I^{non-OECD}$				-0.020***
				(0.006)
Observations	3,081	3,081	3,081	3,081
R-squared	0.983	0.983	0.983	0.983
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Firstly, the results in columns (1)-(2) confirm that financial development, infrastructure investment, and institutions have positive effects on capital goods imports in developing countries ($\beta_1 + \beta_2 > 0$).[2] The results also show that the effect of human capital is positive but not significant.

Secondly, the results reveal that there are statistically different effects of financial development, infrastructure investment, and institutions in developing countries relative to developed countries. The results indicate that financial development and infrastructure investment have greater benefits on the importation of capital goods in developing countries relative to developed countries. In fact, results in column (1) reveal that the positive effect of financial development on capital goods imports in the world is driven by the developing countries. The estimates in column (4) indicate that institutions have less positive benefits in developing countries relative to developed countries.

[2]The coefficient for financial development in developing countries is calculated by adding $(-0.087)+0.183 = 0.096$.

4.4.3. *Determinants of capital goods imports in Africa relative to other developing countries*

In order to determine the differential effects of financial development, infrastructure investment, human capital, and institutions in African countries relative to other developing countries, I reduce the sample size to include only developing countries and estimate equation (4.3).

Table 4.4: Determinants of capital goods imports in Africa relative to other developing countries

	Dependent Variable: ln(Capital imports)$_t$			
	(1)	(2)	(3)	(4)
ln(Financial development)$_{t-1}$	0.108***	0.104***	0.099***	0.086***
	(0.024)	(0.019)	(0.019)	(0.019)
ln(Infrastructure investment)$_{t-1}$	0.357***	0.386***	0.344***	0.346***
	(0.040)	(0.038)	(0.040)	(0.039)
Human capital$_{t-1}$	0.024	0.021	0.073	-0.038
	(0.076)	(0.076)	(0.078)	(0.075)
Institutions$_{t-1}$	0.003	0.004	0.005	0.016***
	(0.003)	(0.003)	(0.003)	(0.004)
Total factor productivity$_{t-1}$	0.074	0.072	0.088	0.066
	(0.060)	(0.060)	(0.061)	(0.059)
ln(GDP)$_{t-1}$	0.273***	0.255***	0.264***	0.279***
	(0.053)	(0.051)	(0.052)	(0.052)
ln(Financial development)$_{t-1} * I^{Africa}$	-0.009			
	(0.033)			
ln(Infrastructure investment)$_{t-1} * I^{Africa}$		-0.047		
		(0.031)		
Human capital$_{t-1} * I^{Africa}$			-0.314***	
			(0.077)	
Institutions$_{t-1} * I^{Africa}$				-0.028***
				(0.005)
Observations	2,002	2,002	2,002	2,002
R-squared	0.971	0.971	0.971	0.972
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Note: The sample size was reduced to account for only developing countries.

The results in columns 1-3 of Table 4.4 indicate that there are no differential effects of financial development, infrastructure investment, and human capital on capital goods imports in Africa and other developing countries. While the heterogeneous effect of institutions is very small between Africa and other developing countries ($0.016 - 0.028 = -0.012$).

4.5 Robustness checks

Next, I consider robustness checks with regards to the results in order to ensure that the findings to this point are in fact robust. First, I consider additional control variables based on the

literature. Secondly, I consider an alternative econometric technique - (Lewbel, 2012) instrumental variables (L-IV) two-stage squares (2SLS).

4.5.1. *Alternative control variables*

The aim of this section is to assess the robustness of the study findings in regard to the inclusion of foreign direct investment (FDI) and the trade policy variables (GATT/WTO entry and the number of RTAs) in the models. In the literature, importing success is increasingly linked to the ability to attract more and better FDI (see e.g., Ali et al., 2017; Harding and Javorcik, 2012; Lall, 2000; UNCTAD, 1999). Ali et al. (2017) finds a strong complementary relationship between capital imports and FDI inflows.[3]

In Africa, much of the FDI dynamics come from the role of multinational corporations (MNCs) activities in special economic zone projects. MNCs have larger advantages over local African firms in the importation and development of new technologies. For example, MNCs activities in South Africa and Morocco automotive sectors enabled the two countries to develop the automotive industry and are now the homes of Africa's biggest automotive exporters.

On the other hand, the imposition of tariffs have significant economic effects on merchandised international trade, changing the price of imports and trade cost (Imbruno, 2016; Koima, 2018; UNCTAD, 2010). A tariff increase reduces imports of specific goods and increases governments revenues. Apart from tariffs' role as a source of government revenues, infant industries' argument states that higher import tariffs provide protection to new industries until they can compete with foreign suppliers. Governments can also use tariffs (and non-tariff barriers) to protect industries they consider valuable for the country's security. On one hand, tariffs can offset foreign dumping by offsetting foreign firms' price advantage, improving the balance of trade by reducing imports (see e.g., Kauppila, 2008; Zhang et al., 2021).

