ZENTRUM FÜR
ENTWICKLUNGSFORSCHUNG (ZEF)

Economic Integration and Development in Africa

A Multifaceted Examination of Trade, Infrastructure, and Resilience

---

DISSERTATION

zur Erlangung des Grades

Doktor der Agrarwissenschaften (Dr. agr.)

der

Agrar-, Ernährungs- und Ingenieurwissenschaftlichen Fakultät

der Rheinischen Friedrich-Wilhelms-Universität Bonn

von

Mengistu Alamneh Wassie

aus

Debre Markos, Äthiopien

Bonn 2025

Referent: Prof. Dr. Joachim von Braun

1. Korreferent: Prof. Dr. Thomas Heckelei

2. Korreferent: Prof. Dr. Jan Börner

Tag der Promotion: September 30, 2025

Erscheinungsjahr: 2025

Angefertigt mit Genehmigung der Agrar-, Ernährungs- und Ingenieurwissenschaftlichen Fakultät der Universität Bonn

Abstract

Africa's path toward economic integration and development is a long-term endeavour fraught with challenges but brims with potential. This dissertation examines the role of trade facilitation measures and trade liberalization, specifically the African Continental Free Trade Agreement (AfCFTA), in driving economic growth, trade, and food security and its potential to promote resilient and inclusive development, particularly in combating climate change. The first analytical chapter presents a review of studies on the potential economic, trade, and welfare impacts of the AfCFTA. This study included peer-reviewed published articles and unpublished reports, comparing the results and methodologies. In addition to the methodological differences that span from gravity and partial equilibrium, as well as general equilibrium models for different countries, regions, and global levels, most studies applied their own contextualized liberalization schedules and mechanisms of implementation. Findings of the reviewed studies indicate that implementing AfCFTA significantly enhances the trade of the continent, gross domestic product (GDP), and welfare, but only if supplemented with reduction of nontariff barriers and trade facilitation implementation.

The second chapter explores the effects of trade facilitation measures on inter- and intra-African trade and presents a calculation of the ad valorem tariff equivalent (AVE) costs. This study reevaluated the impacts of trade facilitation in Africa by utilizing data from the World Bank on the time required for trade, specifically the number of days to export and import. In the structural gravity model, the ad valorem tariff equivalent costs were calculated, which are crucial to assess the general equilibrium effects of trade facilitation. A 1-day delay in trade has a tariff equivalent to 0.9%. Findings indicate that the time required for trade has a more significant influence on intra-African trade than inter-African trade, with a more substantial effect observed in imports than exports. Moreover, counterfactual simulations indicate that halving the number of days to trade of each country could increase African imports and exports by 30.2% and 12.7% on average, respectively.

The third chapter presents an analysis of the impact of climate change on the Ethiopian economy using a recursive dynamic computable general equilibrium (CGE) model. By utilizing data from Waldhoff et al. (2020) projection of temperature and rainfall shocks of crops, the study analyzes these shocks under two emission scenarios: representative concentration pathways (RCP) 4.5 and 8.5, with estimates and projections made at the national and product levels. Findings indicate that climate change will significantly harm the GDP, trade, and food security of the country, with effects rippling beyond the agricultural sector into the broader economy. Meanwhile, the urban and rural poor are projected to suffer the most drastic reductions in income and consumption owing to these shocks. Moreover, the spillover effects from agriculture to other industries reduce domestic demand and production, and some increases in manufacturing and service exports occurred. These dynamics ultimately adversely affect the food security of the country.

The fourth chapter presents an analysis of the implications of Ethiopia's participation in the AfCFTA amid climate change. The challenges posed by climate change to the agricultural sector will notably reduce staple crop output and agricultural GDP in the future; the AfCFTA could enhance production, trade, and employment by enhancing the competitiveness of the country. The gradual elimination of import tariffs and reduction of transaction costs owing to the AfCFTA could significantly boost Ethiopia's trade, especially in mining, processed foods, textiles, and financial services. Although these trade liberalization efforts encourage growth in imports and exports, they may not fully counterbalance the severe impacts of climate change. Moreover, the government may face moderate losses in tariff revenues, estimated at 11.5% of total tariff revenue, potentially straining its budget. Therefore, the Ethiopian government should leverage the economic advantages of the AfCFTA to dampen the adverse effects of climate change, such as production, trade and food security and strengthen its regional economic power.

Zusammenfassung

Der Weg Afrikas hin zu wirtschaftlicher Integration und Entwicklung ist ein langfristiges Unterfangen, das mit Herausforderungen verbunden ist, aber auch viel Potenzial birgt. In dieser Dissertation wurde die Rolle von Maßnahmen zur Handelserleichterung und Handelsliberalisierung, insbesondere des Abkommens über die Afrikanische Kontinentale Freihandelszone (AfCFTA), bei der Förderung des Wirtschaftswachstums, des Handels und der Nahrungsmittelsicherheit sowie deren Potenzial zur Förderung einer widerstandsfähigen und integrativen Entwicklung, insbesondere bei der Bekämpfung des Klimawandels, untersucht.

Das erste analytische Kapitel enthält einen Überblick über Studien zu den potenziellen Auswirkungen des AfCFTA auf Wirtschaft, Handel und Wohlstand. Diese Studie umfasst von Experten begutachtete veröffentlichte Artikel und unveröffentlichte Berichte und vergleicht die Ergebnisse und Methoden. Zusätzlich zu den methodischen Unterschieden, die von Gravitations- und partiellen Gleichgewichtsmodellen bis hin zu allgemeinen Gleichgewichtsmodellen für verschiedene Länder, Regionen und globale Ebenen reichen, wendeten die meisten Studien ihre eigenen kontextualisierten Liberalisierungszeitpläne und Umsetzungsmechanismen an. Die Ergebnisse der untersuchten Studien deuten darauf hin, dass die Umsetzung des AfCFTA den Handel des Kontinents, das Bruttoinlandsprodukt (BIP) und den Wohlstand erheblich steigert, allerdings nur, wenn sie durch die Verringerung nichttarifärer Barrieren und die Umsetzung von Handelserleichterungen ergänzt wird.

Im zweiten Kapitel werden die Auswirkungen von Handelserleichterungsmaßnahmen auf den zwischen- und innerafrikanischen Handel untersucht und eine Berechnung der Wertzolläquivalentkosten (AVE) vorgelegt. In dieser Studie wurden die Auswirkungen von Handelserleichterungen in Afrika neu bewertet, indem Daten der Weltbank über die für den Handel benötigte Zeit verwendet wurden, insbesondere die Anzahl der Tage für die Ausfuhr und Einfuhr. Im Rahmen des strukturellen Gravitationsmodells wurden die AVE berechnet. Eine Verzögerung des Handels um 1 Tag hat ein Zolläquivalent von 0,9 %. Die Ergebnisse deuten darauf hin, dass die für den Handel benötigte Zeit einen größeren Einfluss auf den innerafrikanischen Handel als auf den zwischenafrikanischen Handel hat, wobei die Auswirkungen bei den Einfuhren stärker sind als bei den Ausfuhren. Partielle kontrafaktische Simulationen deuten darauf hin, dass eine Halbierung der Anzahl der Tage für den Handel die afrikanischen Einfuhren und Ausfuhren im Durchschnitt um 30,2 % bzw. 12,7 % erhöhen könnte.

Das dritte Kapitel enthält eine Analyse der Auswirkungen des Klimawandels auf die Wirtschaft Äthiopiens unter Verwendung eines rekursiven dynamischen berechenbaren allgemeinen Gleichgewichtsmodells (CGE). Unter Verwendung von Daten aus der Projektion von Waldhoff et al. (2020) zu Temperatur- und Niederschlagsschocks bei Nutzpflanzen analysiert die Studie diese Schocks unter zwei Emissionsszenarien: RCP4.5 und RCP8.5. Die Ergebnisse zeigen erhebliche negative Effekte auf BIP, Handel und Ernährungssicherheit, wobei die armen städtischen und ländlichen Bevölkerungsschichten am stärksten betroffen sind.

Das vierte Kapitel analysiert die Bedeutung der Teilnahme Äthiopiens am AfCFTA im Kontext des Klimawandels. Während Handelsliberalisierung Chancen für Produktion, Handel und Beschäftigung eröffnet, reichen diese Maßnahmen allein möglicherweise nicht aus, um die schweren Auswirkungen des Klimawandels vollständig zu kompensieren. Daher sollte die äthiopische Regierung die wirtschaftlichen Vorteile des AfCFTA nutzen, um die negativen Auswirkungen des Klimawandels abzumildern und die regionale Wirtschaftskraft des Landes zu stärken.

Acknowledgements

First and foremost, I would like to express my deep gratitude to my supervisor, Prof. Dr. Joachim von Braun, for accepting me as a doctoral student and for his friendly support during my entire doctoral studies, giving insightful, provocative comments and suggestions. I thank Dr. Lukas Kornher for agreeing to be my tutor. This dissertation would not have been possible without your constructive and invaluable support, thank you very much. I also thank Prof. Dr. Thomas Heckelei and Prof. Dr. Jan Börner for being accepted to be members of my defense committee. I also express my profound appreciation for the Volatility project for funding my entire doctoral study through scholarship and research funding.

This work has also been made possible thanks to the stay I enjoyed at the International Food Policy Research Institute, especially Dr. Alemayehu Seyoum Taffesse and other staff during my fieldwork—special thanks to Ermias Engida for the superb training in CGE modeling. I also thank the UN Food and Agriculture Organization, especially Dr. Davide Laborde and Dr. Maximo Torero, for hosting me and giving me an excellent training course on CGE modeling. I would also like to thank all the policymakers I interviewed in Ethiopia. An eye-opening experience and long to list all to thank you, but my special thanks to all.

I extend to all other senior researchers at ZEF, whose immense contribution has shaped my dissertation. I am grateful for the friendships and mutual support from all junior researchers at ZEF, in particular, not only my BIGS-DR batch 2021 and all the ZEF staff, Dr. Silke Tönsjost, Maximilian Voit, Ms. Alison Beck, Wolfgang Bröhl, and Anja Köhler. I would also like to extend my appreciation to a number of friends outside the ZEF community whose support and presence in my life played an important role during my PhD time. I thank all workshop and conference participants who commented and helped me improve the quality of my work through presentations. I extend the same acknowledgment to all journal editors and reviewers who revised my submitted manuscripts. I am also specifically thankful for comments from friends and colleagues, as well as discussions about my chapters and the dissertation.

Lastly, I would like to thank all my friends and family for their care and unconditional support.

Contents

List of Figures

List of Tables

List of acronyms

A

AEC African Economic Community, 18
AfCFTA Africa Continental Free Trade Agreement, iii
AGOA Africa Growth Opportunity Act, 25
AMU/UMA Arab Maghreb Union, 19
AU African Union, 3
AVE Ad Valorem tariff Equivalents, iii

C

cbam Carbon Border Adjustment Mechanism, 112
CEN-SAD Community of Sahel-Saharan States, 19
CEPII Centre d'Études Prospectives et d'Information s Internationales, 29
CES/CET Constant Elasticity of Substitution/Transformation, 89
CGE Computable General Equilibrium model, iii
COMESA Common Market for Eastern and Southern Africa, 9
CPI Consumer Price Index, 96
CV Compensating Variation, 92

D

DC Developed Countries, 1

E

EAC East African Community, 17
ECA Economic Commission for Africa, 9
ECCAS Economic Community of Central African States, 17
ECOWAS Economic Community of West African States, 19
EPA Economic Partnership Agreement, 4
EV Equivalent Variation, 98
ETI Enabling Trade Index, 49
EU European Union, 4

F

FE **fixed** effects, 56
FDI Foreign Direct Investment, 42
FTA Free Trade agreements, 52

G

GDP Gross Domestic Product, iii
GTAP Global Trade Analysis Project, 26
GTP I&II Growth and Transformation Plan I &II, 79
GVC Global Value Chain, 135

H

HGR Home Grown Economic Reform, 81
HS Harmonized System, 35

I

ICBT Informal Cross-Border Trade, 43
IFPRI International Food Policy Research Institute, 89
IGAD Intergovernmental Authority on Development, 17
IMF International Monetary Fund, 32
ISIC International Standard Industrial Classification of All Economic Activities, 95

L

LDC Least Developed Countries, 1
LPI Logistics Performance Index, 49

M

MAGNET Modular Applied GeNeral Equilibrium Tool, 26
MIRAGE Modeling International Relation in Applied G eneral Equilibrium, 26

N

NAFTA North American Free Trade Agreement, 26
NTB Nontariff Barriers, 6

O

OAU Organisation of African Unity, 19
OECD Organization for Economic Cooperation and Development

P

PPI Producer Price Index, 94
PPML Poisson Pseudo Maximum Likelihood, 52
PTA Preferential Trade Agreements, 42

R

RCP4.5 & RCP8.5 Representative Concentration Pathways, iii
RoA Rest of Africa, 119
RTA Regional Trade Agreements, 18
RoW Rest of the World, 119
R & D Research and Development, 1
RECs Regional Economic Communities, 3

S

SSA Sub-Saharan Africa, 51
SADC Southern African Development Community, 9
SAM Social Accounting Matrix, 8
SPS Sanitary and Phyto-Sanitary, 48

T

TC Trade Cost, 64
TF Trade Facilitation, 48
TFP Total factor productivity, 1

U

USA United States of America, 2
USD United States Dollar
UNCTAD United Nation Conference on Trade and Development, 3

W

WTO World Trade Organization, 1

Chapter 1

Introduction

1.1 Background and motivation

The increase in international trade has positively impacted the global economy and has been associated with a notable decline in poverty levels in various regions and globally (Dollar et al., 2004; Engel et al., 2021). The magnitude of the impact of trade liberalization on growth and development in least-developed countries (LDCs) is still debated because it affects the economy in a significantly complex way and involves different environmental, geopolitical, and resilience issues (Kindo et al., 2024; Mealy et al., 2022; Winters et al., 2014; Bartholomae et al., 2023; WTO, 2023). Although trade policies in Africa operate similarly to those in other regions (Rodrik, 1998), the structure and manner of trade integration are crucial to the overall development of the continent. South-South and North-South integration often results in different outcomes. Typically, South-South integration has a significant impact on total factor productivity (TFP) in low-tech industries. Still, it is criticized for being less effective in helping the LDCs catch up economically with the developed countries (DCs). By contrast, North-South integration typically leads to more significant spillover effects from research and development (R&D) in knowledge-intensive sectors, which can enhance productivity and innovation to a greater extent than TFP improvements alone. Although setting priorities is crucial for policymaking, North-South integration can facilitate technology transfer and productivity growth more effectively. By contrast, South-South integration may boost mutual trade to a greater degree. Ultimately, economic and political integration within the South can drive growth; however, each type of integration has distinct advantages (Behar et al., 2013).

Economic integration has long been recognized as a pivotal strategy for fostering sustainable development, particularly in regions characterized by fragmented markets and underdeveloped infrastructure. In Africa, where diverse economies coexist with varying levels of industrialization and resource endowments, pursuing economic integration presents unprecedented opportunities and formidable challenges.

This dissertation, titled Economic Integration and Development in Africa: A Multi-faceted Examination of Trade, Infrastructure, and Resilience, seeks to explore the intricate dynamics of economic integration of the AfCFTA on the continent, with a particular focus on its implications for trade, growth, food security, and resilience in the face of global and regional shocks. Specifically, this study examines the impacts of tariff liberalization[1] and structural constraints of trade facilitation on African trade. Furthermore, it focuses on trade facilitation as a critical driver to enhance trade performance across the continent. By incorporating these factors into a general equilibrium analysis, this dissertation further explores the specific impacts of the AfCFTA within the context of the climate-vulnerable Ethiopian economy, offering insights into how trade integration can mitigate the challenges posed by climate change while fostering sustainable growth. This approach offers a nuanced examination of how trade policies and structural reforms can enhance African resilience and development. By addressing these questions, the dissertation aims to contribute to the growing body of literature on African economic development and provide policymakers, development practitioners, and stakeholders with actionable insights based on empirical results.

The African continent, home to 54 nations and over 1.3 billion people, is at a critical juncture in its developmental trajectory. Despite being endowed with abundant natural resources and a youthful, rapidly growing population, Africa remains the least integrated region in the global economy. Intra-African trade accounts for a mere 15% of total trade[2] , significantly lower than intra-regional trade in Europe (69%) and Asia (59%). This low level of economic integration has been attributed to a myriad of factors, including inadequate infrastructure, restrictive trade policies, and institutional weaknesses. However, recent initiatives of the AfCFTA, launched in 2021, have reignited hopes for a more integrated and prosperous Africa. The AfCFTA aims to boost intra-African trade, stimulate industrialization, and enhance the continent's global competitiveness by creating a single market for goods and services.

It is projected to lift over 30 million people out of extreme poverty and about 68 million from moderate poverty by 2035 (World Bank, 2020a). The limited complementarity of African trade, characterized by a large share and persistence of agricultural imports of food products from the rest of the world, and predominantly unprocessed non-food product exports, suggests a low probability of gaining from intra-African trade (Bouët et al., 2020; UNCTAD, 2021b. In addition, the share of African trade in global trade has declined steadily over the past 50 years (UNCTAD, 2021b). Conversely, intra-African trade needs correction in reports and analyses, as it has been growing, whereas others have been declining. This highlights the need

[1] Tariff liberalization among African countries under the AfCFTA liberalization schedules, as briefly discussed in Chapter 2 of this dissertation.

[2] It is still debated that the share of intra-Africa trade needs re-interpreting, as informal trade accounts for a significant share, and structural factors are important. This is discussed in Chapter 2.

to consider structural economic differences with other regions and the significant informal cross-border trade(Mold, 2022).

While the potential benefits of economic integration are widely acknowledged, the path to achieving it is fraught with complexities (Karakoc et al., 2021). African regional economic communities (RECs) have been criticized for their limited commitment and for failing to reach their full potential. Infrastructure deficits, for instance, remain a significant barrier to trade and economic connectivity. Poor road networks, inefficient ports, and unreliable energy supplies hinder the movement of goods and services across borders, thereby limiting the gains from integration. Moreover, the continent's vulnerability to external shocks, such as fluctuating commodity prices, climate change, and global pandemics, underscores the need for resilience-building measures that can safeguard developmental gains. This dissertation posits that economic integration should be pursued in tandem with investments in infrastructure and resilience to ensure sustainable and inclusive development.

Although integration can mitigate the impacts of food production shocks caused by climate disruptions, conflicts, or trade disputes by allowing adjustments in supply chains, heavy dependence on external trade partners can increase vulnerability during crises. However, heavy reliance on others in a network can create vulnerabilities during crises. Nevertheless, a substantial integration enhances global production and value chains while reducing price fluctuations (Gereffi et al., 2011). Simultaneously, technological advances and a dramatic decline in transportation costs have contributed to intensified trade and global value chains (Togan, 2016; Rodrik, 2018; Hummels, 1999 Hummels, 2007; Glaeser et al., 2004). Therefore, the growth of trade and value-added trade benefits the population involved in the chain. Global real agricultural value added alone grew 89% between 2000 and 2022, whereas labor employed in the sector has declined from 40% to 26% by the same period; meanwhile, the share of GDP is maintained at around 4% (Food and Agriculture Organization, 2024).

Trade liberalization sometimes results in harmful production, employment, and environmental outcomes in the LDCs (Frankel et al., 2017; Santos, 2012; Herz et al., 2011; Krugman, 1995; Krugman, 2008). Not all sectors and individuals are equally affected. A complete liberalization of agriculture could increase dependence on food imports and intensify poverty in most places (Warr, 2014). Thus, trade liberalization could affect resource-rich or resource-poor countries differently, with varying impacts on coastal or landlocked regions. However, skepticism about trade, in general, persists till today (Nicita et al., 2014; Arkolakis et al., 2012; Martin et al., 2007; De Melo et al., 2021) and even more so recently, given the disrupted value chains by COVID-19-related policies and raw material dependencies, such as food and fertilizer trade disruptions (Balistreri et al., 2022; Kappel, 2021).

Between 1995 and 2019, global trade networks in product variety and partnerships expanded significantly. This growth in the number of products traded—referred to as the extensive trade margin—plays a crucial role in bolstering the resilience of individual countries (Jafari et al., 2024). Over the past few decades, African trade has undergone a significant and dramatic shift in terms of trade partners and products. For instance,[3] the share of African trade with the European Union (EU) and the United States has declined. In contrast, trade with emerging markets such as India, Brazil, and Russia has increased. Africa has also shown significant real value-added growth. Despite its small size, it has the highest rate at 164% (Organization for Economic Cooperation and Development, OECD et al., 2013). Although African trade with Europe and the United States declined from 47% to 33% and 17% to 10% from 2000 to 2011, emerging markets such as India, Brazil, and Russia have increased from 2.8%, 2%, and 0.2% to 6%, 3%, and 0.3% by the same period, respectively (Organization for Economic Cooperation and Development, OECD et al., 2013). However, manufacturing exports significantly declined from 44% of the total in 2000 to 39% in 2011 to the EU and from 25% in 2000 to 9% in 2011 to the United States. Another essential feature is the resource boom, primarily driven by the oil export boom and the rise in manufacturing exports to emerging countries.