However, as the world production of high intensive industrial technologies is highly concentrated in few OECD countries Eaton and Kortum (2001); Mutreja et al. (2018), a tariff cut or removal of non-tariff barriers on capital goods imports reduce trade cost and could increase the reallocation of capital goods from developed (OECD) to developing (non-OECD) countries

[3] In the literature, FDI inflows is regarded as one of the channels of international knowledge spillover (see e.g., Branstetter, 2006; Glass and Saggi, 1998; Wang and Blomström, 1992; Xu and Wang, 2000).

(Imbruno, 2016; Mutreja et al., 2018). A tariff cut or removal of non-tariff barriers on capital goods imports positively impact domestic productivity via learning, variety, and due to the foreign technology embodied in those inputs (Amiti and Konings, 2007; Bustos, 2011; Topalova and Khandelwal, 2011).

To account for the impact of tariff changes on capital goods imports, I explore the impact of country's entry into the WTO. The use of a WTO dummy allows me to capture the important shift in access to foreign markets induced by a country's WTO entry. The WTO dummy also allows me to capture other changes associated with WTO membership, such as reductions in non-tariff barriers which are not measured by tariff changes (see e.g., Du et al., 2014). While the reduction of tariffs under trade agreements (i.e, RTAs, PTAs) increases firms' investments in both process and product upgrading (Bustos, 2011). In order to check the robustness of the study findings, I include FDI inflows and GATT/WTO binary variables equal to one for a member country and zero otherwise as control variables and estimate equation (4.1). Table 4.5 reports the findings.

Table 4.5: Determinants of capital goods imports across regions

	Dependent Variable: ln(Capital imports)$_t$			
	(1)	(2)	(3)	(4)
	(World)	(Developed)	(Developing)	(Africa)
ln(Financial development)$_{t-1}$	0.047***	-0.124***	0.104***	0.087***
	(0.017)	(0.023)	(0.021)	(0.032)
ln(Infrastructure investment)$_{t-1}$	0.325***	0.403***	0.288***	0.209***
	(0.039)	(0.057)	(0.042)	(0.050)
Human capital$_{t-1}$	0.080	0.124	0.051	-0.294**
	(0.066)	(0.091)	(0.079)	(0.131)
Institutions$_{t-1}$	0.008***	0.022***	0.005*	0.001
	(0.003)	(0.005)	(0.003)	(0.004)
Total factor productivity$_{t-1}$	0.091	-0.212**	0.071	
	(0.059)	(0.108)	(0.064)	(0.091)
ln(GDP)$_{t-1}$	0.299***	0.208**	0.300***	0.304***
	(0.051)	(0.081)	(0.055)	(0.067)
ln(FDI inflows)$_{t-1}$	0.034***	-0.011	0.044***	0.035***
	(0.006)	0.001	(0.008)	(0.011)
GATT/WTO membership$_t$	0.128***	0.165**	0.127***	0.234***
	(0.030)	(0.075)	(0.034)	(0.055)
RTAs$_t$	-0.001**	0.004***	-0.005***	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	2,853	1,032	1,821	729
R-squared	0.983	0.983	0.973	0.968
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The inclusion of the FDI inflows and GATT/WTO variables does not alter the positive and significant effects of financial development and infrastructure on capital goods imports in devel-

oping countries as well as in Africa. In fact, the inclusion of FDI inflows and trade policy measures reveal the positive and significant effects of institutions in developing countries. Whilst in Africa, they indicate a negative and significant effect of human capital. This might not be of surprise as barriers to capital goods imports are higher in countries with lower levels of human capital (see, Eaton and Kortum, 2001). Foreign capital imports are embody skill-biased technologies that need to be complemented with certain labour skills (Burstein et al., 2013; Raveh and Reshef, 2016), Specially at the early stages of adoption, high skills are required (Bartel and Lichtenberg, 1987; Nelson and Phelps, 1966). Africa is still characterised by lower levels of human capital (see e.g., Acemoglu and Robinson, 2010*b*; UNDP, 2018).

Table 4.6: Determinants of capital goods imports in developing countries relative to developed countries