Despite this potential, intra-African trade remains at a relatively low volume and level of diversification compared to other regions. African trade accounted for only 2.8% of the global trade and 14.4% of intraregional trade in 2019 (Africa Agriculture Trade Monitor, 2021; UNCTAD, 2021a). This low share can be attributed to measurement problems, such as informal trade and unrecorded and unweighted trades (De Melo et al., 2021; Bouët et al., 2022; Bouët, 2008). Structural challenges, including insufficient infrastructure, high transaction costs, weak institutions, and nontariff barriers (NTBs), hinder trade growth within and outside the continent (Kornher et al., 2020; Kareem, 2019). Furthermore, Africa's trade relationship with external partners, particularly the EU, has been criticized for perpetuating colonial legacies and undermining regional integration (Lopes, 2024; Ochieng et al., 2004). For instance, the EU's Economic Partnership Agreements have been viewed as instruments of neocolonial influence that limit Africa's ability to exploit its trade potential. African countries must prioritize harnessing the continent's potential rather than engaging in a tit-for-tat trade with other regions. The EU's divide-and-rule strategy is reflected in the Economic Partnership Agreements established in 2007 (Lopes, 2024). Although the EU promotes certain benefits, such as enhanced investment and technology transfer, others argue that these trade relations have hindered regional integration and reinforced colonial legacies.

This dissertation underscores the trans-formative potential of economic integration

[3] In a recent study, de Melo and Sollender (2025) criticized African Regional Economic Communities (RECs) and other regional trade agreements across the continent for failing to launch intra-African trade and suggested that low tariff rates and FDI have a positive association with regional supply chain.

in Africa while highlighting the need for a holistic approach that addresses trade, infrastructure, and resilience. As the continent strives to overcome its developmental challenges and harness its vast potential, a deeper understanding of these interconnected issues is essential. Through a comprehensive analysis of trade facilitation and modeling a case study of Ethiopia, this study seeks to illuminate the pathways toward a more integrated, resilient, and prosperous Africa.

1.2 Study Justification and Problem Statement

The ongoing debate regarding the role of trade in economic development, poverty reduction, and food security remains highly relevant today. Between 1950 and 2022, global trade increased by a staggering 400 times (WTO, 2024). However, the precise impact of trade on food security and poverty alleviation is complex and multifaceted. Therefore, understanding global trade in relation to its interrelated dynamics, such as trade flows, world prices, wages, and employment, is crucial (Krugman, 1995). Despite this growth, Africa's share and contribution to global trade are smaller than those of other regions. This disparity can be attributed to several challenges, such as high trade restrictions, inadequate infrastructure, bureaucratic hurdles, and macroeconomic and political instability. Notably, nontariff measures have more significant effects on trade than tariffs (Zaki, 2015). The AfCFTA is projected to enhance intra-African trade, investment, and inclusive growth by addressing these longstanding obstacles (World Bank, 2020b; Abrego et al., 2019). The successful implementation of this agreement relies on various factors essential for boosting trade, fostering growth, and reducing poverty across the continent. Therefore, this study analyzed and evaluated the impacts of trade facilitation measures in Africa and their implications for effectively executing the AfCFTA. Moreover, the ongoing continental and global climate crises have impeded trade and slowed the progress in poverty reduction.

The complexities inherent in estimating and projecting the impacts of trade and trade integrations, such as the AfCFTA, significantly emerge from the methodological differences across various analytical frameworks. In Chapter 2, I examined these differences by reviewing empirical estimation methods and partial and general equilibrium simulation models, with a particular focus on the gravity model as a predominant tool in the empirical historical analysis of trade-related issues.

Noteworthy is the application of the CGE models, which facilitate the simulation of potential impacts stemming from various policy shocks. A comparative review of trade models specifically regarding AfCFTA impact projections indicates that the estimated effects are heterogeneous among sectors, countries, and households. This

variability can be attributed to several factors, such as the specificity of scenario development[4], the quality and availability of data, the breadth of regional coverage, and various other methodological aspects identified in this study. Analyzing these models not only contributes to a more precise and comprehensive understanding of the implications of AfCFTA but also underscores the necessity for a more systematic approach to generalize the findings across studies. Therefore, this section is driven by the imperative to effectively interpret the implications of these findings concerning AfCFTA and relate them to other scholarly works, acknowledging the diverse methodologies employed. In addition, recognizing that quantitative models may not fully capture the specific challenges and opportunities associated with the AfCFTA is crucial. This necessitates a qualitative analysis to address these significant segments of policy implications. By incorporating qualitative insights alongside quantitative findings, a more nuanced understanding of the AfCFTA can be developed, ultimately informing policymakers more comprehensively about the potential and broader socioeconomic impacts.

In recent years, NTBs have been identified as the predominant trade costs globally, particularly because traditional tariff rates have reached historic lows. This shift has been significantly influenced by a range of factors, such as the proliferation of bilateral and multilateral trade agreements, which have facilitated more open trade environments while leaving behind the complexities associated with NTBs (Nicita, 2018). In an African context, these barriers present an even more pronounced challenge as the continent grapples with substantial structural and institutional deficits that impede trade and economic development compared with its peers in other regions of the world. Addressing the issue of NTBs and improving trade facilitation can significantly bolster trade flows within Africa and between the continent and the global market. Effectively reducing these barriers is not merely an academic exercise; it has real implications for enhancing economic growth, increasing market access, and fostering regional integration. However, one of the significant hurdles in conducting comprehensive analyses in this area stems from data inadequacies, which have historically limited the scope of empirical research focused on Africa.

Structural gravity models that encompass a broader range of countries, focusing on global trade and intra-African trade dynamics, are employed to address this challenge in Chapter 3. This methodological approach allows us to meticulously estimate the impact of trade facilitation costs, quantifying these effects in terms of AVEs—a metric that represents the tariff equivalent of various trade facilitation measures. AVEs are crucial because they provide a common unit of measurement that can be integrated into general equilibrium models, allowing for the simulation of the effects of policy changes on economies. The significance of the computed AVEs lies in their applicability; they are essential inputs for general equilibrium CGE models,

[4]Tariff with or without NTBs and partial vs. General equilibrium analysis. These and others are discussed in chapter 2.

which are particularly prevalent in trade policy assessments. However, note that such better data, especially for African contexts, are not readily available. Consequently, the availability of these AVEs from my study aims to fill a critical gap in the existing literature, providing a valuable resource for researchers and policymakers who seek to analyze the potential impacts of trade facilitation across different African regions and countries. Estimating these AVEs is another academic endeavor and a vital contribution to the ongoing discussions on trade policy in Africa. By facilitating future studies that utilize general equilibrium approaches at country and regional levels, these findings can help shape more effective trade strategies. The insights gained from this research could inform further studies on a more integrated and prosperous African trade landscape, enabling the continent to fully harness its economic potential and compete more effectively in the global marketplace.

African trade is heavily dominated by agricultural products and primary resources and is particularly vulnerable to global price volatility, weather variability, and climate change. Given that exports and imports of agricultural goods represent a significant portion of trade for many African countries, neglecting the impacts of climate change and sustainability in existing studies can obscure the actual effects on economic dynamics. Ethiopia, for instance, has experienced one of the most severe droughts in the past 40 years (World Bank, 2024a). Projections indicate that the adverse impacts of climate change in Ethiopia could escalate from 1% to 1.5% between 2024 and 2030, reaching as high as 5% by 2040. This increase is likely to exacerbate the country's poverty and food security challenges.

Despite numerous studies utilizing CGE models to analyze these impacts (World Bank, 2008 ; World Bank, 2024d; Gebreegziabher et al., 2016; Solomon et al., 2021; Yalew et al., 2017; You et al., 2010) Significant discrepancies in their projections persist. The fourth and fifth chapters of this dissertation aimed to simulate the agricultural productivity shocks induced by climate change in Ethiopia, employing a recursive dynamic CGE model alongside the country's most recent national social accounting matrix (SAM). By utilizing newly estimated climate change-induced agricultural productivity shocks on an annual basis and at the crop level, this study aims to enhance projections that account for the impacts on rural–urban households and the implications across ten income quantiles, all of which are critical for informing policy.

Trade is an essential adaptation mechanism to climate change by facilitating adjustments in the production of vulnerable goods (Brenton et al., 2022; Janssens et al., 2020; Leichenko et al., 2002). Using the dynamic recursive CGE model for Ethiopia, this research assessed the role of trade liberalization, specifically the AfCFTA, in adapting to climate change. However, current trade conflicts, geopolitical tensions, and rising NTBs across various nations may constrain this potential impact. This study aimed to provide insights into the complex interactions between climate change

and trade within the Ethiopian economy by projecting the effects of trade liberalization (AfCFTA tariffs and trade facilitation) in a climate-affected context. It can contribute to the discourse on trade against climate change in two key ways. First, it is a crucial policy resource for countries such as Ethiopia as they navigate their progress toward WTO accession and the implementation of the AfCFTA. Detailed sectoral and general equilibrium analyses will help identify and address the adverse effects of these initiatives and propose compensatory measures for populations and sectors that may be negatively affected. Second, this research employed recent annual crop-level shocks, unlike previous studies that typically incorporated linear aggregate national crop productivity shocks related to climate change. This provides a more nuanced understanding of the worsening impacts of climate change on agricultural productivity in Ethiopia.

1.3 Research Questions and Organization of the Dissertation

The following are the central research questions of this study.

1. **What are the main approaches employed in analyzing trade and trade-related issues at the global and African levels in terms of methodologies and empirical findings?**

Trade is inherently complex and multifaceted, shaped by various factors such as economic structures, political considerations, cultural dynamics, and geographical contexts. Consequently, analyzing trade policies and their economic implications requires various approaches and methodologies to capture these complexities. Therefore, several key methodologies are commonly employed at the global and African levels, such as econometric modeling, CGE models, and case studies of regional trade agreements. The choice of methodology profoundly influences the results and implications of trade analyses. For instance, gravity models may emphasize the benefits of trade agreements, whereas CGE models often highlight the broader distributional impacts of trade liberalization. Empirical findings from African contexts reveal distinct patterns, such as the role of trade facilitation and trade openness in fostering economic growth within regional economic communities such as the East African Community (EAC), Southern African Development Community (SACDC) and common market for east and southern Africa (COMESA). Recent studies have also underscored the importance of nontariff measures, infrastructure development, and digital trade in shaping Africa's trade performance. These varying approaches and results highlight the importance of carefully selecting methodologies that align with specific research questions, ensuring that policy recommendations are contextually relevant and tailored to address the unique trade challenges faced by African

economies.

2. **What are the impacts of trade facilitation measures on intra- and inter-African trade? A structural gravity approach analysis of the effects and computation of ad valorem tariff equivalent costs.**

Quantifying nontariff trade costs is a crucial step in gaining a comprehensive understanding of the potential benefits from trade facilitation, particularly in the context of Africa's global trade dynamics and intra-African trade relationships. These include procedural barriers, logistical inefficiencies, and regulatory divergences that significantly impact Africa's ability to effectively integrate into the global economy and fully realize the potential of its regional trade agreements, such as the AfCFTA. Notwithstanding the intrinsically challenging nature of the task, most studies rely on simple indicators that are not well-grounded in trade theory and offer only vague definitions of the restrictiveness of the trade regime they attempt to measure (Rodríguez & Rodrik, 2000). In fact, with already fragmented markets and infrastructural constraints posing enormous challenges for Africa, the need for precise, theoretically sound measures has become even more vital. Computing AVEs provides a comprehensive way of interpreting these AVEs into something similar to tariffs, while allowing for an analysis of their economic impact that is also intuitive and thus more likely to prompt action. Such a measure enables policymakers to quantify the "hidden" costs associated with trade barriers while assessing the effectiveness of trade facilitation in alleviating these burdens. Most importantly, the AVEs are particularly valuable in intra-African trade analyses because they facilitate the potential for reducing internal trade costs, thereby fostering regional economic integration and enhancing the competitiveness of African economies within global value chains. Therefore, structural gravity models and AVE computation provide a theoretically consistent and policy-relevant framework that is suitable for understanding the trade barriers impeding not only African–global trade but also intra-African trade flows, thereby facilitating more effective trade facilitation strategies.

3. **What are the economic impacts of the climate change-induced agricultural productivity shock in Ethiopia? A recursive dynamic CGE model analysis.**

Over the past 40 years, climate change has had a particularly intense impact, characterized by six consecutive seasons of inadequate or failed rainfall in Ethiopia (World Bank, 2024d). This trend threatens to diminish agricultural productivity in the coming decades, a sector that presently employs nearly two-thirds of the workforce, including its most vulnerable populations (World Bank, 2024d). To assess the overall economic impact of climate change (temperature and rainfall changes) on the Ethiopian economy, a dynamic recursive CGE model was developed. Because the

impact of climate change is nonlinear over time, the developed CGE model enables us to simulate both the direct and indirect effects from an annual-level projection of climate change. An annual product-level productivity impact of climate change, as reported by Waldhoff et al. (2020), shows that the impact is heterogeneous across products and over time. Thus, introducing productivity shocks at the product and annual levels provides a more accurate picture of the impact, as the negative effects of some products decline over time, while others increase. Unlike previous studies that have the same rate of productivity shock over the years, this different rate of shock introduction enables us to capture the dynamics more effectively. Furthermore, this model development serves as the basis for the analysis of climate change versus trade liberalization presented in the next chapter.

4. **How does trade policy impact the Ethiopian economy under climate change, and to what extent can the AfCFTA potentially mitigate the negative effects of climate change?**

Despite various studies that have focused on the individual impacts of trade and climate change, in Ethiopia and at the regional or global levels, the interaction between these two critical areas remains relatively underexplored. This research question aims to address this gap by examining how trade policy—particularly under the AfCFTA—interacts with the impacts of climate change on the Ethiopian economy. Ethiopia, a developing country highly vulnerable to the adverse impacts of climate change, faces decreased agricultural productivity and high variability in weather conditions, which significantly hinder its economic growth and trade potential. Therefore, this study examined the direct and indirect impacts of tariff reductions and trade facilitation measures on a climate-affected economy by expanding existing climate change models to incorporate AfCFTA-driven trade liberalization. This study focuses on how AfCFTA policy changes, such as in tariff and trade facilitation, better market access, and strong regional trade integration, could compensate for some of the economic costs associated with climate change. In Ethiopia, the interaction between trade liberalization and climate resilience remains a significant issue, given the substantial contribution of agriculture to the country's GDP and exports. Moreover, this study examined the potential mechanisms through which trade liberalization can mitigate the impacts of climate change, including the diversification of export commodities and regional cooperation in adapting to climate-related risks. Furthermore, this study assessed how AfCFTA policies enhance Ethiopia's economic resilience, promote sustainable development, and improve its adaptive capacity to climate-induced challenges. By filling this knowledge gap, the research provided valuable insights into the synergies between trade policy and climate adaptation, which can inform policymaking in Ethiopia usefully. However, this study does not address regional climate change impacts, thereby neglecting the broader effects of

climate change, which fall beyond the scope of this study and require further investigation in future research.

This dissertation is organized into six chapters. The first chapter presents the background of the study, including the research questions and objectives. The second chapter presents contemporary debates regarding trade integration and its role in the growth and poverty of developing countries. Additionally, it includes a brief discussion of AfCFTA formation, implementation, and future challenges, as well as methodological approaches and developments. The third chapter presents an empirical analysis of the impact of trade facilitation measures in Africa. Moreover, it presents a computation of the cost of trade facilitation measures and a straightforward counterfactual analysis. The fourth chapter examines how climate change impacts agricultural productivity in Ethiopia. Applying a CGE model, this chapter presents the direct and indirect impacts of climate change on crops, as well as the yearly estimated shock impacts. The fifth chapter examines the intricate impacts of AfCFTA on Ethiopia's economy under a climate change context, utilizing a recursive dynamic CGE model. Finally, the sixth chapter concludes with policy implications and suggestions for future research.

Chapter 2

African Continental Free Trade Agreement: A Review of Analyses of Likely Impacts and Challenges of Implementation

2.1 Introduction[1]

Trade has played a significant role in the global transition and coincided with dramatic poverty reduction. Apart from efforts to liberalize international trade, several regional trade agreements have been established over the last few decades to accelerate the exchange of goods and services by reducing associated transaction costs. Simultaneously, technological advances and a dramatic decline in transportation costs contributed to intensified trade and global value chains. Trade theory predicts overall gains from trade but also postulates that free trade creates winners and losers; generally, workers and owners of resources benefit in the exporting sectors, while those in the importing sectors lose. Trade liberalization sometimes results in undesirable production, employment, and environmental outcomes in the LDCs (Frankel et al., 2017; Bezuneh et al., 2014; Santos, 2012 ; Herz et al., 2011; Krugman, 2008; Krugman, 1995). The impact of liberalization is heterogeneous across sectors and individuals. Complete liberalization of some sectors can increase dependence and vulnerability to food imports and intensify poverty (George, 2010). Therefore, the extent to which trade liberalization affects an economy may vary depending on whether the respective country is resource-rich or resource-poor and is a coastal or

[1]This chapter was published as: Wassie, M. A., Kornher, L., & von Braun, J. (2022). African Continental Free Trade Agreement: A review of analyses of likely impacts and challenges of implementation. ZEF working paper 217, Bonn, Germany.
The research concept was jointly developed by Wassie A. M., K. L., and von B. J. Wassie A. M. prepared the initial draft of the manuscript. All co-authors contributed comments during the revision process and approved the final version.

landlocked country. However, there is also skepticism about trade in general (Devarajan et al., 2018; Nicita et al., 2014; Arkolakis et al., 2012; Martin et al., 2007), and even more recently because of disrupted value chains by Covid-related policies and raw material dependencies, including in food and fertilizer trade disruptions (Fusacchia et al., 2022; Balistreri et al., 2022; Glauber et al., 2023; Espitia et al., 2022; Michele, 2022).

Regional integration to boost trade in Africa has been a significant international relations issue since the independence of most African countries in the 1960s. In the Abuja treaty of 1991, AU member states agreed to create a single African market. The decision to establish a Free Trade Area was passed during its 18th Ordinary Session meeting of AU member states held in Addis Ababa, Ethiopia, from January 29 to 30, 2012. Meetings and preparations continued, and in February 2016, the first negotiation forum was held on the issue of the AfCFTA. After the seven negotiating principles were adopted in 2016, consecutive meetings were held until the final signing of the AfCFTA establishment agreement in March 2018 in Kigali, Rwanda. Most countries (44 of 55) signed the agreement and launched ratification of free trade. Signing and ratification continued until April 29, 2019. The 22nd country had to ratify for operation after 30 days, as stated in the establishment agreement; however, the COVID-19 outbreak delayed the start of trade under the agreement to January 1, 2021.

African countries trade more with the outside world than within the continent, and trade in goods is very low relative to other developed and emerging countries (Africa Agriculture Trade Monitor, 2021); however, some scholars argue that this is due to measurement problems, such as informal trade, unrecorded, and unweighted trades (Mold, 2022; De Melo et al., 2021; Bouët et al., 2022; Bouët, 2008). Africa's trade accounted for 2.8 percent and 14.4 percent of global and intra-regional trade, respectively, in 2019 (UNCTAD, 2021b). Others argue that low intra-regional trade is attributed to high transaction costs due to insufficient infrastructure, weak institutions, and cross-border trade hindrances (Kornher et al., 2020). African agricultural commodities trade share was limited to 13–20 percent from 2000 to 2013 relative to other regions, such as North, Central, and South American countries (40 percent), Asian countries (63 percent) and European countries (75 percent) (Africa Agriculture Trade Monitor, 2018). Despite in some regions such as SADC the agri-food intra-Africa trade increased 22% in 2005/07 to 37% in 2015/17 (Food and Agriculture Organization of the United Nations, 2020), the NTMs of transportation costs, poor infrastructure and port inefficacies, and weak institutions limited intra-market access and growth (Kareem, 2019).

The rise of international trade has transformed the global economy and coincided with a dramatic reduction in global and regional poverty (Engel et al., 2021). Many countries, especially in East Asia, have used trade to create jobs, integrate into global

and regional value chains, and reduce poverty (Engel et al., 2021). Although global poverty decreased from 36% to 9% between 1990 and 2017, and developing countries increased their share of global exports from 16% to 30%, Sub-Saharan Africa's trade share remains the lowest. Several factors have been identified as contributing to this situation (Svedberg, 1991). These can be categorized into external factors, such as the slow growth of global primary commodity volumes—Africa's primary export—and the deteriorating terms of trade, as well as internal factors specific to each country, including excessive import protection, high taxes, an overvalued exchange rate, and other policies that negatively impact export supply. Withstanding the recent arguments that African trade needs realistic measures that account for informal trade, economic structure, and data limitations, factors such as inadequate infrastructure, institutional inefficiencies-bureaucratic obstacles- and political and macroeconomic stability are identified as the major barriers (Collier et al., 2010; Bouët, 2008; Takpara et al., 2023; Portugal-Perez et al., 2009; Mold, 2022; Collier et al., 2008; Shepherd, 2017; Rodrik, 1998; ElGanainy et al., 2023; De Melo et al., 2024). Several RECs established in Africa could have the potential benefits of boosting trade, employment, industrialization, and food security; however, they are blamed for the lack of commitment to implementation.