	Dependent Variable: ln(Capital imports)$_t$				
	(1)	(2)	(3)	(4)	(5)
ln(Financial development)$_{t-1}$	-0.066***	0.049***	0.043**	0.047***	0.049***
	(0.022)	(0.017)	(0.017)	(0.017)	(0.017)
ln(Infrastructure investment)$_{t-1}$	0.322***	0.298***	0.323***	0.318***	0.323***
	(0.039)	(0.041)	(0.039)	(0.038)	(0.039)
Human capital$_{t-1}$	0.032	0.071	0.275***	0.056	0.065
	(0.065)	(0.066)	(0.092)	(0.067)	(0.067)
Institutions$_{t-1}$	0.007***	0.008***	0.008***	0.026***	0.007***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.003)
ln(GDP)$_{t-1}$	0.299***	0.304***	0.299***	0.292***	0.301***
	(0.050)	(0.050)	(0.050)	(0.049)	(0.051)
Total factor productivity$_{t-1}$	0.100*	0.090	0.076	0.082	0.096
	(0.059)	(0.059)	(0.059)	(0.059)	(0.059)
ln(FDI inflows)$_{t-1}$	0.032***	0.034***	0.035***	0.035***	0.023***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
GATT/WTO membership$_t$	0.112***	0.123***	0.142***	0.135***	0.120***
	(0.030)	(0.031)	(0.031)	(0.030)	(0.031)
RTAs$_t$	-0.000	-0.001	-0.002***	-0.001***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Financial development)$_{t-1} * I^{non-OECD}$	0.155***				
	(0.027)				
ln(Infrastructure investment)$_{t-1} * I^{non-OECD}$		0.030			
		(0.026)			
Human capital$_{t-1} * I^{non-OECD}$			-0.195***		
			(0.069)		
Institutions$_{t-1} * I^{non-OECD}$				-0.021***	
				(0.006)	
ln(FDI inflows)$_{t-1} * I^{non-OECD}$					0.015*
					(0.009)
Observations	2,853	2,853	2,853	2,853	2,853
R-squared	0.984	0.983	0.983	0.983	0.983
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size include both developed (OECD) and developing (non-OECD) countries.

Table 4.6 shows that adding these controls does not alter the differential effect of financial development, infrastructure investment, and institutions on capital goods imports between de-

veloped and developing countries. Column (5) also shows that there is a differential effect of FDI inflows in developing countries relative to developed countries. In developing countries, the positive effects are larger relative to developed countries.

Table 4.7: Determinants of capital goods imports across regions- openness

	Dependent Variable: ln(Capital imports)$_t$			
	(1)	(2)	(3)	(4)
	(World)	(Developed)	(Developing)	(Africa)
ln(Financial development)$_{t-1}$	0.031*	-0.104***	0.082***	0.069**
	(0.017)	(0.021)	(0.020)	(0.028)
ln(Infrastructure investment)$_{t-1}$	0.356***	0.406***	0.305***	0.218***
	(0.039)	(0.057)	(0.042)	(0.048)
Human capital$_{t-1}$	0.012	0.197**	-0.133*	-0.190*
	(0.061)	(0.092)	(0.072)	(0.109)
Institutions$_{t-1}$	0.008***	0.020***	0.003	0.001
	(0.003)	(0.005)	(0.003)	(0.004)
Total factor productivity$_{t-1}$	0.018	-0.305***	0.073	-0.009
	(0.054)	(0.112)	(0.059)	(0.080)
ln(GDP)$_{t-1}$	0.336***	0.244***	0.347***	0.373***
	(0.051)	(0.080)	(0.053)	(0.060)
ln(FDI inflows)$_{t-1}$	0.028***	-0.006	0.034***	0.025**
	(0.006)	(0.006)	(0.008)	(0.010)
Openness$_t$	0.006***	0.005***	0.007***	0.011***
	(0.000)	(0.001)	(0.001)	(0.001)
Observations	2,882	1,032	1,850	759
R-squared	0.984	0.984	0.974	0.971
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Tariffs and non-tariff barriers are an indicator of of a country's openness (Imbruno, 2016; Koima, 2018; UNCTAD, 2010), and often used to measure the effects of trade liberalisation (Koima, 2018). I replaced the WTO dummy and RTAs variables in Table 4.5 with country's openness[4]. In Table 4.7, the inclusion of a country's openness variable does not alter the positive and significant effects of financial development and infrastructure investment on capital goods imports in developing countries as well as in African countries. The findings indicate that openness has a positive and significant effect on capital goods imports in both developed and developing countries.

4.5.2. *Alternative econometric technique*

In order to check the robustness of the empirical methods, I use the Lewbel (2012) instrumental variable two-stage least squares (L-IV 2SLS). I estimate equation (4.1) using the L-IV technique, including both country and year fixed effects. The baseline L-IV (2SLS) estimates of equation

[4]Openness is measured as trade of goods and services as a percentage of GDP

(4.1) are shown in Table 4.8. The results indicate that the use of an alternative econometric technique does not alter the positive and significant effects of financial development and infrastructure investment on capital goods imports in developing as well as in African countries.

Table 4.8: Determinants of capital goods imports across regions: L-IV

	Dependent Variable: ln(Capital imports)$_t$			
	(1)	(2)	(3)	(4)
	(World)	(Developed)	(Developing)	(Africa)
ln(Financial development)$_{t-1}$	0.051***	-0.120***	0.109***	0.104***
	(0.015)	(0.021)	(0.020)	(0.033)
ln(Infrastructure investment)$_{t-1}$	0.315***	0.399***	0.273***	0.212***
	(0.024)	(0.052)	(0.029)	(0.034)
Human capital$_{t-1}$	-0.085	-0.009	-0.220*	-0.197
	(0.100)	(0.144)	(0.130)	(0.193)
Institutions$_{t-1}$	0.007***	0.023***	0.004	0.001
	(0.002)	(0.004)	(0.003)	(0.004)
Total factor productivity$_{t-1}$	-0.097	-0.412***	-0.131	-0.306**
	(0.104)	(0.149)	(0.125)	(0.140)
ln(GDP)$_{t-1}$	0.358***	0.236***	0.384***	0.360***
	(0.043)	(0.073)	(0.054)	(0.068)
ln(FDI inflows)$_{t-1}$	0.036***	0.003	0.046***	0.041***
	(0.005)	(0.007)	(0.007)	(0.010)
GATT/WTO membership$_t$	0.122***	0.168***	0.118***	0.231**
	(0.026)	(0.052)	(0.031)	(0.097)
RTAs$_t$	-0.001*	0.004***	-0.004***	0.002
	(0.001)	(0.001)	(0.001)	(0.002)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	2,853	1,032	1,821	729
R-squared	0.815	0.905	0.796	0.763
Weak ID test	7.566	5.356	4.819	2.563
Sargan statistic	0.000	0.002	0.033	0.158

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The L-IV results in columns (3)-(4) of Table 4.8 confirm the positive and significant effect of financial development and human capital in developing countries as well as in Africa. The coefficient estimates for financial development indicate that a 1% increase in financial development would cause capital goods imports to increase by 0.11% in developing countries and by 0.10% in Africa. While a 1% rise in infrastructure investment is associated with a 0.27% increase in capital goods imports in developing countries and a 0.21% in Africa. Column (4) shows a negative and insignificant effect of human capital in Africa, while a significant negative effect in all developing countries.

The sargan test statistics in columns 1-4 indicate that the instruments (human capital and TFP variables) are not valid to obtain IV estimates for capital goods imports.[5] In the literature

[5]Sargan test has a null hypothesis (Ho): Overidentifying restrictions are valid (instruments are exogenous).

of (Sargan, 1958), the p-value must be greater than 0.05 and less than 0.1.[6] Whilst Roodman (2009) recommend that sargan p-value should be greater than 0.25. However, Parente and Silva (2012) and Guggenberger (2012) argue that the sargan test which is used to check the validity of the instruments by testing the overidentifying restrictions in the model is misleading. This is because the validity of the overidentifying restrictions is neither sufficient nor necessary for the validity of the moment conditions implied by the underlying economic model, and therefore provide little information on the possibility of identifying the parameters of interest (Parente and Silva, 2012).

4.5.3. *Determinants in developing countries relative to developed economies: L-IV*

Using L-IV estimation technique, I also estimate equation (4.2). The L-IV results in Table 4.9 mirrors the fixed effects results in Table 4.6.

Thus both models show positive effects of financial development, infrastructure investment, and institutions on capital goods imports in developing countries. The L-IV results also confirm that financial development has a larger positive effect on capital goods imports in developing countries relative to developed countries, while the positive effects of institutions are slightly smaller. In Africa Table C.1 of Appendix C.1, confirms the positive effects of financial development and infrastructure investment in Africa.

4.6 Conclusion

The main objective of this study was to uncover the determinants of capital goods imports in developing countries. Given a sample dataset of 128 countries covering the period 1980-2015, the study was able to determine the determinants of capital goods importation in both developed and developing regions. The study applied two panel data models: fixed effects (FE) models and Lewbel (2012) instrumental variable (IV) two-stage least squares (2SLS) estimation technique to examine whether financial development, infrastructure investment, human capital,

[6]The higher the p-value of the sargan statistic the better.

Table 4.9: Determinants of capital goods imports in developing countries relative to developed countries: L-IV