Trade's poverty impacts take various channels, with most studies agreeing that trade boosts income and reduces poverty (McCulloch et al., 2001; Winters et al., 2004; Winters et al., 2014). Therefore, AfCFTA has the potential to lift millions out of poverty if its implementation is accompanied by structural reforms such as NTBs and trade facilitation. The trade reform aspires to cut off tariffs and eliminate NTBs through trade liberalization for goods and services and eventually for factor mobility, investment (domestic and foreign), and competition. Furthermore, AfCFTA is also expected to solve some problems in overlapping RECs in conflict resolution, rules of origin, and payment systems or currency-related problems. AfCFTA seeks to eliminate barriers to trade and investment and gradually create Africa's largest Free Trade Area and African Economic Community, with a market size of 1.3 billion people and a combined GDP of about 3.4 trillion US dollars (USD) (World Bank, 2020b). As the largest free trade agreement by the number of countries (54 countries) next to the WTO, AfCFTA could lift more than 30 million people out of extreme poverty and about 68 million people out of moderate poverty by 2035 (World Bank, 2020b). However, Africa's intra-trade is limited in volume and diversification compared to other regions. The limited complementarity of African trade or the large share and persistence of Africa's agricultural imports of food products from the rest of the world and predominantly unprocessed non-food products export suggests a low probability of gaining from intra-African trade (Bouët et al., 2020; UNCTAD, 2021a). Furthermore, the share of Africa's manufacturing trade in world trade has decreased steadily in the last 50 years (UNCTAD, 2021b). In contrast, De Melo et al. (2021) shows that intra-Africa trade needs correction in reports and analysis arguing that intra-Africa

trade has been growing while others show a declining trend, stressing the need to consider structural economic differences with other regions and the significant informal cross-border trade.

Trade under AfCFTA started on January 1, 2021, and while various negotiations are underway for expected future completion (Africa Union, 2022; Van Der Ven et al., 2021), several studies projected the agreement's impacts under different scenarios, methodologies, and spatial coverages before and after its establishment.

This paper reviews

- · the existing trade models and briefly explains which models are used for AfCFTA,
- the existing studies' potential impact assessment of the AfCFTA on trade, income, poverty, inequality, etc.,
- discuss the studies' results and how they can be compared to each other and with other prior studies on regional trade agreements. Furthermore, we discuss
- how other factors not incorporated in the simulations can affect the projected outcomes, and the period of the gain (i.e., short, medium, and long run) by supplementing information from different sources.

2.1.1 Pre-view of Findings

We can say up front that different modeling and scenario approaches applied in analyses of the AfCFTA lead to different results. Existing studies applied various methodologies, stretching from the gravity model to partial and global general equilibrium models. The models' heterogeneities help to anticipate the determinants of resulting differences in findings, providing mixed results for concerned bodies; however, in addition to using diverse scenarios, most studies also used narrow scenarios of tariff elimination with a static model for the trade in goods. With this approach, the models, by nature, only capture the cumulative impacts of the agreement. Other studies used a dynamic model simulating different tariffs, nontariff reductions, and trade facilitation scenarios.

The crux of most models in their assumptions regarding full employment, perfect competition market, constant returns to scale, and current account balance assumptions significantly affect the simulations by over simulating or under simulating. The basic perfect competitive market and full employment of labor with frictionless and full participation are among the determinants of the simulated outcomes requiring

cautious interpretations of results. Another important assumption in such kinds of analysis concerns model closure.

How AfCFTA-implementing countries proceed in their budget compensation of the tariff revenue loss in a budget deficit situation will critically impact welfare simulations. Countries may increase borrowing to finance the loss that will compromise future welfare as the debt service starts. In contrast, other economic gains arise from trade balance improvement due mainly to trade reform; therefore, the assumption on the current account balance in the simulations also affects the projected outcomes.

This review concludes that the successful implementation of AfCFTA can have substantial positive welfare, inter- and intra-trade, and real income gains for Africa. The tariff revenue loss from the tariff cut is modest in all studies concerning the low effective applied tariff rates in the intra-trade from existing regional integrations. The predicted tariff revenue loss ranges between 0.03 to 0.22 percent of GDP, likely caused by the low share of tariff revenue from intra-African trade. Most studies used a full tariff elimination scenario in their study designs and wide and high NTBs elimination scenarios (35 to 100 percent) though the recent global nontariff performances show increments rather than reductions (Nicita, 2018).

Despite using different methodologies and scenarios, most studies present comparable welfare results; however, various factors determine the agreement's implementation and outcomes. Nontariff barriers and trade facilitations are significant gain sources as the existing regional arrangements have already reduced tariff rates. In a complete tariff elimination scenario, welfare is predicted to increase between 0.1 and 0.5 percent, while in a combined tariff and nontariff reduction, welfare increases by 1.3–2.2 percent, intra-trade by 33 to 82 percent, and real income rise by 7 percent from the tariff, nontariff, and trade facilitation (World Bank, 2020b). Furthermore, studies on AfCFTA's sectoral impact indicate some differences, while some studies projected agriculture as the most positively affected in some regions other than manufacturing.

The lack of informal trade in the trade database, low public awareness, and failure to have explicit adjustment costs in the modeling makes those results uncertain in the gain's amount and timing. Existing regional trade agreements are building blocks of the AfCFTA that facilitate the implementation by sharing risks, reducing costs, especially for deeply integrated countries and negotiating and submitting the tariff offers together. Conversely, the significant integration differences among RECs potentially threaten the less integrated countries and RECs. Even if AfCFTA helps to bring informal traders to formal trade through different regulations and formalities (Simola et al., 2021) by reducing trade costs, customs duties, and risks, massive public awareness must be created. For example, the Afrobarometer survey (Sanny et al., 2021b) showed that 82 percent in their survey in Gabon and Mali, 81 percent

in Guinea, 78 percent in Burkina Faso, and 76 percent in Côte d'Ivoire believe it is difficult to cross borders for work or to trade.

The paper is presented in five parts. Section 2 presents AfCFTA at a glance, proceeding with Section 3 approaches to measuring trade agreement outcomes, focusing on the shallow empirical models and not the theoretical developments due to time and space limitations. Section 4 presents the critical review and descriptive analysis and finally, Section 5 concludes.

2.1.2 AfCFTA at a Glance

RECs in Africa and Scopes and Objectives of AfCFTA Regional trade agreements (RTAs) have proliferated exponentially globally and in Africa in the past few decades, and nearly all countries participate in at least one regional trade agreement (RTA) (Yang et al., 2005). Notifications from RTAs to the WTO have dramatically increased from 97 between 1948 and 2000 to 482 between 2001 and 2022, with current notifications totaling 579. According to the WTO (2022) database, there were only 15 RTA notifications between 1948 and 2000; from 2000 to 2022, this figure more than doubled, with an additional 34 notifications in Africa.

The goal of regional economic agreements in Africa within so-called RECs exceeds the economic and trade objective to promote democracy, prevent regional conflicts, and harmonize institutional development (De Melo et al., 2013). Even though RTAs' history in Africa dates back to the beginning of the 20th century, RTAs began proliferating and flourishing during the 1990s after sluggish growth since independence. Powered and energized by historic Pan-Africanism, African trade integrations have included numerous arrangements at regional and sub-regional levels.

The Lagos Plan of Action, followed by the 1991 Abuja Treaty, established the African Economic Community (AEC) with sub-RECs envisaged as the AEC's building blocks (Yang et al., 2005); however, African RTAs live less than the economic expectation in member countries due to below-potential market integration that reflects high trade barriers in the region (De Melo et al., 2013). Regional integration benefited more landlocked countries that are also resource-dependent in their exports (Collier et al., 2010).

However, Africa remains highly fragmented politically and a less integrated market than other countries that had a similar feature in the 1980s (Brenton et al., 2012). Collier et al. (2010) argue that even if Africa had common features of population, per capita income, and human development with Southeast Asia in the 1980s, Africa is geographically fragmented into more countries than the Asians which would make Africa more challenging to integrate.

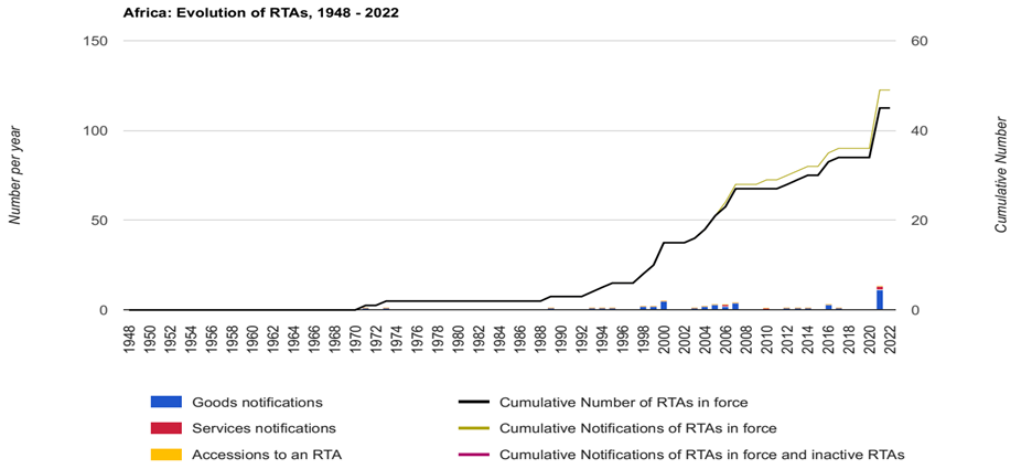

FIGURE 2.1: Notifications of RTAs to the WTO 1948 to 2022 (Africa)

The cost of fragmentation has hurt Africa for three main reasons: the increasing inequality cost in the distribution of natural resources, the cost from the loss of scale economies in production, and the loss of public goods as the scale of political cooperation.

The establishment of the Organisation of African Unity (OAU) and the Economic Commission for Africa (ECA) has contributed to the creation of different RTAs providing tremendous support. OAU and ECA adopted the 1980 Lagos Plan of Action to create an African Economic Community by strengthening the existing RECs and establishing a new one. Later in 1991, the Abuja treaty recognized the eight RTAs as the building blocks of the AEC and the AfCFTA. The Economic Community of West African States (ECOWAS), Arab Maghreb Union (AMU/UMA), East African Community (EAC) Intergovernmental Authority on Development (IGAD), Southern African Development Community (SADC), Common Market for Eastern and Southern Africa (COMESA), Economic Community of Central African States (ECCAS) and Community of Sahel-Saharan States (CEN-SAD) are the AU officially recognized building blocks of the AfCFTA. The extent of regional trade integration within the different RECs varies across different economic zones, and the share of trade is limited both within and between RECs.

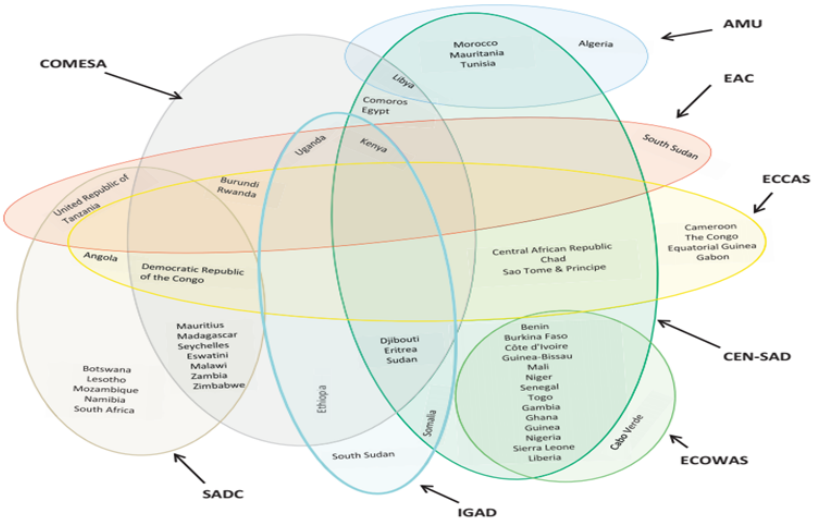

FIGURE 2.2: RECs and overlapping member countries (eight AU recognized)

Despite the integration differences, some RECs have a common external tariff, such as the ECOWAS, COMESA, and EAC.

A few primary and agricultural commodities dominate intra-Africa trade. For example, the export values reach up to 52 percent for mineral and fuels export from the ECOWAS, copper (42 percent) from the ECCAS, mineral fuels (32 percent) from the CEN-SAD, precious stones (19 percent) from the EAC, mineral fuels (19 percent) from the AMU, copper (13 percent) from the COMESA, edible vegetables (11 percent) from IGAD, mineral fuels (8 percent) from the SADC (Tralac, 2022).
Total intr-Africa trade growth from 2020 to 2021 shows an uneven pattern; AMU (+19%), SADC (+18%), COMEA (+6%), CEN-SAD (+3%), ECCAS (-19%), IGAD (-10%), ECOWAS (-8%) and EAC (- 6%). The performance of the RECs' also shows a limited regional value chain but moderate non-regional and forward value chains (De Melo et al., 2021). EAC is the least globally integrated with forwarding and backward value chains among the four RECs (i.e., EAC, ECOWAS, COMESA, and SADC); SADC and COMESA have the highest integrations where the forward value chains outpace backward value chains. This integration contrasts with the1990s integration in East Asia and Pacific, Europe, and Central Asia.

The free trade areas' establishment decision was passed during the 18th Ordinary Session meeting of AU member states held in Addis Ababa, Ethiopia, from January 29 to 30, 2012. The Summit also endorsed the Action Plan on Boosting Intra-Africa Trade, which identified seven priority action clusters: trade policy, trade facilitation and productive capacity, trade-related infrastructure, trade finance, trade information, and factor market integration (African Union, 2012). After many negotiations and several engagements, the AfCFTA was established to enhance the continent's

intra-trade and inclusive growth. AfCFTA came into force on March 30, 2019; however, due to COVID-19 and negotiation issues, trade started in January 2021. The AfCFTA is governed by five operational instruments of the Rules of Origin: an online negotiating forum, monitoring and eliminating NTBs, a digital payments system, and the African Trade Observatory.

The agreement's scope is much larger than previous sub-RTAs regarding the number of countries, area coverage, and objectives. AfCFTA is the largest next to the WTO, with 54 signatory countries. The agreement aspires to eliminate tariffs and NTBs to trade in goods and services, trade facilitation, investment, intellectual property rights protection, dispute settlement, and e-commerce areas as a continent-wide Free Trade Area.

Three phases of implementation set the fundamental objectives of the agreement. African countries are members of many RECs, some of which overlap more than once, such as Burkina Faso, Mali, and Niger belonging to UEMOA, ECOWAS, CEN-SAD, and CILSS5. AfCFTA can help to achieve policy coherence, including relationships with African parties or different African countries, by resolving the challenges of multiple and overlapping trade arrangements. The founding document of AfCFTA put the agreement's objectives under article 3 as follows. (i) Create a single market for goods and services, facilitated by the movement of persons and capital to deepen the economic integration of the African continent. (ii) Create a liberalized market for goods and services through successive rounds of negotiations. (iii) Contribute to the movement of capital and natural persons. (iv) Lay the foundation for establishing a Continental Customs Union at a later stage. (v) Promote and attain sustainable and inclusive socio-economic development, gender equality, and structural transformation and enhance the competitiveness of the economies of State Parties. (vi) Promote industrial development through diversification and regional value chain development, agricultural development, and food security by resolving the challenges of multiple and overlapping memberships.

In pursuance of the stated objectives, the negotiations have undergone three phases. Phase one includes trade on goods and services by eliminating tariff barriers and NTBs, phase two includes intellectual property rights, investment, and competition policy, while phase three covers e-commerce.

2.2 Modalities of Implementation

AU's eight officially accepted RECs are the building bloc of the agreement, which came into force on May 30, 2019, after the 22nd country deposited the rectification instrument; trade in goods started on January 1, 2021. The AfCFTA agreement is the founding document, providing the details of the implementations, protocols,

and stakeholders; however, negotiations on the detailed schedules of tariff concessions or rules of origin started only after the first implementation phase, despite that phase's protocols. The general modalities for tariff reductions and the actual shares of tariff lines for sensitive and excluded products were defined at the 3rd Meeting of the AU Ministers of Trade in 2017 and the 32nd AU Ordinary Session in 2019 (Tröster et al., 2021).

Single-state parties (i.e., the AU Member States that have ratified the AfCFTA Agreement or acceded to it and for which the AfCFTA Agreement is in force) or RECs were supposed to report the detailed schedules by tariff lines in 2020 (Tröster et al., 2021). The AU member states are the negotiating parties. Furthermore, the AfCFTA establishing Agreement states that "State Parties that are members of other RECs, regional trading arrangements, and customs unions, which have attained among themselves higher levels of regional integration than under this Agreement, shall maintain such higher levels among themselves" (in Article 19[2]) (African Union, 2018).

The negotiations on modalities contain decisions about the level of ambition, treatment of sensitive and excluded products, and time frames for tariff phase-downs. The tariff offers should comply with the tariff negotiation modalities; they are as follows.

1. On 90 percent of tariff lines, tariffs are to be eliminated on non-sensitive goods. Eliminate over 5 years for Non-Least Developed Countries and over 10 years for LDCs.

2. Seven percent of tariff lines can be sensitive goods. Non-Least Developed Countries liberalize tariffs of sensitive goods over ten years and LDCs over 13 years.

3. Three percent of tariff lines can be excluded from liberalization. The value of these imports may not exceed 10 percent of total intra-Africa imports.

Despite using an anti-concentration rule or the allegation of not excluding an entire sector from the tariff cut in the establishment agreement, the 90 percent tariff line cut is ambiguous. This is because of the absence of information if the 90 percent tariff line refers only to the tariff line or includes both trade value and tariff line. This complicates defining simulation scenarios. For the excluded products, both the tariff line and values (3 percent of the tariff line that does not exceed 10 percent of the trade value) are determined; however, there is no determination for the sensitive products that affect the outcomes of the implementation and the products under implementation or trade reform. The trade reform sequencing issue highly depends on the type and number of commodities presented to the liberalization. In this regard,

in a retrospective analysis, the EU, WTO, and East Asia have somewhat similar sequences during their respective integration in manufacturing goods, with liberalization preceding the service, agriculture, and investment (Evenett, 2004; Bond, 2008). The most important question concerns whether manufacturing goods should precede agricultural goods or whether simultaneous liberalization can ensure Africa's success.

Africa is a much-diversified continent; therefore, countries need domestic policies that adhere to their physical and political geography, such as landlocked vs. coastal and resource-rich vs. resource-poor countries (Collier, 2007). The success of AfCFTA depends highly on each country's reforms and commitments to implement the agreement; however, such heterogeneity may also cause some objective biases. The realization of AfCFTA in the continent is also highly dependent on the unilateral free trade agreements or partnership agreements that individual countries will sign and implement.

The negotiations are in three phases (I, II & III).