	Dependent Variable: ln(Capital imports)$_t$				
	(1)	(2)	(3)	(4)	(5)
ln(Financial development)$_{t-1}$	-0.067**	0.054***	0.048***	0.050***	0.053***
	(0.027)	(0.015)	(0.015)	(0.015)	(0.015)
ln(Infrastructure investment)$_{t-1}$	0.311***	0.286***	0.315***	0.307***	0.314***
	(0.024)	(0.035)	(0.024)	(0.024)	(0.024)
Human capital$_{t-1}$	-0.151	-0.059	0.061	-0.126	-0.101
	(0.102)	(0.102)	(0.146)	(0.100)	(0.102)
Institutions$_{t-1}$	0.006***	0.007***	0.007***	0.026***	0.006***
	(0.002)	(0.002)	(0.002)	(0.005)	(0.002)
Total factor productivity$_{t-1}$	-0.075	-0.101	-0.088	-0.104	-0.081
	(0.103)	(0.103)	(0.104)	(0.102)	(0.104)
ln(GDP)$_{t-1}$	0.359***	0.358***	0.353***	0.353***	0.359***
	(0.042)	(0.043)	(0.042)	(0.042)	(0.043)
ln(FDI inflows)$_{t-1}$	0.033***	0.035***	0.036***	0.036***	0.024***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.009)
GATT/WTO membership$_t$	0.107***	0.115***	0.133***	0.130***	0.115***
	(0.026)	(0.026)	(0.027)	(0.026)	(0.026)
RTAs$_t$	0.000	-0.001	-0.001**	-0.001**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Financial development)$_{t-1} * I^{non-OECD}$	0.161***				
	(0.029)				
ln(Infrastructure investment)$_{t-1} * I^{non-OECD}$		0.036			
		(0.027)			
Human capital$_{t-1} * I^{non-OECD}$			-0.136		
			(0.103)		
Institutions$_{t-1} * I^{non-OECD}$				-0.023***	
				(0.005)	
In(FDI inflows)$_{t-1} * I^{non-OECD}$					0.016*
					(0.009)
Observations	2,853	2,853	2,853	2,853	2,853
R-squared	0.817	0.815	0.815	0.816	0.815
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Weak ID test	7.497	7.473	5.033	7.705	7.384
Sargan statistic	0.000	0.000	0.000	0.000	0.000

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size account for the full data sample.

and institutions determine the importation of capital goods in developing countries as well as in Africa.

The research finds that financial development, infrastructure investment, and institutions are important determinants of capital goods imports in developing countries. Thus, the importation of capital goods increases with better levels of financial development, infrastructure investment, and strong institutions in developing countries. The findings also show that there are statistically different effects of financial development and institutions. In developing countries, financial development has a larger positive effect on capital goods imports relative to developed countries. While institutions have smaller positive effects in developing countries. In Africa, financial development and infrastructure investment are key determinants of capital

goods imports. The findings also indicate that there are no heterogeneous effects of financial development and infrastructure investment between Africa and other developing countries.

Appendix C: Additional Results

C.1 *Determinants of capital goods imports in Africa relative to other developing countries*

In this section, I reduce the sample size to only account for the 92 developing countries and estimate equation (4.3) using the Lewbel (2012) IV estimation technique (L-IV). Table C.1 reports the findings.

Table C.1: Determinants of capital goods imports in African countries relative to other developing countries: L-IV

	Dependent Variable: ln(Capital imports)$_t$				
	(1)	(2)	(3)	(4)	(5)
ln(Financial development)$_{t-1}$	0.100***	0.110***	0.106***	0.096***	0.105***
	(0.023)	(0.020)	(0.019)	(0.020)	(0.020)
ln(Infrastructure investment)$_{t-1}$	0.272***	0.304***	0.274***	0.270***	0.272***
	(0.029)	(0.033)	(0.029)	(0.029)	(0.029)
Human capital$_{t-1}$	-0.204	-0.219*	-0.101	-0.272**	-0.243*
	(0.129)	(0.130)	(0.129)	(0.131)	(0.131)
Institutions$_{t-1}$	0.004	0.004*	0.005*	0.013***	0.004*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Total factor productivity$_{t-1}$	-0.063	-0.142	-0.065	-0.113	-0.102
	(0.121)	(0.125)	(0.120)	(0.123)	(0.123)
ln(GDP)$_{t-1}$	0.370***	0.365***	0.352***	0.379***	0.366***
	(0.053)	(0.055)	(0.053)	(0.053)	(0.054)
ln(GDP)$_{t-1}$	0.045***	0.047***	0.045***	0.043***	0.062***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.009)
GATT/WTO membership$_t$	0.123***	0.105***	0.107***	0.081**	0.100***
	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)
RTAs$_t$	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Financial development)$_{t-1} * I^{Africa}$	0.024				
	(0.035)				
ln(Infrastructure investment)$_{t-1} * I^{Africa}$		-0.052*			
		(0.027)			
Human capital$_{t-1} * I^{Africa}$			-0.149		
			(0.099)		
Institutions$_{t-1} * I^{Africa}$				-0.022***	
				(0.005)	
ln(FDI inflows)$_{t-1} * I^{Africa}$					-0.030***
					(0.011)
Observations	1,821	1,821	1,821	1,821	1,821
R-squared	0.797	0.796	0.798	0.798	0.797
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Weak ID test	5.086	4.716	3.404	4.82	4.826
Sargan statistic	0.008	0.048	0.000	0.014	0.011

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Note: The sample size was reduced to account for only developing countries.

The L-IV estimation coefficients also indicate that financial development and infrastructure have positive effects on capital goods imports in Africa. The L-IV results also confirm there are no differential effects of financial development and infrastructure investment on capital goods

imports between Africa and other developing countries. Also for institutions, it is essentially zero.

C.2 *Coastal vs Landlocked Developing Countries*

In international trade literature, being landlocked is associated with increased import prices and lack of sea access is the primary reason that landlocked developing countries are unable to benefit from international trade (see e.g., Arvis et al., 2010; Behar and Venables, 2011; Hoekman and Nicita, 2011; Hummels, 2007). Given that importing capital goods helps developing countries to diversify their export composition (see Chapter 3), examining the determinants of capital goods imports in landlocked developing countries is important. The research has 29 landlocked countries, the majority of them are in developing countries, only 6 landlocked developed countries.

Since a country is always coastal or landlocked, fixed effects regressions will make the variable fall. In the study, I investigate the determinants of capital goods imports in developing countries as well as in Africa. I also examine the differential effects of the determinants of capital goods imports in landlocked developing countries relative to coastal developing countries. Table C.2 report the determinants of capital goods imports in landlocked and coastal developing countries.

The results in column 1 of Table C.2 indicate that financial development, infrastructure, and FDI inflows have positive and significant effects on capital goods imports in coastal developing countries. The effects of human capital, institutions, total factor productivity are not significant. While in landlocked developing countries (column (3)), financial development, infrastructure investment and FDI inflows have positive and significant effects on capital goods imports. While the effect of human capital is negative and significant.

For coastal and landlocked African countries, columns (2) of Table C.2 indicate that infrastructure, human capital and FDI inflows have positive and statistically significant effects on capital goods imports in coastal African countries. The effect of financial development is positive but insignificant. In landlocked African countries (column (4)) infrastructure investment has a positive and significant effect on capital good imports. Thus the results suggest that to

Table C.2: Determinants of capital goods imports in coastal and landlocked developing countries

	Dependent Variable: ln(Capital imports)$_t$			
	Coastal countries		Landlocked countries	
	(1)	(2)	(3)	(4)
	(Developing)	(Africa)	(Developing)	(Africa)
ln(Financial development)$_{t-1}$	0.099***	0.005	0.093**	0.193
	(0.025)	(0.055)	(0.039)	(0.122)
ln(Infrastructure investment)$_{t-1}$	0.241***	0.390***	0.106**	0.438***
	(0.049)	(0.068)	(0.051)	(0.107)
Human capital$_{t-1}$	-0.067	0.849***	-0.542***	0.692
	(0.083)	(0.245)	(0.133)	(0.487)
Institutions$_{t-1}$	0.004	0.004	0.008*	-0.005
	(0.004)	(0.006)	(0.005)	(0.012)
Total factor productivity$_{t-1}$	0.071	0.006	-0.006	-0.092
	(0.073)	(0.165)	(0.099)	(0.227)
ln(FDI inflows)$_{t-1}$	0.042***	0.053***	0.034***	0.034
	(0.009)	(0.018)	(0.013)	(0.023)
ln(GDP)$_{t-1}$	0.349***	0.259**	0.349***	0.320
	(0.061)	(0.131)	(0.067)	(0.264)
GATT/WTO membership$_t$	0.083**	0.217***	0.265***	0.592**
	(0.039)	(0.067)	(0.063)	(0.292)
RTAs$_t$	-0.003***	-0.027***	0.003*	-0.008
	(0.001)	(0.007)	(0.002)	(0.012)
Observations	1,411	410	518	211
R-squared	0.969	0.941	0.973	0.898
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 . For 92 developing countries in the study, 23 countries are landlocked, which include 13 African countries

tackle the costs of being landlocked, it is more important for African landlocked countries to develop their infrastructure e.g., transport infrastructure. In Arvis et al. (2010), landlocked countries face much higher transport costs and transit times than coastal countries.

C.3 *Determinants in landlocked developing countries relative to coastal developing countries*

To model the specific effects for landlocked developing countries in relation to coastal developing countries, I interact the variables of interest with a binary variable equal to one if a landlocked country and zero if a coastal country. Table C.3 report the findings.

Firstly, the results in Table C.3 confirm the positive effects of financial development, infrastructure investment, and FDI inflows in landlocked developing countries. Secondly, the findings reveal that there are differential effects of infrastructure, and FDI inflows in landlocked developing countries relative to coastal developing countries. In landlocked countries, the positive effects are larger.

Table C.3: Determinants of capital goods imports in landlocked developing countries relative to coastal developing countries