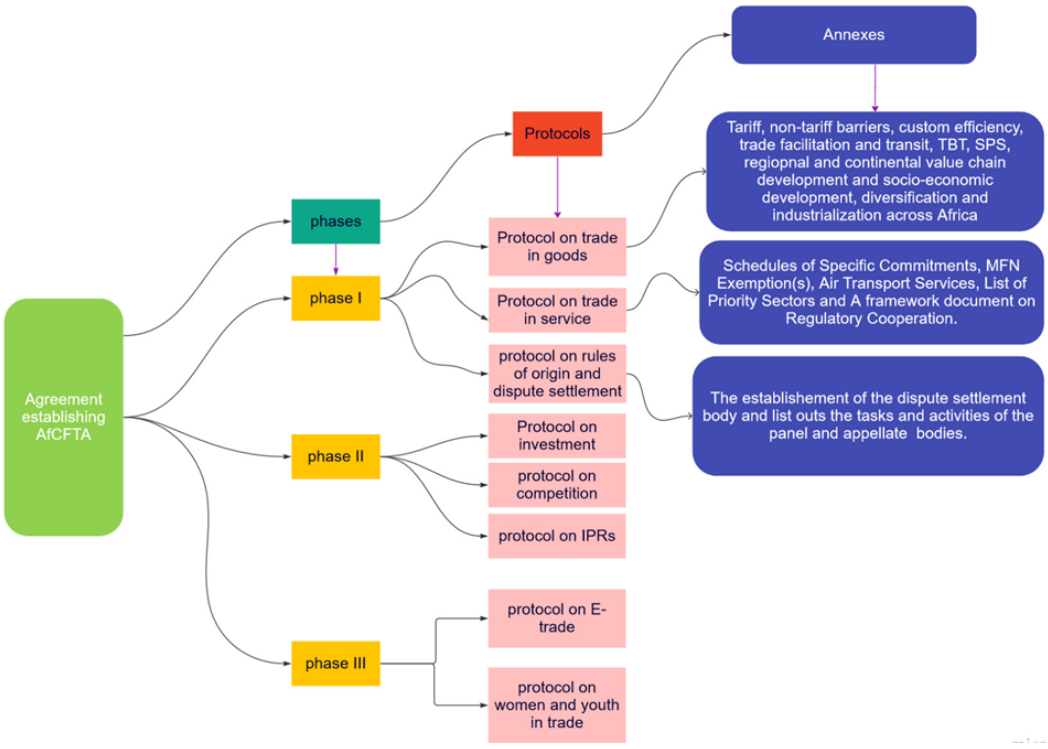

FIGURE 2.3: AfCFTA negotiation phases

The primary gain of intra-trade in Africa arises from its significant diversification when it trades with itself rather than outsiders. Luke et al. (2020) argue that Africa has already exploited its potential benefit from trade with the EU from its prior preferential agreements. In contrast, the EU can have substantial market access as EU exporters currently face a relatively high tariff. On the other hand, nontariff barriers are trade-inhibiting for African exports to the EU. Therefore, any trade agreement between African countries and the EU comes at the expense of intra-African agreements' benefits unless it does not address the high transaction costs that African exporters face when accessing the EU market.

Luke et al. (2020) further elaborate that sequencing trade agreements and negotiations have ramifications on the AfCFTA outcomes and implementations. Prioritizing AfCFTA over other agreements enhances the benefits for Africa by reinforcing the engagement power as a single rather than a fragmented entity. Currently, African countries enjoy diverse international trade preferences that complicate the integration of these rules in the AfCFTA agreement. LDCs enjoy free access to the EU market under "the everything but arms" agreement. Furthermore, several African countries have signed individual trade agreements with third countries, specifically the US, the EU, and China. Kenya negotiated an FTA agreement with the USA in 2020. From the EAC countries, Kenya and Rwanda also signed an Economic Partnership Agreement (EPA) with the EU, while other member countries are observing to follow. In contrast, Ethiopia has been suspended from its Africa Growth Opportunity Act (AGOA) trade advantage with the US because of the war in the Northern parts

of the country. Still, despite the COVID-19 shock, while intra-Africa trade in the region has been declining year on year, trade of most AGOA beneficiary countries with the US has increased significantly (Stuart, 2022). Empirical studies are rare on such prioritization of trade agreements or partnership negotiations for the sequential implementations of the agreements.

2.3 Measuring Trade Outcomes: Methodological Approaches

The nature of international trade is complex, involving hundreds of countries with different endowments and consumer preferences, thousands of products, and a great variety of national policy instruments that complicate the choice of a single methodology of analysis for all situations (Cockburn et al., 2008; Teichmann, 2016). Thus, international trade analysis involves choosing between descriptive statistics, modeling approaches, econometrics estimation and simulation, ex-ante and ex-post approaches, and partial and general equilibrium models (Bacchetta et al., 2012). Bond (2008) groups these approaches into three primary areas: spatial and non-spatial equilibrium models, gravity equations, and single- and multi-country computable general equilibrium models. They generally fall into two major strands: ex-post and ex-ante approaches. Ex-ante studies use behavioral parameters typically drawn from various sources so that the model can reproduce precisely the data of a reference year (calibration) for later use of simulation, i.e., "what if," In contrast, ex-post analyses use historical data to analyze the effects of past trade policies.

Ex-ante trade reform analysis approaches can be presented in two broad categories of partial and general equilibrium models. Partial equilibrium analysis focuses on one or multiple specific markets or products, ignoring the link between factor incomes and demand but providing sector-specific results. In contrast, general equilibrium models explicitly account for all the links between the different sectors and output and factor markets of an economy of households, firms, governments, and the rest of the world; however, this approach sacrifices detailed sector-specific results (Bacchetta et al., 2012). Naturally, researchers can select any approach based on the nature and complexity of the research questions (Bacchetta et al., 2012; Teichmann, 2016).

Ex-ante approaches require sound baseline data, and databases, calibrated with actual economic data to different base years, can provide detailed country coverage. For instance, several models, such as the Global Biosphere Management Model or the Common Agricultural Policy Regionalised Impact model, do not allow the modeling of individual African countries except for economic heavyweights. Therefore, any analysis of the AfCFTA requires a different database. Almost all ex-ante studies sources data from the Global Trade Analysis Project (GTAP), a semi-public data

and model owned by Purdue University; GTAP has been updating and expanding its data coverage by extending the number of countries and sectors since its establishment in the 1990s. The latest version of GTAP 10 contains 141 countries and 65 sectors. With greater flexibility for partial and general equilibrium analysis, GTAP also has data and models other than trade, such as for environmental and climate change analysis GTAP-E and agro-ecological zone disaggregated land allocation-GTAP-AEZ. Another model, the Environmental Impact and Sustainability Applied General Equilibrium Model is fully designed to analyze climate change-related problems. Despite being owned and frequently used by various modelers and institutions, these and other models source their data from GTAP. An overview of major trade models is compiled in table 2.1.

The simulation methods for ex-ante studies have flourished in their development and application since the 1980s and 90s trade liberalizations. Table 1 summarizes some of these simulation methods, their affiliated institutions and areas, and countries of applications. Even though CGE models cover diverse areas such as tax, trade reforms, climate change, land allocation and environmental issues, and growth-poverty and inequality analysis, we include only those widely used for trade reform analysis in our review, which relates to our topic.

The most commonly used is the GTAP model, an open-access model and data source that can be used within the model or on other models. Since its establishment, GTAP has been the primary data source for various models, such as the Modeling International Relation in Applied General Equilibrium (MIRAGE) model or the Modular Applied GeNeral Equilibrium Tool (MAGNET), LINKAGE. These big models are used in either a static or dynamic version under the assumption of a perfect or in the imperfectly competitive market. The static version does not consider the full effects, focusing on the implementation (or hypothetically assumed) completion time outcomes; conversely, the dynamic models simulate the outcome/impact following the ongoing year-by-year (any assumed timeframe). The static and dynamic versions of the models are also used for various national, regional, or international issues, such as the Doha development agenda, Chines accession to the WTO, the North American Free Trade Agreement (NAFTA) the EU, and various trade agreements.

There seems to be a pattern of trade policy analyses: looking at the emphasis and timing of the analyses in table 1 suggests that trade modeling on potential policy changes is connected to events of emerging policy changes. Thus, despite the sheer number of studies on sub-regional trade, for instance between the EU and African sub-regions, the empirical analyses for the (Pan) continent have been limited until the AfCFTA came about, or at least until the related political process became apparent. Policy research unfortunately lagged behind African policy making. Trade policy research could have earlier provided guidance on policy options. The choices

TABLE 2.1: Summary of the major trade analysis models and their applications

Models and data sources	**Developers/ Advanced users**	**Applications**
GTAP (v1-v10)	Thomas W. Hertel (1997)	The main source of data for others
TASTE-Tariff analytical and simulation tool for economists	Corong, McDougall, Tsigas, and van der Mensbrugghe (2010, 2017)	The East Asian Meltdown: It's Not All Bad News
	Ianchovichina and Walmsley (2005, 2012)	China's accession to WTO and East Asia
Market Access Map-MAcMAPHS6	Mark Horridge and David Laborde (2008)	Extensively used for various trade agreements analysis
LINKAGE	World Bank: Bourguignon, Ferreira and Lustig (2005)	Growth-distribution-poverty nexus
CGE-GIDD		Global trade policy analysis
microsimulation	Maurizio Bussolo, Rafael E. De Hoyos, and Denis Medvedev (2008)	World Bank used for AfCFTA
GTAP database		
MIRAGE (2002)	IFPRI: Antoine Bouët, Carmen Estrades, Fabienne Fémenia, David Laborde, and Marcelle Thomas	Trade policy analysis
MIRAGE-HH		ECA used the static and dynamic versions for AfCFTA
MIRAGRODEP	AT CEPII: Yvan Decreux (2007), Cristina, Maria Priscila, Christophe Gouel, Hugo Valin, and Jean Fouré (2006, 2018)	Special features are imperfect competition, product differentiation by variety and by quality, and FDI explicit inclusion
	The African Growth and Development Policy Modeling Consortium	International trade and trade policy in Africa
	David Laborde, Véronique Robichaud and Simla Tokgoz (2013)	Bouët et al., (2014) for potential evolution of international trade in Africa and Bouët et al., (2021) for the EU-SADC EPA
	Antoine Bouët, David Laborde, Véronique Robichaud, Fousseini Traoré and Simla Tokgoz (2022)	
MAGNET (Modular Applied GeNeral Equilibrium Tool)	Wageningen Economic Research	Agricultural, environmental, Food and trade policy analysis
	Joint Research Centre of the European Commission (JRC) and the Thünen Institute (TI)	EU JRC for AfCFTA impacts on agriculture and food trade and food security
	Woltjer, Kuiper, van Meijl, Hans, and Geert (2006, 2008, 2014)	
	Simola, Antti, Emanuele Ferrari, Pierre Boulanger, Ole Boysen and Victor Nechifor (2021)	
Macro-micro simulations (country-level)	Bernard Decaluwe (1988, 1999) and Andrea Lemlin, Helene Maisonnave, and Veronique Robichaud (2010, 2013, 2014)	Trade liberalization and Public policy changes
		China WTO accession
Partnership for Economic Policy PEP)	Bourguignon, Fournier, and Gurgand, (2000) and Decaluwé, Dumont, and Savard (1999)	For various independent countries such as cote d'Ivoire, Madagascar, Ethiopia, and Kenya
	Denis Cogneau and Anne–Sophie Robilliard-Madagascar (2000)	
	Chen and Ravallion (2003)	
	Robilliard, Bourguignon, and Robinson (2003)	

made in the trade policy research – including maybe some of its post-colonial patterns - may warrant further study of the political economy of research.

2.4 Economic and Welfare Assessments and Challenges in Implementing African CFTA

This section continues the previous section with a detailed and specific empirical application review of the AfCFTA studies. Those studies' modeling and assumptions are reviewed with discussion supplemented with different information and data from various sources.

The AfCFTA can substantially grow intra-African trade flows and employment creation, GDP, and welfare, driven mainly by removing NTBs and implementing trade facilitation agreements. The positive impact of trade mainly depends on the infrastructure to support trade, nations' reforms on domestic economic policies to promote trade, and steering their youth toward jobs in industries that depend on trade, as seen in Asian countries (Engel et al., 2021).

Among the several ex-ante studies on the different impacts of AfCFTA, some used partial equilibrium or direct impacts on specific products, such as agriculture and food products (Simola et al., 2021; Fusacchia et al., 2022), cereals (Pasara et al., 2020), while many others used global level either static or dynamic CGE models. The partial equilibrium study by (Simola et al., 2021) results corroborate that AfCFTA can improve intra-agricultural trade, food security, and Africa's regional and global trade value chain. AfCFTA can enhance Africa's agri-food export by 3.7 percent from a tariff reduction that would increase food availability and consumption; however, the tariff reduction would create a price increase that would adversely affect vulnerable groups or the poor. Mevel et al. (2012) assessment of the AfCFTA impact on 16 African countries indicates that sugar and dairy products are the most positively affected sectors; however, comparing results needs cautious interpretation that must consider the model, data use, regional or continental coverage, the type of scenarios designed, and other factors. Sub-regional studies that did not make a distinction between the rest of the world and remaining African countries would give a different result. Despite the detail prons of studying specific regions, the magnitude of the impact depends on how remaining African countries are included in the rest of the world such that if these countries are merged in one with the rest of the world, the magnitude of the trade effect, for instance, will be lower than in the case of separate representation of rest of African countries and the remaining rest of the world. For instance, below, we present the significant potential impact assessment studies for the most important indicators. Some studies assessed the impact using dynamic CGE models, whereas others used static versions.

Tariff revenue effect: Overall, the tariff revenue loss is estimated to be modest for most African countries. As the financing of welfare states or public provision and security, activities after international or regional integrations are at the center of debate (Andersen, 2003). The implication of trade integrations hinges on factors of tax base expansion or income gain after the trade agreement and the revenue loss from tariff cuts. Saygili et al. (2018) predicted a tariff revenue loss of 9.1 percent of current revenues for the AfCFTA member states. The tariff revenue loss falls from 0.03 percent to 0.22 percent of GDP, with a significantly higher gain later from the tax base expansion or import expansion; however, the short-run loss burden is undeniable for most countries that need alternative financing or budget rearrangement.

Real income and Welfare effects: The tariff cut effect on the continent's GDP growth stretches from 0.01 by Mevel et al. (2012) to 0.7 percent by Saygili et al. (2018); however, this impact increases when including NTBs reductions and trade facilitation to 1.5 percent by Jensen et al. (2015). The World Bank (2020b) found an overall 2.4 percent real income increase from the 97 percent gradual tariff cut and 50 percent NTB reductions which rises to 7 percent when trade facilitation is included. Abrego et al. (2019) found a 2.6 percent and 2.1 percent potential welfare gain from tariffs elimination and 35 percent NTBs reductions using a static model, for SSA and the continent, respectively. This welfare gain is significantly higher than the tariff-only gains of 0.07 percent for SSA and 0.05 percent for Africa. Economic Commission for Africa and the Centre for International Research and Economic Modelling (CIREM(CEPII)) (2021) predicted mixed welfare impacts and adverse welfare effects for Kenya, Tanzania, and Rwanda in the EAC analysis. These welfare effects are comparable to prior studies of trade agreements, such as NAFTA by Caliendo et al. (2015), who found 1.31, 0.08, and –0.06 percent for Mexico, the US, and Canada, respectively. Therefore, we conclude that the real income growth impacts of the AfCFTA from the tariff cut are less economically significant but the effects from NTB reduction and trade facilitation are much stronger.

Trade effects: Even if most studies are relatively close in their findings, the intra-Africa export impacts show a larger difference in tariff only and NTM reductions. The trade gains of African CFTA are highly heterogeneous among countries where high trade influence the less pre-integrated countries (Fofack et al., 2021). The potential intra-Africa trade increase reaches up to 81 percent (World Bank, 2020b; Abrego et al., 2019), and ECA predicted intra-African trade to grow by 33 percent and Africa's total trade deficit cut by half. Chauvin et al. (2017) report an uneven increase in trade across African countries. Abrego et al. (2019) found similar results in the full and partial tariff cut; however, NTB reductions led to significant growth with substantial welfare gain variations across the countries. Despite no consensus on the level and share of internal and external trade in Africa, AfCFTA's assessment shows that tariff and nontariff cuts can boost African trade, as tariff barriers and NTBs form a substantial obstacle to African trade (Bouët et al., 2017).

Recently, intra-Africa trade concerning processed and value-added products has grown more rapidly than other agricultural goods. Bouët et al. (2020), in the Africa Agriculture Trade Monitor report, argued that this increase could indicate African potential to build regional supply chains and meet local demands if supported by regional coordination, like AfCFTA, which can contribute to Africa's food security by enhancing forward and backward linkages. A more integrated and value-added product trade in Africa can reduce the continent's external dependence and its vulnerability to shocks. Developing countries can reduce the collateral effects of trade wars among the developed countries (e.g., the USA and China) by deepening regional integrations that can enhance real income and GDP growth (Bouët et al., 2019; Devarajan et al., 2018). Enhancing the agricultural and food sector's forward and backward linkage through the AfCFTA integration and its direct contributions to food security can somewhat insulate Africa from external global shocks (Simola et al., 2021; Fusacchia et al., 2022).

Trade theory is ambiguous about the welfare effects of preferential trade agreements (Krugman, 1991; Limão, 2016) but also emphasizes that gains are heterogeneous and that producers and workers in importing sectors could experience welfare losses. Heterogenous effects need to be monitored as inequality is Africa's overarching problem next to poverty and food insecurity. Inequality in Africa has continued to grow in most countries, making Africa the second-most unequal continent; approximately 0.0001 percent of the continent's wealthiest people own around 40 percent of the total wealth (Seery et al., 2019). According to Bhorat et al. (2017), the Gini coefficient measure in Africa is also higher than in the overall developing countries; Africa's estimated average Gini index is 0.43, while all other developing countries average 0.39. Heterogeneous effects could increase inequality in Africa across and withing countries.

The level of existing heterogeneity in the level of development, the economic and political fragmentation, and comparative advantages among African countries may unevenly distribute the agreement's potential benefits. In the African continent, over 60 percent of the population lives in rural areas where subsistence farming is the form of livelihood; the structural transformation has been aborted, and inequality is severe. AfCFTA's overall impact on Africa could be immense. The World Bank estimated that the resource and service sectors are the most affected, whereas agriculture will decline by 0.5 percent from the baseline by 2035. Despite the country-level heterogeneity, some countries will increase the expansion of the service sector, which is blamed for the low productivity growth contributing to the failure of African transformation. In a recent study covering 1960 to 2015, Mensah et al. (2023) showed that resources have been dragged into the slow productive service sector; however, value-added and employment are also declining in the agriculture sector, stunting the overall productivity growth of the continent and the structural change move toward the productive sectors. This result has a favorable implication for the

overtime-increasing challenge of the crowding out of cities, challenges of migrations to cities and towns, and expansion of informal business participation.

As the service sector is around cities/towns, any expansion can impact on the cities and towns' public service provision, administrations, and public budgets, potentially aggravating the already tightened government budget deficits and public services provision.

The World Bank (2020b) assessed that the AfCFTA would fill the gender and wage gap, so unskilled workers benefit more from the trade agreement than skilled male and female workers, finding significant cross-country differences. The distribution strongly depends on people's propensity to be employed and the sector that becomes competitive after opening the border. Recent studies on the impact of trade liberalization on unemployment, adjustment costs, and intra-sector compared to intersector mobility show significant and sometimes persistent shocks (Pavcnik, 2017. Most existing general equilibrium model studies are based on the strong assumption of full employment and perfect competition. Studies from the United Nations Economic Commission for Africa (2018), United Nations Conference on Trade and Development (Saygili et al., 2018), and Abrego et al. (2019) at the International Monetary Fund (IMF) are the exceptions, allowing imperfect competition. Saygili et al. (2018) used a static model that allows overall employment changes and predicted a long-run employment impact of 1.2 percent. Of the significant drawbacks of using a static version model that lacks the adjustment dynamics, the explicit simulation for the impact on the (un)employment is rare. For this, the World Bank used a detailed, dynamic, gender-integrated model; however, the model only captures the sectoral reallocation, not the job creation effect of AfCFTA. The reallocation of labor is mainly governed by the intensity of employment and trade cost reduction from the AfCFTA; the World Bank predicted more employment in the public sector followed by recreation-related services, whereas agricultural employment declined to 29.7 in 2035 from 35.9 percent in 2020. In addition, women's wages grow faster than men's in all regions except North Africa, mainly due to the expansion of the manufactured and sophisticated services that need skilled workers. Again, those results are based on the strong assumptions of frictionless labor mobility and fixed labor force participation that underestimate the adjustment costs and benefits.

CGE models have been a hot spot of critics; despite their improvement in many aspects of data, theoretical framing, and sector classification (Ziesmer et al., 2023; Dixon et al., 2013; Bouët, 2008). Many blamed CGE models for exaggerating the welfare gains from trade agreements; the gain for the poor, especially the small farmers, will probably be lower than predicted. Among others, the two major factors of baseline are data sources of projections and calibration methods (Ziesmer et al., 2023): low level of trade in the baseline will underestimate the impact of the future gains from a trade agreement in dynamic simulations. Trade diversification in products

TABLE 2.2: Summary of studies on AfCFTA

Authors and year	Models and scenarios	Main Results
Fofack et al (2021)	General Equilibrium PPML Partial and dynamic GE	Welfare gain or real output growth of (0.119 and 0.249), intra-African trade by 24.07 percent and 25.26 percent, and export to the RoW by 2.39 and 2.72 percent Total Africa export by 1.85 and 2.6 percent
Simola et al. (2021)	GTAP with global, multiregional model Tariff and NTBs reduction	Intra trade by 22 percent and food availability and consumption but a price increase An agri-food export rise of 3.7 percent for tariff reduction only
Fusacchia et al. (2022)	HS-GTAP 10 database with MAcMAP tariff data, static model Full tariff only cut	2.1. percent gross Agri-food exports and 24.6 intra-agreement increase A) More change in trade cost of agriculture and food and backward intra-regional integration than on forwarding participation
Pasara and Diko (2020)	WITS-SMART simulation model for SADC member countries (15)	Minimal gain in cereals but moderate for more crops included in the model
Carrico et al., (2021)	HS6-GTAPv7 MAGNET model-Full tariff cut for vegs and fruits	Less than 1 percent GDP increase but vary across countries Most trade effects from West and South Africa
Mevel and Karingi (2012)	MIRAGE multi-country and multi-sector CGE dynamic model, with the GTAP database 7; 1, Full intra-tariff removal 2, Tariff + TFA	1) This comprises real income of (0.2 percent), total African export (4 percent), intra-Africa-trade 51.7 percent, the wage for unskilled non-agri 0.80 percent, agri 0.74 percent, and skilled 0.54 percent. Food and agriculture are most affected by 53.1 percent, and industrial products by 53.3 percent. In a vis-à-vis of RFTA and CFTA, the gains are much higher for CFTA, and losses are less in CFTAs. 2) Intra-Africa trade increased by 128.4 percent, doubling the share from 10.2 percent in 2004 to 21.9 percent in 2022, projected at 15.5 percent.
Zongo A. (2020)	GTAP v8 multi-country multi-sector CGE liberalizations for ECOWAS and SADC 1) tariff +50 percent NTB (service restriction) 2) NTB + 50 percent NTB with service restrictions 3) 50 percent tariff +50 percent NTB	In the long-run (in the bracket are SR) 1) GDP gain of 5.7 percent (0.11) for ECOWAS and 3.52 percent (0.07) for SADC 2) GDP increase of 3.35 percent (0.09) for ECOWAS and 1.95 percent (0.04) for SADC 3) GDP increase of 4.39 percent (0.11) for ECOWAS and 2.62 percent (0.05) for SADC

continued

Authors and year	Models and scenarios	Main Results
Oyelami and Zongo (2022)	GTAP v10 multi-country CGE 1) 90 percent tariff +50 percent nontariff for agri and industry 2) 1+50 percent NTMs in service	boosts transport and telecom services more from the ECOWAS side than SADC 1) 0.22 percent and 0.95 percent GDP in the SR and LR 2) 0.70 percent and 1.07 percent GDP in the SR and LR
Jensen and Sandrey (2015)	GTAP CGE Static model, with the GTAP database 9.2; A) full tariff removal, B) NTM –50 percent and trade transit time cost –20 percent (Agricultural trade only)	GDP A, 0.6 percent; B, 1.5 percent Welfare (EV) A, 2–57 percent; B, 7–30 percent and 2–50 percent Welfare (USD 7.3 billion), GDP (0.7 percent), export (3.11 percent)
Saygili P. and Knebel, (2018)	GTAP CGE Static model and the GTAP database; full tariff removal	Short-run welfare (4.6 billion USD), net of revenues lose long-run welfare (USD 16.1 billion), GDP (0.97 percent), Export (2.5 percent), employment 1.17 percent, intra-trade 33 percent, trade deficit –51 percent when special sensitive products include GDP 10.7 billion USD (0.3 percent), employment 0.35 percent, intra-trade 24.2 percent, and export 1.9 percent
ECA, AU & ADB. (2018). & **2020**	A recursive Dynamic CGE-MIRAGE multi-country and multi-sector model, with the GTAP 9.2 and the MAcMap tariff with harmonized system 6-digit level of products (MAcMap-HS6) 1. Africa CFTA a) full tariff on goods trade b) full tariff + double trade facilitations 2. Africa continental custom union; a) full tariff on goods trade + COMESA CET; b) full tariff + double trade facilitations	1, a) real income effect 0.2 percent, African export 4 percent, by sector (agriculture 7.2 percent, industry 4.7 percent) Intra-Africa trade increase by 52.3 percent in value b) Intra-Africa trade 11.7 percent in volume, Africa exports 6.2 percent, 2, a) real income effect of 0.17 percent, African imports by 3.4 percent, export by 4.2 percent b) Intra-Africa trade by 9.6 percent Africa import by sector (total 3.4 percent, Agriculture and food 3.3 percent, industry 3.9 percent, service 1.9 percent) Total African exports (total 4.2 percent, agri and food 2.5 percent, Industry 4.2 percent, service 5.1 percent)
	PE and CGE with a static GTAP 10; full tariff removal	0.97 percent GDP, East Africa's intra-African trade 13 percent increase (737 million USD), total employment increase of 1.17 percent

continued

Authors and year	Models and scenarios	Main Results
Abrego et al. (2019)	I. PC[a] a) Full tariff b) Full tariff and 35 percent NTBs II. IPC[b] a) Full tariff b) Full tariff and 35 percent NTBs	i. GDP improve by 0.037 percent b) welfare or real income increase by 2.6 percent for SSA and 2.1 percent for Africa I. 2.1 percent welfare gain, intra-Africa export 82 percent, overall trade 8.4 percent II. a) 0.05 percent welfare gain, b) 1.92 percent, intra- Africa export 78 percent, overall trade 7.6 percent tariff revenue loss of 0.03 percent
ADB (2019)	GTAP model A) a) Full tariff B) b) Full tariff, NTMs C) C) Full tariff, NTBs, and TFA	real income: **a)** 0.1 percent, **b)** 1.25 percent, **c)** 3.5 percent Intra-Africa trade: **a)** 14.6 percent, **b)** 107 percent **b)** Africa export 44 percent, import 35.7 percent; **c)** Africa imports 40 percent, rest of the world –0.8 percent
World Bank 2020	Recursive CGE-GIDD, a) a) gradual 97 percent tariff reduction b) b) tariff 97 percent, NTBs 50 percent, and TFAs 50 percent capped at 10 percent	Overall, 7 percent real income from full implementation a) A) 0.22 percent real income b) 2.4 percent real income b) Employment for unskilled and females, which fills the wage gap and inequality c) GDP 4.20 (413 billion USD), African trade by 29 percent, intra-exports 81 percent, extra-export by 19 percent
IFPRI (Bouet et al., 2021)	MIRAGRODEP global CGE with GTAP 10 A, full tariff cut B, 97 % tariff & 50 NTBs	GDP a, from -0.3 to 0.3 b, -0.2 to 0.3 Intrtrade 15% increase from the baseline by 2035

Source; Author's compilation

and trade to different countries after the reform may be excluded in simulations, undermining the projected benefits. Furthermore, using the initial trade shares in the simulation gives a lower share of benefits or costs of the trade reform, especially in African countries, as the initial or base year trade volume is relatively low.

Furthermore, many multi-country multi-sector CGE models in the ex-ante analysis produced strikingly divergent results due to their different experiments, data, behavioral parameters, and theoretical features (Bouët, 2008). The behavioral assumptions and the methodological uses are other sources of divergence. Still, CGE models are the most commonly used tools in the ex-ante analysis of policy reforms. Gravity models are also used in trade reform analysis; however, they are less common in simulations as results are limited. Several studies have simulated the possible welfare, trade gain, poverty, and government revenue effects of AfCFTA at the country-level and for the continent or sub-regions. Many papers also analyzed the impact at the sector level, especially in agriculture.

The tariff and nontariff elimination scenarios used would significantly influence the result variations. While some studies, such as (Carrico et al., 2020), used the lower Harmonized System (HS) level disaggregation to apply tariff eliminations on vegetables and fruits in partial equilibrium analysis, other studies used GTAP-adapted HS6. Furthermore, whether the static or dynamic version of the model used in the analysis also takes different assumptions that produce mixed results. The model's dynamic version considers the changes throughout the implementation time (for instance, year on year), whereas static models only compute the change at the exact end of the simulation or implementation time. The time of the trade barriers (tariff and nontariff) elimination significantly affects the gain from the trade reforms. While some studies recommend complete tariff reductions (Jensen et al., 2015); Mevel et al., 2012; Saygili et al., 2018), others, like the (World Bank, 2020b), promote gradual and progressive eliminations. Furthermore, studies on the sectoral impacts of AfCFTA indicate that agriculture and food trade contribute more to the gain (Mevel et al., 2012; Carrico et al., 2020) than manufacturing (World Bank, 2020b; Abrego et al., 2019). Any differentials in these outcomes cannot be ignored, as these generalizations are essential for policymakers and state parties to join and implement the agreement.

In the following sub-sections, we discuss how different factors that are either directly or indirectly related to the modeling affect the projected and actual outcomes of the AfCFTA. The lack of explicit adjustment costs in the modeling, the challenges and opportunities of overlapping RECs, the policy coordination challenges of Africa, the potential impacts of informal trade on the trade, gender gap, and welfare and public awareness are discussed along with others supported by information collected from different sources.

A. Baseline development and economic adjustment costs

Recent trade policy developments not yet reflected in the current GTAP database must be considered in the baseline development. The most recent GTAP v10 has the base year of 2014 and is almost the sole data source for all AfCFTA studies; however, changes have been occurring since then that can significantly affect the outcomes of policy change simulations. A prohibition of trade in a specific sector/country following a shock, such as disease outbreaks or pandemics, may result in zero trade record in the base year and no tariff for that commodity, which can significantly affect the simulation result in dynamic simulations (Nilsson, 2018). Therefore, such problems are prevalent in intra-African trade, which has a low level and diversification, ultimately affecting the dynamic simulation results of AfCFTA. The significant heterogeneities among African countries and RECs regarding GDP, population and cultural differences, trade among each, the distribution of free trade gain, and the distribution or concentration of some economic activities, such as manufacturing and value-added, need more attention and consideration in any AfCFTA analysis. African trade concentrates on some selected products, most from the south-SADC region and Northern Africa. This concentration of commodities in a few products and regions results in unevenly distributed gains from the AfCFTA.

Additional factors that may cause variations in the trade reform benefits among countries include the differences in data and estimation methods and times in the computations of elasticities of substitutions. The values of elasticities of substitution for the source of origin of commodities could result in different welfare measure outcomes (Mold et al., 2017). The IMF's study used the Caliendo et al. (2015) estimates for the elasticity of substitutions for NAFTA countries. This use of substitution measures poses at least two minor problems. First, despite the NAFTA member countries are from the LDCs and DCs categories, Africa's value would have some biases. Second, the behavioral differences in these two big groups of countries would also bias the simulation results as the substitution effect significantly affects the welfare measures in the CGE models, as corroborated in many empirical studies.

In CGE models, macroeconomic balances, such as government budgets, external accounts, and savings-investment relationships, are maintained through closure rules, which define how the economy adjusts to shocks. Model closures have important implications, especially concerning welfare measures. The closure rule does not influence the calibration or the base results whereas the implication is significantly critical and imperative in the policy shocks impact. The neoclassical approach and the steady state often called the "conservative" closure, are the two most commonly used. The former fixes the factors of endowments and allows the market price to adjust employment, while the latter allows capital stock to adjust (endogenously) by fixing the rate of return. Thus, the current account is fixed in the second case,

whereas investment adjusts to accommodate the change in total savings from an exogenously constant saving rate (saving is a constant percentage of income). In contrast, in the first closure, the global investment is responsive to the rate of return that affects the savings and current account balance. These closure rules should be contextualized with the study objectives, economic context (developing vs developed) and data requirement for some mixed closure rules. For instance, for government budgets, flexible government savings (fixed spending and tax rates) allow savings to adjust, reflecting stable fiscal policies but failing to capture tax policy impacts. Alternatively, fixed government savings require tax rates to adjust, enabling fiscal policy analysis but assuming unrealistic tax flexibility. For external accounts, a flexible exchange rate closure fixes foreign savings and lets the exchange rate adjust, suitable for economies with stable capital inflows, while a flexible foreign savings closure fixes the exchange rate and adjusts foreign savings, ideal for aid-dependent economies but less applicable for exchange rate-focused studies. In the savings-investment balance, an investment-driven closure reflects growth-oriented scenarios where savings adapt to fixed investment, though it risks overstating savings flexibility. Conversely, a savings-driven closure sets investment to match fixed savings, fitting savings-constrained contexts but overlooking investment's role in growth. A balanced closure, adjusting savings, consumption, and spending, offers realism but adds complexity. The choice of closure depends on the economic context - developed economies favor investment-driven closures, while developing economies often use savings-driven - and research objectives, such as welfare analysis or growth simulations.

Not all the CGE ax-ante studies can include the current changes in Africa's socio-politics and policy environments. Shocks like COVID-19 and the Russia–Ukraine war have ramifications on trade and related policies that could have a long-lasting effect, and other alterations on the ongoing reforms should be addressed in the model scenarios and closures. For instance, tax policies may compensate for the tariff revenue cut after the tariff liberalization to balance the fiscal burden of governments, which has been increasing due to many factors.

Trade liberalization involves costly short-term macroeconomic adjustments. Choudhri et al. (2006)), indicating that there are losers and winners; therefore, different compensations must be prepared and implemented for the losers (Dixit et al., 1986; Dixit et al., 1980; Davidson et al., 2006). Adjustment costs are costs related to the transfer of resources from one (less productive) to the other (productive or competitive) (Cordoba et al., 2006); thus, the main challenge in this regard is whether the gain covers all losers and how the losers should be compensated. Furthermore, adjustment costs are borne before the benefits reap, making trade agreements fragile and less implementable during the early stages (Bond, 2008). Conversely, the decision of gradual or just complete liberalization depends on the cost of the resources transfer from the less competitive to the competitive.

The EU, WTO, and East Asia (to some extent) had undertaken integration in investment, service, and agriculture after a substantial integration in manufacturing goods (Bond, 2008). Although trade improves income, the fear of adjustment costs makes policymakers reluctant to implement trade reforms (Tarr et al., 2005; Cordoba et al., 2006). Globalization (trade) has created massive efficiency gains and fueled sustained, trade-led economic growth; however, it also sometimes results in permanent losses in living standards, employment opportunities or wages, and other working conditions due mainly to governments failing to make economic adjustments (European Commission, 2021). The short and medium-term labor adjustment cost of AfCFTA is less known and has not been modeled in most previous studies; however, empirical studies corroborate that this cost would be very high. Therefore, despite the application of various models and scenarios to explore the potential benefits of the AfCFTA; there are numerous factors that can significantly affect both the projected and actual outcomes such as the quality and coverage/scope of data, model, and assumptions; the lack of explicit adjustment costs from the resource mobility and sectoral specializations.

B. **Overlapping RECs memberships and AfCFTA implementation opportunities and challenges**

The success of the AfCFTA depends on various political, historical, and institutional factors. Most previous studies agree on the prominent role of each nation's commitment to implementing and domestically harmonizing the AfCFTA; however, overlapping REC memberships can complicate implementation. The different integration levels that stretch from FTA to TFTA and the customs union need customized treatments and governing rules. While the already well-integrated countries within the RECs need few adjustments for the AfCFTA, others, especially those in shallow RECs that are more protective, require more AfCFTA liberalization, resulting in a differentiated tariff elimination process among countries. For instance, how LDCs and non-LDCs countries within the same customs union will liberalize differentially as per the AfCFTA modalities remains challenging (Gumede, 2020). The sub-optimal performance of regional trade arrangements in Africa arises from the considerable cost differences among the members due mainly to an RTA having three outcomes: decreasing welfare or trade diversion; low trade complementarity among RTA members; high NTBs within the blocs (high trade costs, i.e., 'hard' infrastructure-transport costs and 'soft' infrastructure-harmonized rules and regulations) and a high degree of diversity among RTA members (De Melo et al., 2021). The resource-abundant vs. resource-poor, landlocked vs. coastal, artificial borders, cultural, monetary, and other differences result in diverse interests among RTA members.

The low value and diversification of intra-Africa trade are also concentrated in some countries and sectors. According to (African Export-Import Bank, 2022; Mirito,

2022), South Africa alone contributed 32 percent and 13 percent of intra-Africa exports and imports during 2019–2020. Of the 26 billion USD value of intra-Africa trade, agriculture accounts for 22 percent and 14 percent of exports and imports, respectively. SADC member states and Uganda from the EAC contribute the most to intra-trade. Intra RECs trade share also shows a highly dispersed pattern; however, Africa has a limited agricultural competitive advantage in the global market (Sithole, 2021; Africa Agriculture Trade Monitor, 2021). This heterogeneity in the share of participation in the continents' trade can make the AfCFTA gains uneven, as the extant literature corroborates.

Another example is the AfCFTA relationship with the recently finalized Tripartite Free Trade Area, which covers three RECs (EAC, SADC, and COMESA); (Chidede et al., 2018). Thus, its success depends on the conditions of eliminating all barriers to trade, good governance, and infrastructure development, including information communication technologies (Moyer et al., 2021 ; Gumede, 2020). Lacking or diminished trade diversification and a much-diversified language and currency inspires Africans to create an AEC. Despite some efforts toward creating a single currency (Nilo) for the AEC, the debate regarding the African language remains unresolved (Gumede, 2019). Although the overlapping membership of countries at different RECs is seen as an advantage in distributing risks and benefits, the challenges related to different regulatory requirements for each REC are undeniable. African RECs' intra-trade is characterized by the lack of regulatory coherence, transparency, and the "spaghetti bowl" effect of overlapping, incompatible, and sometimes contradictory trade policies, regimes, and laws. These are some of the challenges that may significantly limit or at least make uncertain the above empirical simulation results. Thus, as the existing RECs would help the implementation of AfCFTA by sharing risks, enhancing the implementation and negotiating power of countries, the inconsistences regarding the coming up with a common currency, common external tariff determination, highly concentrated trade features in a few RECs and other existing institutional and structural hurdles poses a significant difficulty in implementation of the policy intervention at hand.

C. Africa's intra-trade tariff and non-tariffs reduction performance

Article 13 of annex 5 of the AfCFTA establishment document requires governments to prepare a national time-bound matrix, i.e., their strategies for removing NTBs categorized by the Annex. Even though the existing RTAs have significantly reduced the tariff trade barriers, other barriers, such as weak infrastructures (transport, communication, and information and exchange costs) and corruption (abusive controls and illicit payments from corridors), remain obstacles to trade in SSA (Melagne et al., 2021). Technical barriers, customs procedures and costs, and local regulatory conditions (costs linked to local distribution and pricing policy of agri-food stuff)

are other impeding factors of SSA's agri-food trade. The weak productive capacity, limited role of the private sector in regional integration initiatives, low levels of diversification of traded products, the small size of consumer markets, and the quality of institutions are responsible for the low intra-Africa agricultural commodities trade (Africa Agriculture Trade Monitor, 2018). Almost all studies agree that although tariff reductions or gradual eliminations generate positive gains that can surpass the government revenue loss, nontariff and trade facilitation implementations are the most vital source of gain. Countries are expected to reduce NTBs as they are in the hands of individual countries (Mevel et al., 2012; Jensen et al., 2015; Nicita, 2018). UNCTAD defines NTBs as "*policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both.*"

The impact of NTBs on African trade surpasses the traditional tariff barriers (Carrère et al., 2011). Therefore, given that the agreement allows LDCs longer tariff phase-down periods of 13 years for sensitive products versus 10 years for non-LDCs (African Union, 2018), some RECs may face difficulties in resolving tariff liberalization (Hartzenberg, 2019). As used in the ex-ante analysis in the AfCFTA case, implementation of nontariff barriers has many challenges in the data sources, measurement, and application of the models. A few studies only modeled the impact of NTBs on AfCFTA using various data sources. Those studies (African Development Bank, 2019; Abrego et al., 2019; World Bank, 2020b) used different nontariff reductions. Some of these scenarios are against the actual African context of global competitiveness and reduction of NTBs (as discussed above), such as a 100 percent elimination, which is less probable for developing countries that are highly fragmented and less efficient in nontariff measures reductions. Despite the global tariff reductions in the past decade, NTBs have shown incremental changes (Nicita, 2018). As reported in the World Economic Forum, most African countries' global competitiveness also deteriorated in the past few decades.

Tapping the potential benefits of AfCFTA requires urgent reforms to reduce the infrastructure deficit and other critical NTBs (Abrego et al., 2019), such as customs and administrative and document requirements, to impede the trade of goods that Africa struggles to produce. According to the World Bank's logistics performance index, African countries are not in the top 50s. From over 198 countries, South Africa's, among the best performer in Africa, overall logistics performance index value fell from 3.53 in 2007 to 3.38 in 2018, reaching an all-time high of 3.77 in 2017. In the World Economic Forum's global competitiveness index measure, a few countries, such as Mauritius, Rwanda, South Africa, and Botswana, ranked 45, 58, 61, and 63, respectively, among the 137 countries in 2018. Many countries' competitiveness ranks, such as Tunisia at 39, South Africa at 43, and Morocco at 64, fell to 59, 96, and 72 in 2018, respectively.

In a regional comparison of countries in the global rankings through time, Africa has not experienced any significant improvement; instead, some countries have lost their competitiveness. According to the Global Competitiveness measure, among the 20 less competitive countries, the number of African countries has increased from 13 in 2008 (out of 131 countries) to 17 in 2018 (out of 137 countries). While a few countries, such as Ethiopia, Uganda, and Cameroon, showed progress and escaped the least 20 performers list, countries like Mali, Chad, Burundi, Lesotho, Mauritania, Mozambique, and Zimbabwe deteriorated or showed no improvement. In general, the performance of African countries in tariff reduction through different trade arrangements showed a significant improvement, while the global competitiveness, NTBs, and trade facilitation were sluggish and had some structural nature; simulation on the impacts of AfCFTA needs to be carried out under realistic scenarios. This requires efficient estimations of the NTBs and trade facilitation tariff equivalent measures of Africa as these measures are the most significant source of gains despite the common data limitations of Africa.