	Dependent Variable: ln(Capital imports)$_t$				
	(1)	(2)	(3)	(4)	(5)
ln(Financial development)$_{t-1}$	0.086***	0.098***	0.085***	0.102***	0.098***
	(0.024)	(0.021)	(0.022)	(0.021)	(0.021)
ln(Infrastructure investment)$_{t-1}$	0.287***	0.253***	0.280***	0.288***	0.286***
	(0.042)	(0.045)	(0.042)	(0.042)	(0.041)
Human capital$_{t-1}$	0.050	0.068	0.022	0.061	0.065
	(0.079)	(0.077)	(0.079)	(0.081)	(0.079)
Institutions$_{t-1}$	0.005*	0.005	0.005	0.004	0.005
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Total factor productivity$_{t-1}$	0.069	0.048	0.064	0.073	0.066
	(0.064)	(0.066)	(0.064)	(0.064)	(0.065)
ln(GDP)$_{t-1}$	0.304***	0.318***	0.338***	0.303***	0.307***
	(0.055)	(0.054)	(0.056)	(0.055)	(0.055)
ln(FDI inflows)$_{t-1}$	0.044***	0.044***	0.044***	0.045***	0.037***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)
GATT/WTO membership$_t$	0.122***	0.121***	0.116***	0.125***	0.122***
	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)
RTAs$_t$	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Financial development)$_{t-1} * I^{Landlocked}$	0.064				
	(0.041)				
ln(Infrastructure investment)$_{t-1} * I^{Landlocked}$		0.096***			
		(0.031)			
Human capital$_{t-1} * I^{Landlocked}$			0.459***		
			(0.131)		
Institutions$_{t-1} * I^{Landlocked}$				0.004	
				(0.006)	
ln(FDI inflows)$_{t-1} * I^{Landlocked}$					0.027*
					(0.015)
Observations	1,821	1,821	1,821	1,821	1,821
R-squared	0.973	0.973	0.973	0.973	0.973
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only developing countries.

C.4 *Determinants in landlocked African countries relative to coastal African countries*

To model the specific effects for landlocked African countries in relation to coastal Africa countries, I reduce the sample to include only the 40 African countries in the study. Similarly to the above section, I interact the variables of interest with a binary variable equal to one if a landlocked African country and zero if a coastal African country. Table C.4 report the findings.

The results confirm the positive effects of financial development and infrastructure investment in landlocked African countries. Moreover, the findings reveal that infrastructure has a larger positive effect in landlocked African countries relative to coastal African countries. For financial development, there is no differential effect between landlocked and coastal African

Table C.4: Determinants of capital goods imports in landlocked African countries relative to coastal African countries

	Dependent Variable: ln(Capital imports)$_t$				
	(1)	(2)	(3)	(4)	(5)
ln(Financial development)$_{t-1}$	0.070*	0.096***	0.081**	0.092***	0.088***
	(0.037)	(0.033)	(0.033)	(0.033)	(0.033)
ln(Infrastructure investment)$_{t-1}$	0.211***	0.173***	0.207***	0.209***	0.209***
	(0.050)	(0.054)	(0.050)	(0.049)	(0.049)
Human capital$_{t-1}$	-0.300**	-0.252*	-0.298**	-0.371**	-0.284**
	(0.132)	(0.129)	(0.128)	(0.149)	(0.132)
Institutions$_{t-1}$	0.001	0.002	0.002	0.004	0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Total factor productivity$_{t-1}$	-0.007	-0.027	-0.025	0.001	-0.016
	(0.092)	(0.092)	(0.092)	(0.092)	(0.092)
ln(GDP)$_{t-1}$	0.310***	0.316***	0.334***	0.287***	0.307***
	(0.067)	(0.066)	(0.069)	(0.069)	(0.067)
ln(FDI inflows)$_{t-1}$	0.035***	0.035***	0.036***	0.033***	0.032***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.012)
GATT/WTO membership$_t$	0.236***	0.227***	0.237***	0.230***	0.233***
	(0.055)	(0.054)	(0.055)	(0.053)	(0.055)
RTAs$_t$	0.002	0.002	0.002*	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Financial development)$_{t-1} * I^{Landlocked}$	0.065				
	(0.080)				
ln(Infrastructure investment)$_{t-1} * I^{Landlocked}$		0.096*			
		(0.053)			
Human capital$_{t-1} * I^{Landlocked}$			0.308		
			(0.275)		
Institutions$_{t-1} * I^{Landlocked}$				-0.011	
				(0.008)	
ln(FDI inflows)$_{t-1} * I^{Landlocked}$					0.010
					(0.018)
Observations	729	729	729	729	729
R-squared	0.968	0.968	0.968	0.968	0.968
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. *Note*: The sample size was reduced to account for only African countries. For the 40 African countries in the study, 13 countries are landlocked countries

countries.

CHAPTER 5

CONCLUDING REMARKS

Recent international trade literature argues that not all trade matters for productivity and economic growth. Trade in technology intensive goods (i.e., capital goods) is considered to have the most beneficial effects on economic growth and development. Countries that produce and export capital goods tend to have stable growth and they develop faster than those that specialise in producing and exporting primary goods. Whilst countries that are far removed from the world technology frontier benefit from importing capital goods. Capital goods (i.e., industrial machinery and equipment) are embodied with technologies that enhance firm productivity growth and innovation, to the extent that can enable the importer to export similar goods.