D. External relationship of Africa with other trade partners and policy coordination

In the last decade, the African, Caribbean, and Pacific (ACP) Preferential Trade Agreements (PTA) with the EU have been proliferating on an asymmetrical basis, meaning the EU provides better market access for ACPs on a region-to-region basis. The various regional and country-level arrangements including the PTAs' signed and ongoing negotiations concerning the West Africa-EU, the Central African-EU, the East African Community-EU, East Africa-EU, Easter and Southern Africa, and the SADC-EU. Despite the custom union formation is not the focus of AfCFTA for the time being, the determination of a common external tariff is still an outstanding issue as many argued that the use of different external tariffs by different RECs complicates the determination and implementation. Thus, those agreements at the regional and national level with other countries and regions will complicate the negotiation and agreements towards a common external tariff. Despite a few exceptions, most of the existing studies (Simola et al., 2021; World Bank, 2020b; Abrego et al., 2019) did not consider the scenarios of the common external tariff that needs to be addressed in future studies.

There has been a slight improvement in African trade since the 2000s, mainly due to rising export prices, again attributed to the rise in demand for primary products by BRICS countries (Brazil, Russia, India, China, and South Africa) and investment (FDI), and the EU has remained Africa's leading trade partner (Kappel, 2021). Kappel (2021) argues that Africa has continued in the peripheral region losing its international investment share from 5.3 percent in 1967 to 2 percent in 2018. The AfCFTA has far-reaching consequences on Africa's external relationships that demand cautious model assumptions. The issue of determining the origin and common external

tariffs remains unresolved, as some, like ECOWAS and ECA, have different common external tariffs. Therefore, the access to the African market and the access to foreign markets by African exporters may be different across AfCFTA members, i.e. between countries that have signed an EPA with the EU vs. countries that have not. In reality, the free movement of goods and services within Africa will make the origin of African products hardly distinguishable. It could cause significant transaction costs for African exporters in the worst case.

There is a strong belief that industrialization precedes development or wealth accumulation and improves the standard of living (Peet, 1987). Africa has a very less diversified export and continuously increasing import dependence. Thus, a continental-wide trade agreement would have immense implications for macroeconomic stability (UNCTAD, 2022). Therefore, import substitution policies to protect infant industries and to increase self-sufficiency in strategic goods are commonly used among African countries. However, in free trade areas, like the AfCFTA, policy sameness can also be a potential trade integration problem in Africa and the AfCFTA (Olafuyi, 2019). Olafuyi, 2019 retrospective analysis argues that some industrial policy sameness among countries in some regional arrangements (i.e., the ECOWAS West Africa) is rendered ineffectively. For instance, a policy that aims at improving the competitiveness of national production will not work when other countries implement similar policies, i.e. subsidization of inputs. For this reason, policy coordination among the countries of the free trade area is needed for the implementation of successful industrial and agricultural policies. CGE models, however, are not able to include this in their modeling framework. In consequence, the gains of trade liberalization could be overrated particularly for protected sectors. Thus, beyond the internal policy copying among countries that will distort the industrialization or competitiveness objectives of Africa by adversely affecting the investment and trade of Africa, inconsistent external trade arrangments also complicate the applications of the AfCFTA concessions.

E. Potential Impacts of informal trade and public awareness

AfCFTA may help to formalize informal trade, which needs multiple regulatory changes to be brought into the formal system (Bouët et al., 2022). As the current database does not contain informal trade or made any kind of adjustment, the simulated impacts may underestimate the potential impact. AfCFTA can ease legal procedures, costs, time, bureaucracy, and other challenges and improve African trade. Informal Cross-Border Trade (ICBT), despite its heterogeneity across regions, countries, and products, accounts for a significant share of the total African trade. ICBT trade is mainly motivated by the high cost of formal trade, trade rules, and regulations, and less enforceability can have an immense role in the poverty reduction of Africa (Bouët et al., 2022). As informal traders, producers, and consumers are from the lowest income group, any improvement can significantly affect Africa's

poverty reduction and food security. ICBT constitutes approximately 60 percent of the regional trade of the continent, whereas it accounts for 30–40 percent of the intra-SACU trade (Olafuyi, 2019).

The share of ICBT rises in the country-level figure, reaching 20 percent of the GDP in Nigeria and 75 percent in Benin. In some other countries, ICBT exceeds official or formal trades. If AfCFTA is implemented successfully, ICBT can enhance the AfCFTA gains and reduce gender disparity. According to the Food and Agriculture Organization and Africa Union Commission (2021), 60–70 percent of cross-border traders are women, and women and youth account for 90 percent of Africa's informal workers. In Southern Africa alone, women account for 70 percent of ICBT traders (Macheng, 2021). By reducing tariffs, AfCFTA can make the formal trade system affordable, and other nontariff and trade facilitations also attract formal trade by lowering costs and enhancing efficiency. Therefore, AfCFTA's success in contributing to participatory and inclusive continental prosperity will ultimately be weighed against the hardships faced during its implementation.

Apart from the economic advantages of AfCFTA, many proponents argue that it can enhance people's political participation; however, a significant public awareness limitation exists. For instance, in Nigeria, a survey from the Centre for the Study of the Economies of Africa shows that over 60 percent of the surveyed businesses are unaware of the free trade agreement. Unless massive public awareness creation and training are provided to enable businesses to take advantage of the free trade arrangement, its costs and benefits may create unbalanced benefits and uncertain outcomes, i.e., short, medium, or long-run impacts. In other words, even if the projected outcomes are realizable, the benefits may not be collected by the expected time. In contrast, the Afrobarometer (Sanny et al., 2021a) survey report across different countries indicates that most countries (two-thirds) believe crossing borders for trade or work is complicated and very difficult. The figures from the report are very high, i.e., Gabon (82 percent), Mali (82 percent), Guinea (81 percent), Burkina Faso (78 percent), Côte d'Ivoire (76 percent), Botswana (41 percent), Angola (43 percent), and Namibia (52 percent). From a sample of 18 countries, an average of 66 percent of respondents felt it was (very) difficult to cross the border; only 21 percent of the sample thought it was easy.

Therefore, the successful implementation and enhancement of the impacts of AfCFTA hang on different domestic or national policies that each country could design and implement (World Bank, 2020b; Saygili et al., 2018). Furthermore, member countries vary significantly regarding public awareness, national implementation plans, and strategy preparation. Kenya is the pioneer in preparing the national strategic plan. The Kenyan national plan lists the objectives with its prioritized stakeholders, strategies, and institutions. For the AfCFTA to be a game changer, member countries

must adopt policies that enhance consistency between trade measures, diversification of objectives, and inclusivity; otherwise, the Free Trade Area may be restricted to a trade liberalization agenda and thereby not fulfill the hopes and aspirations of African people.

2.5 Conclusions

This chapter examined the research literature on the economic, welfare, and trade impacts of the recent implementation of the AfCFTA. We summarize the findings of existing literature but also provide a review of the methodologies and assumptions used in these simulation models. Despite the approaches, coverage, and data usage variations, most studies found comparable results. The results corroborate the positive potential gains from AfCFTA; however, these gains are primarily driven by the reduction NTBs and much less by tariff reduction. Moreover, the primary differences in the static and dynamic versions of the CGE model used, the market assumption, and model closure have a potential cause of result variation among the studies and the actual projected outcomes. Several studies used a static model that fails to account for dynamics. The projected outcomes show that the real income effect, from static-dynamic concerning tariff plus NTMs and trade facilitations (under perfect competition-imperfect competition), is optimistic. Intra-Africa trade is also predicted to increase from 33 percent to 82 percent (World Bank, 2020b; Abrego et al., 2019). Africa has the lowest intra-regional trade relative to other regions, such as Europe and North America, which indicates the country's potential to enhance the region's integration and trade. In partial equilibrium analysis, some studies also confirmed that AfCFTA could enhance the agri-food intra-Africa trade (by 22 percent) and the continent's food security. Conversely, the AfCFTA implementation's tariff revenue loss is modest, indicating that RECs have already effectively reduced the applied tariff rate; however, the predicted gains are from the nontariff reductions and trade facilitations. Africa has shown significant infrastructural development in the past few decades. However, its competitiveness in the global index has deteriorated in some countries or shown limited improvements, making the possibility of NTBs reductions doubtful, as the global trend also showed an increase in NTMs.

The gains from AfCFTA are heterogeneous among countries, regions, sectors, and even within countries among skill levels and gender; thus, we attempted to substantiate the effect of other factors, such as informal trade, public awareness, and readiness to trade under AfCFTA, and other model related factors. Implementing AfCFTA could reduce informal traders' costs, customs problems, and risks to attract to formal trade, and the gain from the agreement would be much higher than the models predicted by enhancing the tariff revenues and reducing the gender gap;

however, surveys from different sources revealed that public awareness and readiness to trade under AfCFTA are much low. Even if such factors and other security problems in Africa create potential threats, AfCFTA can continue as a potential regional coordinator; as its objectives aspire to surpass the trade to other political and strategic developments. Simple tariff and nontariff reductions alone cannot provide Africa's expected poverty reduction, inclusive growth, and transformation. Instead, whether Africa should prioritize industrialization, as seen in Europe, North America, and to some extent in Asia, over the agriculture sector or vice-versa remains a critical, unanswered question.

Chapter 3

Revisiting the impact of Trade facilitation Measures in Africa: Structural Gravity Approach

3.1 Introduction[1]

Over the past few decades, international trade has grown globally in a significant way, thanks to tariff reductions, RTA, infrastructure improvements, and the expansion of global value chains. For instance, in Africa, the number of RTAs increased from 15 between 1948 and 2000 to over 50 between 2001 and 2022. While RTAs have drastically reduced tariffs(Goldberg et al., 2023; UNCTAD, 2023b; World Bank, 2020b; Anderson, 2011; Wilson et al., 2004; Anderson et al., 2004), nontariff measures (NTMs) such as trade regulations, and behind-the-border barriers, such as bureaucratic inefficiencies, and infrastructural gaps contribute to the high cost of international trade and continued to increase in recent years(Hoekman et al., 2011; Nicita, 2018; Hendy et al., 2021), posing significant limitations on trade growth. This is particularly the case for African countries. Indeed, trade in Africa is characterized by high transaction costs, including transport and communication expenses, delays and charges at roadblocks, slow customs and administrative processes at ports and border posts, inefficient international payment and insurance mechanisms, and strict international trade standards (UNCTAD, 2023b; Porteous, 2019; Zaki, 2015). This is why trade facilitation is key for a deeper integration in Africa as it includes custom procedure harmonization, improving border management, upgrading infrastructure, and implementing single window systems. Thus, this paper examines the

[1]This chapter was published as: Wassie, M. A., Kornher, L., & Zaki, C. (2025). Revisiting the impact of trade facilitation measures in Africa: A structural gravity approach. The Journal of International Trade & Economic Development, 34(7), 1604–1634. https://doi.org/10.1080/09638199.2025.2519105. The research concept was jointly developed by Wassie A. M., K. L., and Z. C. Wassie A. M. did the data collection, preparation, analysis and the initial draft of the manuscript. All co-authors contributed comments during the revision process and approved the final version.

trade impacts of trade facilitation (TF) and computes ad-valorem tariff equivalents of trade facilitation for Africa.

Poor infrastructure in Africa has reduced economic growth by 2% and productivity by as much as 40% annually; domestic food prices are 13% higher than average due to Sanitary and Phyto-Sanitary (SPS) measures and NTMs that account for 50% to 60% of marketing costs in Sub Saharan Africa (Food and Agriculture Organization and Africa Union Commission, 2021). To overcome these challenges, international institutions such as the World Trade Organization (WTO), World Custom Organization, and UNCTAD have developed various trade facilitation initiatives and programs to reduce trade costs, promote development, and enhance trade. Trade facilitation has been proven to boost trade and real income worldwide by reducing the cost of trade, including in the LDCs (Sakyi et al., 2019; Beverelli et al., 2023). Despite these positive outcomes, trade barriers and regulatory differences still account for nearly 14% of trade costs, hindering trade and reducing global welfare, especially in African countries(International Chamber of Commerce, 2023; Beghin et al., 2021) constituting a significant proportion of the overall costs of trade in Africa(Johns et al., 2016).

In fact, these costs are higher in Africa than in any other developing region, which is a roadblock to integrating African nations into global markets and achieving greater intra-African integration (ElGanainy et al., 2023; De Melo et al., 2021; Rippel, 2011). Lowering costs for African agricultural producers and supporting the development of higher value-added activities in agribusiness, manufacturing, and services, including participation in regional and global value chains, require the improvement of trade facilitation. Moreover, there are additional costs of inaction on trade facilitation because African economies are exposed to international competition, whiletrade facilitation efforts globally make trading with African countries relatively more expensive (Bueno Rezende De Castro et al., 2023). However, the implementation of the AfCFTA in 2021 is an opportunity to redesign the continent's trade rules that facilitate intra-African trade (Wassie et al., 2022).

The agricultural sector is key to Africa's economic development (Baumüller, 2020). While Africa has shifted from being a net exporter to a net importer of agricultural products, Latin America, Southeast Asia, and India have remained consistent net exporters of agricultural products. The growth of global agricultural trade has been slower than that of other products for various reasons, such as the decline in agriculture's share of global GDP, limited expansion in the agricultural sector compared to industry, and trade-restricting policies in the agriculture sector (Anderson, 2022; Food and Agriculture Organization, 2017; Odjo et al., 2024). More specifically, NTMs are of particular importance in the agricultural sector in Africa. The rise in SPS has led to additional regulations and procedures, like increased customs bureaucracy, and complicated rules of origin that increased trade costs in countries with limited

export infrastructure (Kornher et al., 2024). Coupled with additional constraints, such as trade financing, security issues, and infrastructure, they still constitute significant trade barriers.

Nonetheless, multilateral trade arrangements had a significantly positive impact on agricultural products trade by reducing WTO-bound tariffs (Anderson, 2022). Thus, reducing NTMs and trade facilitation would contribute to the growth of trade in goods and services. For example, the World Bank (2020b) predicts that trade facilitation can significantly raise the real income of African countries by 2035. However, administrative impediments such as registration requirements can lead to a 15 % price increase on imported agricultural products. International harmonization of such trade measures can help reduce such costs (Goldberg et al., 2023; Disdier et al., 2019).

From a policy perspective, quantifying nontariff trade costs is essential to understand the potential benefits of trade facilitation. Even though measuring trade restrictiveness is difficult, studies use simple indicators that are not well grounded in trade theory and often only vaguely define the aspects of the restrictiveness of the trade regime they attempt to measure (Rodríguez et al., 2000). Therefore, sound and theoretically grounded trade restrictiveness measures are vital to predict trade impacts of trade facilitation (Kee et al., 2009). Indeed, several measures have been developed, and data have been collected by various institutions such as the Trade Across the Border and Logistics Performance Index (LPI) of the World Bank, the Trade Enabling Index (ETI) of the World Economic Forum, and different trade facilitation measures of the Organization for Economic Co-operation and Development (OECD), and UNCTAD. Time to trade has become one of the most important factors in determining business competitiveness (Hummels et al., 2004). Thus, reducing the time to trade can have immense benefits for international trade and developing countries like Africa. The impact of longer delays on trade is comparable to that of a tax on exports or imports due to the depreciation of goods (Djankov et al., 2010). In contrast, the ETI of the World Economic Forum's measures shows the extent to which the institutions, policies, infrastructure, and services facilitate the free flow of goods over borders and to their destination. The LPI is a World Bank measure to assess a country's overall logistics performance, considering factors such as the quality of infrastructure, and the time it takes to receive shipments.
Against this background, this study explores the possible effects of trade facilitation on trade flow and determines its ad valorem tariff equivalents (AVE) for specific products at a disaggregated level (using the HS2 classification for 97 products). To achieve this, time to trade (number of days to export/import) is used, and a structural gravity model is employed covering from 2006 to 2020. In addition, we simulate the effect of the reduction of time to trade in a partial equilibrium framework using the gravity model output.
The remainder of this paper is structured as follows. Section 2 reviews the empirical

literature. Section 3 presents the types of trade facilitation measures and their data sources. Section 4 is dedicated to the methodology. Section 5 analyzes the main results, and section 6 presents the counterfactual simulation. Section 7 concludes and provides some policy implications.

3.2 Literature Review

Trade facilitation measures reduce the costs and time associated with importing and exporting goods. These measures include simplifying and standardizing customs procedures, automating documentation, and improving transportation infrastructure. While there is a growing body of literature on the benefits of trade facilitation, data and methodological challenges still need to be addressed and there are unexploited areas in the studies of trade facilitation, especially for African countries (Heid et al., 2021; Piermartini et al., 2016; Shepherd, 2017; Shepherd, 2013).

Andersen (2003) argue that behind the border barriers that are part of trade costs are particularly high in developing countries. Baier et al. (2007) find that trade facilitation measures have a limited impact on trade, reducing trade costs by 1%, resulting in only a 0.7% increase in trade volumes due to market access, infrastructure, and institutional quality. The means of transportation also affects trade facilitation. Using US import data, Hummels et al. (2013) estimate consumers' time valuation and calculate the premium paid for air shipping and time lags for ocean transit. They found that a one-day delay in imports has a 1.3% AVE. In the same vein, Zaki, 2015 estimates the impact of time to export and import on bilateral trade flows among 138 countries from 2005 to 2011. The analysis shows that the time to export and import exerts a significantly negative impact on trade, with the impact more pronounced for perishable goods such as food and seasonal products. The impact of trade facilitation measures on trade is highly dependent on the specific measure being implemented, and the impact may be limited by factors such as corruption and political instability (Cadot et al., 2015). Thus, trade facilitation significantly impacts trade costs across countries and income groups, and it is more effective in promoting trade than traditional trade liberalization measures (De Melo et al., 2021).

Two of the most critical factors are the time required to complete a trade and the associated costs, which can greatly impact trading activities' overall efficiency and profitability. In this regard, (Kim et al., 2020) use five trade facilitation indicators, including time to clear border crossing, cost at border crossing clearance, cost to travel corridor section for a 20-ton cargo per 500km, speed to cross the region with delay, and speed to travel without delay. Their findings reveal that time is a more significant factor than the cost of imports and that a trade elasticity of 0.14 % is found for time to trade in the intraregional trade.

Minor (2013) makes a seminal contribution to the trade analysis by quantifying time delays as AVEs for over 6000 products at HS6 level and integrating them into the GTAP database. Utilizing estimates of Hummels (2007), which estimates the willingness of U.S. consumers and producers to pay for the reduction of one day of time in trade, computed product and country level AVEs that corroborates the heterogeneity across products that indicates the time sensitivities. After adjusting for missing values in the daily AVEs of products, AVEs of 0.7, 0.9, and 1.1% depending on whether the missing values were filled with zeros, included nonsignificant values, or excluded missing values, respectively. Notably, in African countries, the product-level AVEs are higher for items such as metals, vegetables, and food. This trend reflects the significant impact of time costs on perishable or complex goods. Conversely, basic commodities like forestry products, grains, and oil or gas exhibit lower AVEs, as they are less affected by time delays. It is essential to recognize that these estimates of time to trade data are derived from U.S. data, which may introduce certain biases.

Furthermore, studies on the impact of trade facilitation on value-added trade (e.g., Moïsé et al., 2015; Shepherd, 2017; Shepherd, 2022; Takpara et al., 2023) argue that trade facilitation is sector-specific in the global value chain and that border and transport efficiency are important for upstream food and beverage value chain participation in Sub-Saharan Africa (SSA). For instance, the nature of the product will determine the sensitivity of time (Minor, 2013). In the same vein, trade facilitation has become increasingly important for the resilience of the global supply chain. Progress in the areas of information availability, simplifying and harmonizing documents, and automating and streamlining procedures in both developed and developing countries are critical to the growth of trade (Sorescu et al., 2022). Fontagné et al. (2016) argue that better information availability, advance ruling, and appeal procedures mainly benefit small firms, whereas document simplification and automation tend to favor large firms' trade.

The literature on trade facilitation effects in Africa is relatively scant. Riedel et al. (2019) investigate the impact of African trade integration, focusing on the COMESA-EAC - SADC Tripartite free trade agreements (FTA) with data from 1995 to 2010. Using a gravity model with Poisson pseudo-maximum likelihood (PPML) estimations, the study finds that tariff barriers are one of the major constraints to trade and have a negative effect on bilateral imports. However, the impact of FTA is predicted to be less uniform. For instance, effects of EAC are positive while those for COMESA and SADC are mixed, suggesting other than trade liberalization complementary measures - such as trade facilitation and improved infrastructure-may be warranted to increase intraregional trade.

Meanwhile, Persson (2012) expands the impact analysis to the extensive margin of

trade for new products and shows that trade facilitation - measured by the number of days required for trade has a greater impact (0.6%) on differentiated products than on homogeneous products (0.3%). Additionally, countries' logistics performance significantly impacts their comparative advantage in the manufacturing sector, which has a high intensity of logistics use (Yang et al., 2022). Improving logistics is critical for export expansion, however, the specific logistics factor needs further studies. Individual indicators, such as reasonably priced shipments, the ability to track and trace shipments, and trade and logistical transit standards are identified as the most critical factors in the case of exports from Pakistan (Gul et al., 2023).

Another strand of literature focuses on estimating AVEs (Hoekman and Shepherd, 2015) of trade facilitation suggesting that trade responsiveness to trade facilitation is relatively low in advanced economies but may be higher in developing countries where trade costs are generally higher. Oberhofer et al. (2021a) find a negative significant impact of a one-day border delay AVE of 0.4 percentage points. However, most existing studies are at the aggregate or broader sectoral level, with few studies being firm-level analyses. Based on customs data for Egypt, Hendy et al. (2021) conclude that delays caused by administrative barriers hurt both the intensive (value of exports) and extensive (number of products and destinations) margins of trade.

For a more comprehensive analysis of the impact of trade facilitation, another approach involves a counterfactual simulation using a CGE model (such as Zaki (2014), which allows for an economy-wide examination of the potential effects of trade facilitation measures. A study by Francois (2019) analyzes the impact of the Trade Facilitation Agreement (TFA) on global trade and welfare and finds that the TFA could increase global welfare by up to $1 trillion. The benefits of the TFA would be shared across all regions and income levels. They also note that implementing the TFA would require significant infrastructure and institutional capacity investment, particularly in developing countries. Reducing trade costs in developing countries is crucial because even a small reduction impacts trade more than the ambitious Doha Round market access outcome, highlighting the need to complement market access commitments with measures to lower trade costs (Hoekman et al., 2011).

In addition to the TFA, there has recently been a growing focus on digital trade facilitation, which refers to using digital technologies to simplify and streamline customs procedures, such as electronic documentation and automated border clearance. A study by the World Bank (2020b) confirms that TFA will have a much higher real income effect from implementing the AfCFTA. However, the benefits of the implementation are widely dispersed across countries and sectors. In fact, a recent study by Bouët et al. (2022) argues that simply reducing tariffs may not significantly increase Africa's trade and welfare. According to a recent review of the AfCFTA literature, implementing trade facilitation has a much higher impact than tariff liberalization (Wassie et al., 2022). Therefore, it is crucial to have an ambitious implementation

plan for both tariff liberalization and NTMs to achieve the desired outcomes. The TFA of the WTO increased trade, particularly in agriculture, between developing countries that made commitments and worldwide agricultural trade increased by 5% due to TFA implementation, with total trade increasing by 1.17% (Beverelli et al., 2023).

In summary, the impact of trade facilitation measures on trade is central to trade policy. While some studies suggest that such measures can significantly impact trade, others argue that the impact may be less significant than previously understood. However, African countries are expected to benefit more from trade facilitation than tariff liberalization. This study assesses the trade impacts of different trade facilitation measures through a theory-based structural gravity framework and calculates AVEs at a detailed product level. Additionally, it conducts a counterfactual analysis to evaluate the effects of trade facilitation reductions on trade flows, aiming to enhance understanding of this underexplored area within the African context.

3.3 Data and Stylized Facts

This study relies on different sources of data. We combined an unbalanced panel data set of 164 countries to conduct our empirical analysis. We chose this number based on data availability from 2006 to 2020. As shown in Table A1, the number of years included in each data set varies. We began in 2006 because data on one of our primary variables of interest, time to export and import, was only available in 2006. To gather the remaining data, we used sources such as CEPII-BACI, World Bank Doing Business, World Economic Forum, World Development Indicators, and the World Bank Logistics Performance Index[1]. For more information on the available years and adjustments made before using the data, refer to Table A1 in the Appendix[2].

For trade facilitation, exporting goods involves three stages: 1) gathering all necessary domestic documents, 2) complying with border regulations and going through customs, and 3) transporting the goods domestically to the national port of departure. The World Bank collects data on the time taken to export and import through questionnaires from exporting firms, port and customs authorities, and domestic freight companies.

According to Figures 3.1 and 3.2, there is a difference in the time it takes to facilitate trade, as measured by the number of days it takes to export or import, across countries at different levels of development. The data show that countries with the least number of days have an average of less than 10 days to export/import, while

[2]Refer descriptive statistics in the appendix in Table A2.

top African countries have an average of more than 10 days. Interestingly, the average number of days it takes to export is lower than that of import across countries. However, for countries with the least number of days, the number of days it takes to export is higher than imports, in Africa and worldwide.

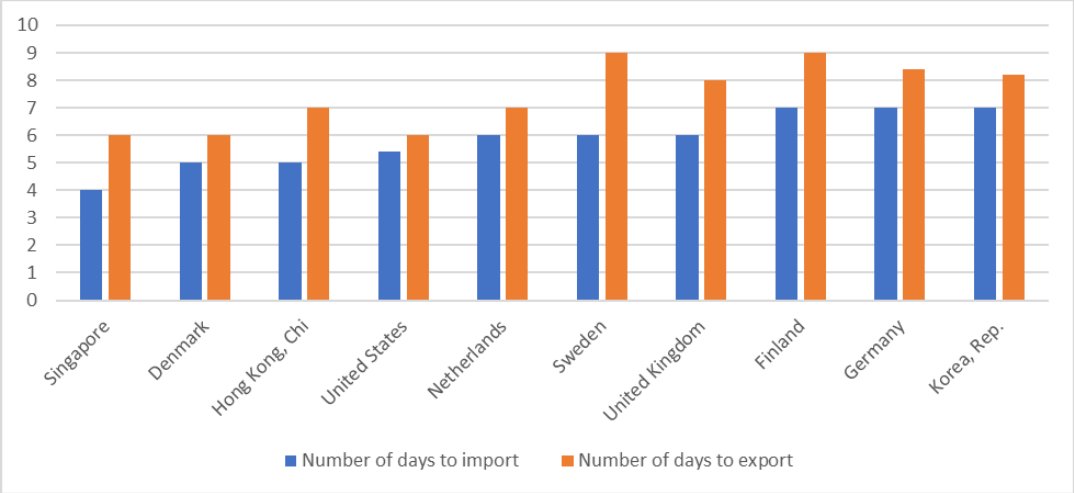

FIGURE 3.1: Average number of days to export/import in the top (shortest days) 10 countries – World level (2006-2020)

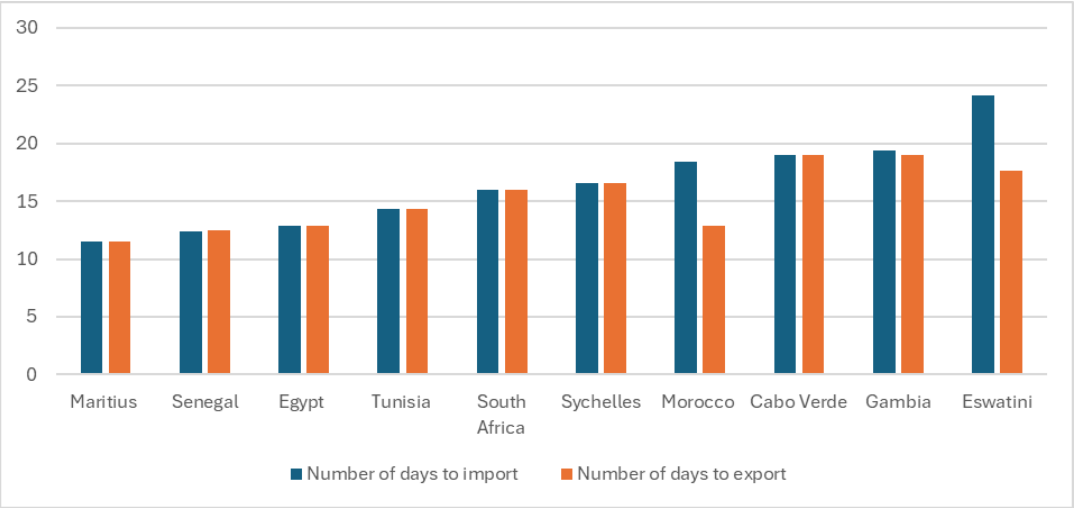

FIGURE 3.2: Average number of days to export/import in the top (shortest days) 10 countries – African level (2006-2020)

Figure 3.3 compares exporting and importing times at the regional level. North America has the shortest trade times, taking an average of 3.56 days to export goods and 3.98 days to import goods, reflecting highly efficient logistics in trade. In contrast, Sub-Saharan Africa is the most time-consuming, taking 20.34 days for exports and 25.52 days for imports, indicating critical delays in infrastructure or procedure bottlenecks. Relatively more efficient regions include Southeast Asia and Europe, where trade times have fallen below 15 days. Middle East and North African economies exhibit moderate efficiency in trade but lag behind Europe and North America. These disparities underline the need for targeted interventions in less efficient regions to improve trade infrastructure and reduce procedural delays.

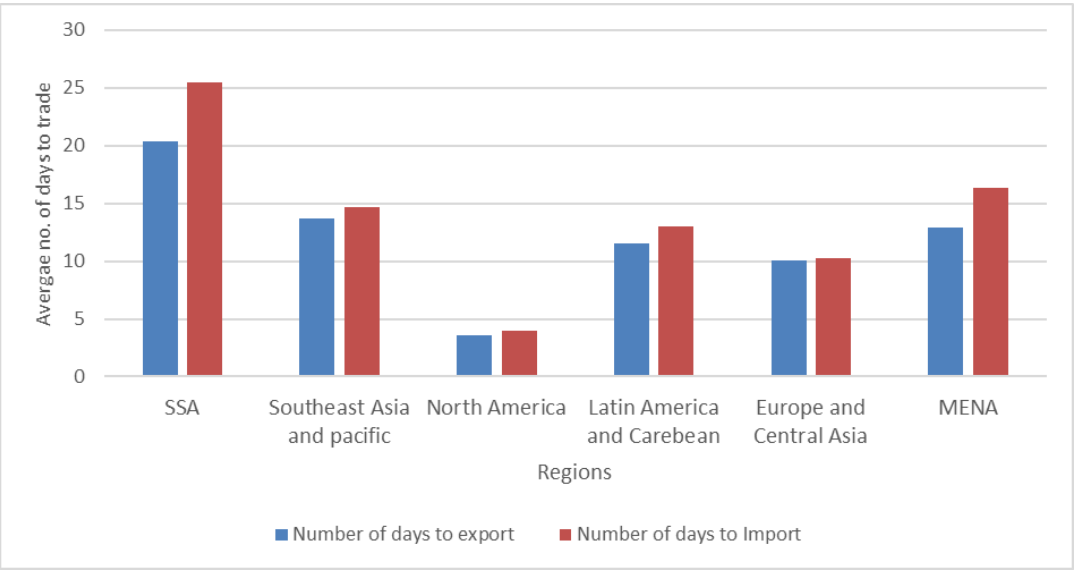

FIGURE 3.3: Comparison of Time to Export and Import Across Regions (2006-2020)

After presenting those different descriptive statistics, we proceed with the empirical part that estimates a gravity model.

3.4 Methodology

3.4.1 Theoretical Framework

The gravity model is the most common approach in analyzing trade and trade-related issues (Yotov, 2022). Its theoretical foundations, simple data requirements, easy interpretability, and strong predictive power make it a reliable approach for obtaining accurate results (WHITESHIELD, 2022). This paper follows, among others, Piermartini et al. (2016) and Heid et al. (2021) to estimate the trade elasticities of trade facilitation indicators and compute the AVEs across different countries and products.

The structural gravity model is used to estimate the trade flow impacts of the trade facilitation indicators. This model is specified as follows:

$$X_{ijt}^{k} = \exp\left[\rho_{it}^{k} + \gamma_{jt}^{k} + \pi_{ij} + \theta_1 \cdot (1 + \text{tariff}_{ijt}^{k}) + \theta_2 \cdot \text{TFI}_{ijt}\right] \cdot \epsilon_{ijt}^{k} \tag{3.1}$$

Where, X_{ijt}^{k} is the trade flow (import/export) of product k between country i and j at year t, tariff_{ijt}^{k}) is the applied tariff imposed by country j on the import of product k from country i at year t. TFI_{ijt} is the trade facilitation measures. ρ_{it}^{k}, γ_{jt}^{k}, π_{ij} are the importer-product-year, exporter-product-year and the exporter-product-importer fixed effects (FE). ϵ_{ijt}^{k} is the stochastic error term. The fixed effects in structural gravity measures multilateral resistance and bilateral trade costs better than the standard set of gravity variables (Egger et al., 2015; Agnosteva et al., 2014). The country pair fixed effects, absorb all possible time-invariant bilateral trade costs (Egger et al., 2015; Agnosteva et al., 2019) and mitigate endogeneity concerns related to the bilateral time-varying trade policy variables (Baier et al., 2007; Yotov, 2022)[3].

TFI_{ijt} includes bilateral time to trade [4], the logistics performance and enabling trade index. It is important to note that time to trade is unilateral and needs to be converted to bilateral to not be wiped out by the importer-year and exporter-year fixed

[3] See Table A2 for a summary of descriptive statistics of our main variables of interest.

[4] The bilateral trade facilitation measures were calculated using three methods: average, simple difference, and absolute difference. The latter two methods resulted in the loss of some observations when logarithmic transformation was applied. To address this, estimations were conducted with treatments, specifically by filling lost observations using the average of the positive difference values. Alternatively, estimations were performed with fewer observations (after dropping negative values), and the results do not change. The results are presented in the appendix in Tables A3 and A4.

effect. The bilateral trade facilitation measures are computed differently to be estimated in a structural gravity model that includes the aforementioned fixed effects. The equal-weighted average of the exporter and importer's trade facilitation measure is the first approach that presumed that one unit (for instance a one-day) change in the trade facilitation indicator has a similar impact on the trade flow of the importer or exporter side. The one-day delay is assumed to have an equal effect whether the delay is for the exporter or importer country. This kind of restriction has been presumed by prior studies such as (Heid et al., 2021). The other two approaches are the simple difference and absolute value of the difference in the number of days to export and import. Finally, the logistic performance replaces the time trade bilateral variable and enabling trade index for the two TF models.
We use the PPML estimator with a high dimensional fixed effect for the following reasons. First, following the works of Santos Silva et al. (2006), the structural gravity model is estimated in the multiplicative form of the PPML estimator that accounts for heteroskedasticity, which often plagues trade data. In addition, the PPML takes advantage of the information contained in the zero trade flows as it estimates the equation at a level, not in logs. Finally, PPML is the best approach to estimating theory-consistent general effects (Anderson et al., 2015). Following the The bilateral trade facilitation measures were calculated using three methods: average, simple difference, and absolute difference. The latter two methods resulted in the loss of some observations when logarithmic transformation was applied. To address this, estimations were conducted with treatments, specifically by filling lost observations using the average of the positive difference values. Alternatively, estimations were performed with fewer observations (after dropping negative values), and the results do not change. The results are presented in the appendix in Tables A3 and A4.

3.4.2 AVE Calculations

As the estimated coefficients are the quantity impact measures, they must be converted to price equivalent effects. The price equivalents of these quantity impacts are the AVE, which represents AVE as the domestic price effects of non-tariff or trade facilitation (Kee et al., 2022; Kee et al., 2009; Zaki, 2014).

The Average Tariff Equivalent (AVE) is given by:

$$\text{AVE} = \frac{\partial \ln(\text{Price})}{\partial \ln(\text{TFI})} \tag{3.2}$$

The above expression is linked with the gravity model, either using our own estimated tariff elasticities or trade elasticities from the literature and substituting them in the following equation:

$$\frac{\partial X_{ijk}}{\partial \text{TFI}_{ij}} = \frac{\partial X_{ijk}}{\partial P_i} \cdot \frac{\partial P_i}{\partial \text{TFI}_{ij}} = \pi_k \cdot \text{AVE}_k \tag{3.3}$$

$$\text{AVE}_k = \frac{1}{\pi_k} \cdot \theta_2^k = \frac{\theta_2^k}{\pi_k} \tag{3.4}$$

$$\text{AVE}_{(i/j)} = \frac{1}{\pi_{(i/j)}} \cdot \theta_2^k = \frac{\theta_2^k}{\tau_{(i/j)}} \tag{3.5}$$

Where, π_k and $\tau_{(i/j)}$ are tariff elasticities of trade for product k and/or tariff elasticities for importing/exporting country , respectively. θ_2^k is the trade facilitation elasticities of trade estimated at the product level. Finally, total AVEs to export/import are calculated at the product and country levels by multiplying the number of days by the estimated AVE of one day. Finally, country-level AVEs are calculated as the sum of AVE to export and import. [5]

$$\text{AVE}_{(i/j)} = \text{AVE}^{\text{imp}}_{(i/j)} \cdot N_{\text{days import}} + \text{AVE}^{\text{exp}}_{(i/j)} \cdot N_{\text{days export}} \tag{3.6}$$

The $AVE_{(i/j)}$ is total ad valorem tariff equivalents for the importer/exporter country i/j .

3.5 Empirical results

This section focusses only on the PPML estimation results[6] The computed AVEs are reported at the product level whereas the simulated trade impacts of time to trade reduction are reported by the country. Our estimation reported here is based on pooled data for the HS2-level products.

3.5.1 Impacts of time to trade on Africa-global trade

Table 3.1 shows that our results for trade facilitation are stable and consistent across the three computation methods.[7] These results are comparable to values found in the empirical literature. The PPML coefficients represent the percentage change in the

[5]The AVEs computation is limited to the time to trade. Yet, we do not make the same calculations for LPI and ETI as they are indices, which their economic interpretation when converted to AVE not reliable. This is why, we used them as robustness checks for the impact of trade facilitation measures on trade.

[6]Our analysis starts from the standard gravity model using OLS estimation. The results of the fixed effect are not reported here for the sake of brevity, however, available on request.

[7]To maintain a constant number of observations, we applied treatments to both the absolute difference and the simple difference. The results presented here are based on the treated data. For additional context, details regarding the loss of observations due to the logarithm of negative differences are included in the appendix.

dependent variable (bilateral trade flows) for a one-unit change in the independent variable. In PPML regression, unlike standard linear regression, the interpretation involves exponentiation of the coefficients, as the model accounts for non-linearity in trade flows[8]. In comparison to the previous literature, our results of -0.15 (-13.93%) and -0.13 (-12.19%) for imports and -0.17 (-15.7%) and -0.12 (-11.42%) for exports, however, are at the lower bound, but comparable to the results of prior studies of -0.41 found in (Oberhofer et al., 2021b) and -0.36 found in (Heid et al., 2021). This result suggests that an additional day to export and import reduces trade flows by 17% and 15%, respectively.

The lengthy border processing times have a detrimental effect on both imports and exports, but the impact is more pronounced on imports because the number of days required for imports is higher than that for exports. In fact, the average time African countries take for exports and imports is 23.8 and 26.8 days, respectively. Unlike previous studies focusing on exports or imports, this study analyses the different impacts of trade time on exports and imports, specifically focusing on African countries involved in global and intraregional trade. Africa is a region that has the highest trade costs and the least implementation of trade facilitation measures (Sorescu, 2023 ; Crivelli, 2023). The agriculture and manufacturing sectors face the highest costs or receive the most benefits from implementing trade facilitation.

Economies with higher costs for international trade have less trade facilitation that is linked with documentation and customs procedures. They are also subject to clearance and inspection requirements that entail costs in terms of time and uncertainty regarding the procedure's outcome, including possible rejection at the destination country (Piermartini et al., 2022). When we use the time to trade as a proxy for trade facilitation, we find that border delays significantly and negatively affect African trade. The estimate on time is statistically significant at the conventional level with a magnitude of -0.12 (-11.31%), i.e., a 1% increase in the average time to trade between two countries decreases the bilateral trade flow (import) by 0.12 (11.31%), 0.13 (12.2%) and 0.15 (13.93%) in the three bilateral TF specifications. This figure is similar to the findings of Oberhofer et al. (2021a) and Heid et al. (2021) who, using a slightly different setup (an intranational and international trade), found a coefficient of -0.41 and -0.36 for a one-day time to trade (export) reduction.

In contrast, the estimates of the time to trade on Africa's export flows to global partners have a significant and negative impact. However, the coefficients are smaller than the time impact on the import flow. Indeed, a 1% on average time to trade increase leads to a 15.7% and 11.31% export trade flow decrease in the two trade facilitation specifications of the average absolute value difference. Overall, the trade impacts of time are significantly negative, whereas the impact is much higher in the

[8] If θ is the coefficient of an independent variable (time to trade in our case), the percentage change in trade flows is calculated as $(e^{\theta} - 1) * 100$. The coefficients are reported and exponentiated in the bracket.