In Africa, trade has been analysed at the aggregate level and export-led growth dominates the literature. The role played by imports is almost completely forgotten, despite the continent being far removed from the world technology frontier. Imports of capital goods may be of major importance to most African countries whose manufacturing firms are at the early stages of development. In this thesis, I attempted to establish how Africa's trade composition (both exports and imports), with the primary purpose of assessing how its export and import compositions are structured - what type of goods does Africa export and import, and how have the structures changed over time. Secondly, I investigate the effects of capital goods imports on technological export composition (low, medium, and high technology manufactured goods) in developing

countries, particularly in Africa. Lastly, I examine the drives of capital goods imports, as these determinants may provide the channels that can complement the positive effects of capital goods imports and assist Africa to transform its export composition to more technology intensive goods.

In Chapter 2, I analysed how Africa's export and import compositions are structured and changed over time, using a dataset of 54 African countries over the period 1980-2015. I decompose Africa's trade data into five categories; primary goods, resource-based manufactured goods, low technology, medium technology, and high technology manufactured goods. I find that Africa's import composition is concentrated in capital goods (medium and high technology manufactured goods), mostly from China. Its export composition is highly concentrated in primary goods (destined mostly to China and the United States), accounting for over 60% of its total exports on average. This might explain the continent's trade underperformance which is highly documented in the literature, as this has contributed to the decline of its share of global exports. This pattern of trade impedes the continent's sustainable economic growth as this can only support limited growth. Countries that specialise in the production and export of primary goods are less integrated into the world. They are limited to downstream production, down the global value chains. The continent's manufactured exports are low and concentrated in resource-based manufactured goods, which are also characterised by very volatile prices.

I also find that regions within Africa have similar technological trade composition structures. Southern Africa region dominates the continent manufacturing exports, with about 50% of Africa's total manufactured exports, and its role has been increasing over time. I observe that a few notable countries such as South Africa, Morocco, Egypt, and Tunisia that have incorporated some low and relatively technology intensive goods into their export composition are also the leading importers of capital goods. They account for the bulk of Africa's manufactured exports. They are better financially developed, better endowed with human capital, infrastructure, and institutions than other African countries.

In Chapter 3, based on the finding in Chapter 2, I investigate if capital goods imports are contributing to the diversification of the continent's export composition, as evidenced in the literature for countries that have managed to diversify their export compositions. I find that capital goods imports have positive effects on technological export composition (low, medium, and high

technology exports) in developing countries. I observed heterogeneous effects of capital goods imports on the technological export composition in developing countries relative to developed countries. In developing countries, the positive effects of capital goods imports are larger. In Africa, capital goods imports also have a positive effect on the technological export composition. However, the positive effect of capital goods imports is smaller in high technology exports relative to other developing countries and larger in low and medium technology exports.

Potential reasons for Africa not benefiting much in high technology exports compared to other developing countries are first, the bulk of Africa's capital goods imports is from other developing countries (i.e., China) which the literature considered to be of lower quality than from developed countries, and they are highly concentrated in medium technology goods. Second, Africa is characterised by poor levels of human capital, infrastructure, financial markets, and institutions, as evidenced in the literature document that higher levels of factor endowments and technical competence are required for the adoption of capital goods imports. Thus, the success of capital goods imports is not just a matter of importing them but often depends on the compatibility of factor proportions required to adapt and modify them before they can function effectively in the source country.

Since capital goods imports are important in diversifying developing countries' export composition, Chapter 4 investigates the determinants of capital goods imports in developing countries, with a special focus on Africa. The findings indicate that financial development, infrastructure investment, and institutions are important determinants of capital goods imports in developing countries, with financial development having a larger positive effect relative to developed economies. In Africa, financial development and infrastructure investment are key determinants of capital goods imports, with infrastructure investment being critical in landlocked countries.

Given the thesis findings, African countries have greater opportunities to develop their domestic manufacturing firms through capital goods imports, thereby diversifying their export composition into more low-medium and relatively high technology manufactured exports. However, this might involve a broad and integrated set of policy interventions. African governments should play major roles through gazetting policies that encourage and support the importa-

tion of capital goods, the development of financial markets, and domestic manufacturing firms. African governments should invest in public infrastructure and institutions such as creditor and intellectual property rights.

The overall findings in this thesis highlight the importance of capital goods imports in achieving export composition diversification, and hence stable economic growth. Furthermore, the findings reveal the importance of development factors that can complement capital goods imports, which can result in increased export composition diversification and economic growth. The findings may assist policymakers to (1) examine national trade structures, specifically to see how faster they have transformed over time; (2) understand the source of Africa's underperforming trade, which is highly documented in the literature; (3) have a good understanding of the linkages between capital goods imports, technological export composition, and the rest of the economy; and (4) attain the best trade and industrial policies for their economies.

As part of future research, I intend to examine the channels or mechanisms through which capital goods imports promote productivity in developing countries. I expect that human capital, financial development, and institutions to play major roles. Factor endowment should not discourage African countries from only exporting primary and resource-based goods. I also intend to investigate whether the source country/region of capital goods imports matter for export and economic growth.

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