TABLE 3.1: Africaglobal trade impacts of time to trade

	Dependent: Import			Dependent: Export		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (1+Tariff)	-1.09**	-1.19***	-1.13***	-1.00***	-1.29***	-0.90***
	(0.84)	(0.04)	(0.05)	(0.04)	(0.28)	(0.04)
Ln (Time) ave	-0.12**			-0.17***		
	(0.06)			(0.03)		
Ln (Time) abs diff		-0.13***			-0.12***	
		(0.01)			(0.01)	
Ln (Time) diff			-0.15***			-0.05***
			(0.02)			(0.01)
Constant	11.84***	11.60***	11.66***	13.66***	13.55***	13.56***
	(0.19)	(0.09)	(0.11)	(0.08)	(0.05)	(0.04)
Importer-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer-product-exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1062363	1062363	1062363	659963	659963	659963

Standard errors in parentheses. *Note:* Standard errors are in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are run using a PPML high dimensional fixed effect estimator.

import flow. Our estimate of the direct effect of tariffs is consistent with prior studies both in magnitude and significance. Tariff effects of trade are negative and significant, at the lower bound of prior structural gravity studies of Oberhofer et al., 2021b between -6 and -5.5% and Head et al. (2014) find between -6.7 and -5%. The estimated coefficients of almost all variables are comparable in the three different methods of calculating bilateral trade facilitation indicators (simple average, the absolute value of the difference, and the simple difference of the indicators). Our estimations confirm that trade facilitation has a significant trade-enhancing effect in developing countries and much higher intra-Africa trade heterogeneously across countries and products, as shown by our AVE calculation and counterfactual simulations in the following sections.

3.5.2 Impact of time on intra-Africa trade

The coefficients of all indicators in Table 3.2 for the intra-Africa model specifications, have the expected negative sign and are statistically significant. The impact is slightly higher for import trade than exports and Africa-global trade. The results suggest that trade facilitation could significantly enhance intra-Africa trade (by 17.3% and 11.31% for imports and exports for a 1% time-to-trade reduction). While the share of intra-African trade has not grown over the past 15 years due to

high trade costs, trade facilitation can reduce this cost to boost trade within Africa (Bouët et al., 2022). This is why trade facilitation in Africa could have a higher impact on intra-African trade impact than on extra-African one. However, the impact is positive and significant on both inter and intra-African trade. According to prior studies of De Melo et al. (2021) and Zaki (2015), the time delay in African and developing countries' trade significantly negatively impacts both global and intraregional trade, with a higher effect on the intra-African trade than on global trade and greater impact on imports than exports. Improving trade facilitation in Africa can have significant policy implications for initiatives such as AfCFTA and other regional integrations. Africa is currently one of the least efficient regions for trade facilitation. Despite the ongoing debate surrounding Africa's trade share at the regional and global level (Bouët et al., 2022; Mold, 2021; Bouët, 2008), the need for improvement remains paramount.

TABLE 3.2: Intra-Africa trade impacts of time to trade (number of days)

	Dependent: Import			Dependent: Export		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (1+Tariff)	-1.11***	-0.92***	-0.26***	-0.11	-1.12***	-0.26***
	(0.02)	(0.03)	(0.08)	(0.08)	(0.08)	(0.08)
Ln (Time) avg.	-0.19***			-0.12***		
	(0.04)			(0.04)		
Ln (Time) abs diff.		-0.15***			-0.09**	
		(0.02)			(0.04)	
Ln (Time) diff.			-0.17***			-0.17***
			(0.05)			(0.05)
Constant	11.95***	11.92***	12.55***	11.95***	11.92***	12.55***
	(0.17)	(0.15)	(0.21)	(0.17)	(0.15)	(0.21)
Importer-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer-product-exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	199986	199986	199986	197345	197345	197345

Standard errors in parentheses. *Note:* Standard errors are in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are run using a PPML high dimensional fixed effect estimator.

3.6 Extensions

We extend our previous analysis in three ways. First, we introduce alternative measures of trade facilitation as it was mentioned before, especially those relying on the LPI and ETI indices. Second, as time to trade increase trade cost, we examine the nexus between them. Finally, time to trade can be costly for farther countries. This is why we investigate the relationship between distance and time to trade.

3.6.1 Alternative Measures of Trade Facilitation

The two significant trade cost determinants across all income levels and sectors are information and transaction costs as well as transport and travel costs (Piermartini et al., 2022; Rubínová et al., 2021), which are highly linked with countries' infrastructure and logistics performance. In this section, we examine the trade facilitation impact measured by both the LPI and ETI.

Some African countries have shown either stagnation or decline in their logistics performance in recent decades. According to Duval et al. (2022), the 2017 WTO trade facilitation agreement, which currently has only 10 African countries not participating, reduced trade costs between 1- 3%. The statistically positive correlation between LPI and ETI and exports and imports (see Table A5 and A6 in the appendix) signifies that logistics is an important determinant of international trade in Africa as improved trade-related logistics and competitiveness could facilitate more trade. A 1% improvement in the LPI index will increase extra-African imports and exports by about 2.83 and 2.33%, respectively, whereas the intra-Africa trade effect is 3.47 and 3.84% respectively. The estimates for LPI are positive and significant at the 1 % level. However, the effects of LPI on intra-African trade is higher than the effect on extra-African trade in the two specifications.

In the estimate of the ETI, we also find a positive and significant impact on trade. However, the LPI and ETI include trade facilitation measures other than the time to export and import such as infrastructure and transport quality, ICT use, and transport service efficiency. A 1 % improvement in the ETI index increases Africa's imports and exports with global trade partners by 1.90 and 1.42%, respectively. The intra-Africa trade impact is also positive and significant, at magnitudes of 1.44, 2.07, and 1.8%. However, the intra-Africa import impact is insignificant in the average bilateral specification. This is an important empirical finding regarding trade facilitation, as it has been shown in different policy debates that trade facilitation is the major determinant of trade. Nevertheless, although intra-Africa trade is growing, Africa trades more with the rest of the world than with itself. This result confirms that the impact of custom-related and infrastructural factors on international trade is significant and robust in Africa consistent with prior studies (Tandrayen-Ragoobur

et al., 2023; Donaubauer et al., 2018; Ismail et al., 2015; Francois, 2019; Nordås et al., 2004).

3.6.2 Trade Facilitation and Trade Cost

In order to further verify the reliability of our trade facilitation measures, we conducted two additional analyses. First, we performed correlation (see appendix, Table A.7) and econometric analyses using trade cost data (estimated trade costs in the Jacks et al. (2011) approach) from the World Bank and UN ESCAP. The correlation analysis revealed positive results, albeit with small coefficients. In our econometric estimation, we try to see how trade facilitation affects trade cost. This is why we regress trade cost on trade facilitation in addition to other variables. Table 3.3 shows that there is a positive and significant association between our time to trade measures and trade cost. Alternatively, we estimate the same equation using pair fixed effects as a control for other trade costs. The result confirms that our estimates are consistent. However, some variables are less significant (see Table A.9 the appendix).

In the analysis, we explore the impact of trade costs and trade facilitation on trade flows, considering the differences between exporter and importer perspectives. The model separates the effects of TF on trade costs (TC) and further on trade in two stages. The TC is calculated by subtracting the part attributed to TF, represented as the trade facilitation coefficient multiplied by the TF value. The resulting difference is then introduced in the second stage as an explanatory variable, alongside the trade facilitation variable, to examine their distinct effects. The findings suggest that while unexplained variations in time-related trade costs negatively impact Africa-global trade, they seem to have a more complex and even beneficial role in intra-Africa trade. This could be due to factors such as regional trade agreements or enhanced trade facilitation measures within Africa, which cushion the impact of time-related trade costs and promote trade within the continent. Furthermore, the impact of time to trade is consistent with the previous estimation in its negative impact and significance.

3.6.3 Trade Facilitation and Distance

In addition, we consider the effect of distance on trade, adopting the approach of Lin et al. (2023) by testing the interaction of trade facilitation and distance to determine if countries that are most distant and experience long trade delays exhibit higher trade costs.

TABLE 3.3: OLS Trade Cost on TF Estimation

	Dependent: TC (Africa-global)			**Dependent: TC(Intra-Africa)**		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Time trade diff)	0.03***			0.03***		
	(0.00)			(0.00)		
Ln(Time trade ave)		0.05***			-0.08***	
		(0.00)			(0.00)	
Ln(Time trade diff abs)			0.03***			0.04***
			(0.00)			(0.00)
Ln(1+tariff)	0.20***	0.19***	0.19***	0.23***	0.31***	0.31***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln(Dist.)	0.09***	0.10***	0.09***	0.16***	0.17***	0.16***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Adjacency	-0.30***	-0.35***	-0.34***	-0.26***	-0.29***	-0.30***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Common colonizer	0.08***	0.10***	0.10***	0.09***	0.13***	0.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Common religion	-0.01***	0.003	0.003	-0.06***	-0.04***	-0.04***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
RTA	-0.33***	-0.33***	-0.34***	-0.29***	-0.30***	-0.31***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-5.66***	-15.52***	-4.65***	-8.96***	0.59	-7.38***
	(0.32)	(0.38)	(0.29)	(0.80)	(0.97)	(0.67)
Observations	834184	834184	834184	183777	183777	183777
Adjusted R^2	0.86	0.81	0.86	0.89	0.84	0.85

Country and year-fixed effects were included in the estimation but, abstain from reporting for brevity purposes. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results in Table 3.4 show[9] the important role that trade facilitation and distance play in determining trade flows. The interaction between average time to trade and distance negatively influences trade flows in both Africa-global and intra-Africa contexts with coefficients of -0.23(-20.6%) and -0.19 (-17.3%), respectively. This would imply that greater trade delays, along with distance, result in disproportionately higher trade costs, although at a slightly stronger level for global trade. Independent from distance, it also shows implicitly that longer trading times significantly affect trade flows negatively by pointing to a need for improvement in customs procedures and diminishing delays. The disparities in trade efficiency among partners, as inferred from the large negative coefficients of absolute and relative differences in trade time, are another deterrent factor for trade flows, especially within Africa. Tariffs remain a high barrier: its negative impact is higher for intra-Africa trade at -1.73 compared to -1.24 for Africa's trade with the globe. These findings highlight the

[9]Country-product-year and country pair FE were included in both estimations. Left from reporting for brevity.

need for harmonization of trade facilitation measures, reduction of disparities, and tariff reduction under the AfCFTA-type frameworks as part of measures to improve trade integration and competitiveness.

TABLE 3.4: PPML HDFE estimation (trade impact of time to trade and distance interaction)

	Africa global			Intra-Africa		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (1+tariff)	-0.99***	-1.24***	-1.37***	-1.73***	-1.46***	-1.09***
	(0.05)	(0.06)	(0.06)	(0.05)	(0.04)	(0.06)
Ln (average time C dist)	-0.23***			-0.19***		
	(0.003)			(0.018)		
Ln (average time)	-0.17***			-0.19**		
	(0.04)			(0.09)		
Ln (abs diff time C dist)		-0.04			-0.03	
		(0.03)			(0.04)	
Ln (Abs diff time)		-0.13***			-0.15***	
		(0.00)			(0.00)	
Ln (diff time C dist)			-0.10***			-0.16***
			(0.04)			(0.06)
Ln (diff time)			-0.16***			-0.15***
			(0.05)			(0.07)
Constant	12.73***	13.40***	12.88***	12.71***	11.63***	11.19***
	(0.27)	(0.27)	(0.26)	(1.21)	(0.33)	(0.29)
Observations	1102794	1102794	1102794	113420	113420	113420

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.7 AVE results

The AVEs are computed using the trade facilitation coefficients from the product level estimation results (available on request) and the tariff elasticities of trade from the results of the regression, (Fontagné et al., 2022; Kee et al., 2009)[10]

Our computed AVEs are in line with previous findings that reducing the time to export and import has a strong trade-boosting impact on some products. The heterogeneity in the AVEs suggests the nature of product time sensitivity. Perishable products such as cattle (meat), vegetables and fruits, sugar, wheat, rice, and manufactured products are used as input for other products, and technological products are more time-sensitive. Products such as coal, gas, oil, and nonferrous metals from the energy sector and nonperishable manufactured products such as manufactured apparel, textiles, tobacco, paper and paper products, and manufactured rubber and plastics are less time-sensitive than those indicated by the lower bound values of the AVEs. Our estimates align with prior studies Sorescu (2023) that suggest machinery, plant-based and food products, electrical equipment, and wood products are the most affected sectors. Minor (2013) also find a high AVEs for items such as food, vegetables, and metals that reflects the significant impact of time costs on perishable or complex goods whereas conversely, basic commodities like oil or gas, grains, and forestry products exhibit lower AVEs, as they are less affected by time delays, for African countries.

[10] AVEs computed using the two (Fontagné et al., 2021; Kee et al., 2009) tariff elasticities are reported in the appendix Figures A3 and A4.

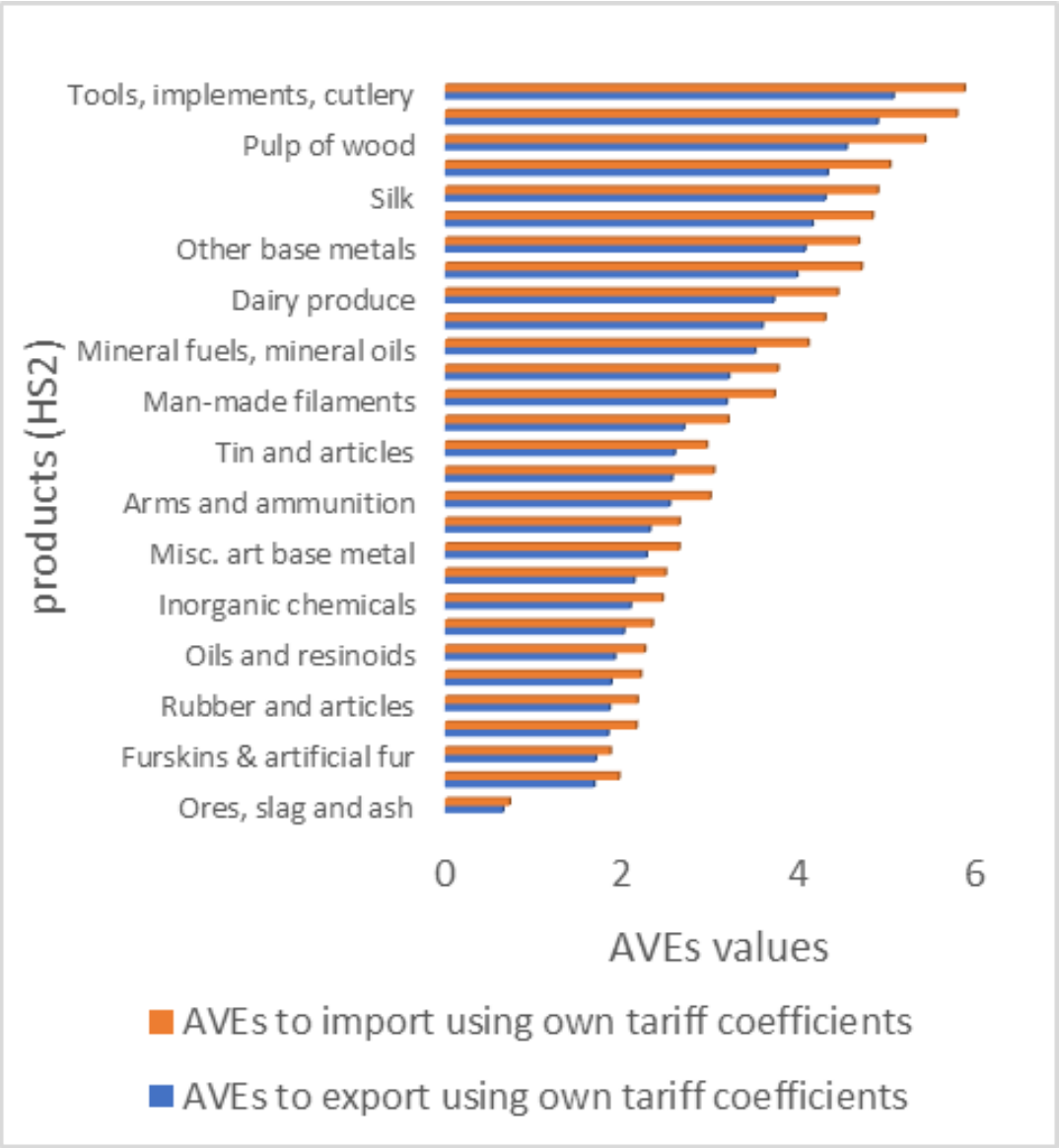

FIGURE 3.4: Panel A: AVEs of the least cost products
Source: Own compilation based on computed AVEs

classifications using tariff coefficients from our own estimations[11] The large trade-enhancing potential of time reduction at customs for developing countries is demonstrated by comparing AVEs across different groups. Given that clearance time is low in developed countries, their AVE is lower than in developing countries. Our computed AVEs are consistent with those of prior studies. For instance, De Melo et al. (2021) find AVEs range from 1.8% to 4.7% for Africa. Our estimated one-day AVEs for the Africa-global model are at the lower bound of the prior studies at 0.9%, with minimum and maximum values of 0.09% and 6.3%, respectively. Looking at the AVEs for time to import, we observe considerable variation across countries. Countries with higher AVE costs for imports from Africa including Rwanda, the

[11]Products are grouped into three equal groups to draw the graphs and the cost categorization as least, medium and high is Random.

FIGURE 3.5: Panel B: AVEs of medium cost products

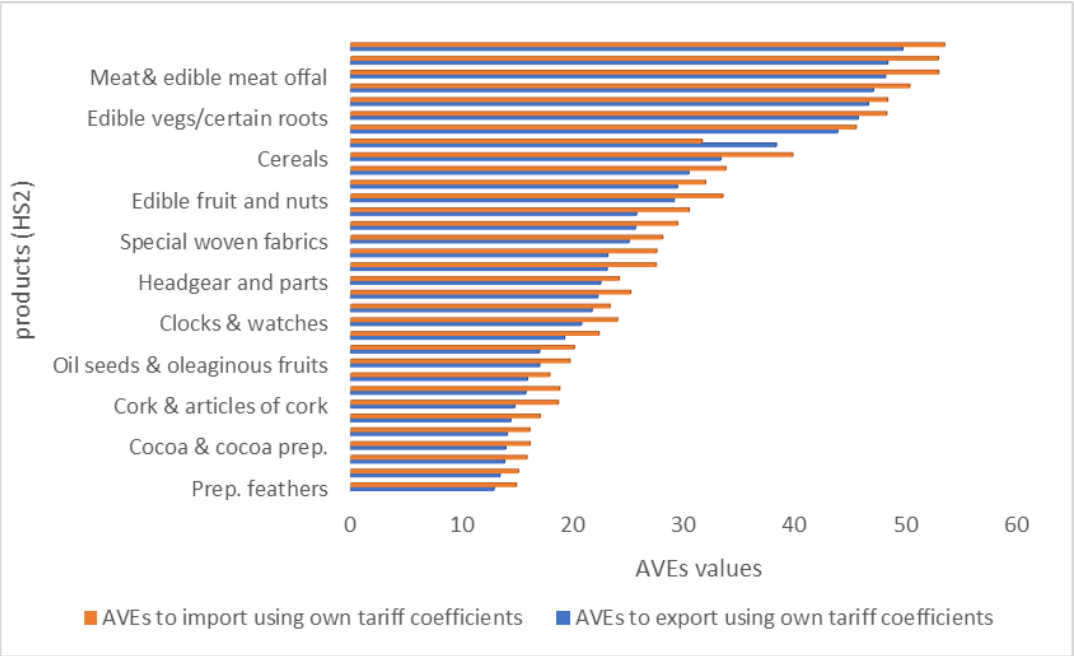

FIGURE 3.6: Panel C: AVEs of high-cost products

Central African Republic, Ethiopia and Togo have high AVEs of the time to export and import. These countries experience relatively longer delays of more than three weeks, which negatively affects their production, employment, and consumption of imported goods due to bureaucratic procedures, infrastructure limitations, and customs inefficiencies (Adom, 2022). They also have a cost of trade above the African average of USD 1,500 from document preparation, customs terminal handling, and inland transportation (Valensisi et al., 2013). Conversely, countries with small AVEs for imports, indicating a shorter time to import, demonstrate relatively efficient importing processes, which can be attributed to streamlined customs procedures, advanced logistics networks, and effective trade facilitation measures. Moving on to the AVEs for time to export, similar patterns emerge. Countries with high AVEs for exports could experience significant delays in exporting goods, hindering their competitiveness in international markets. Conversely, countries with small AVEs for exports, have an efficient export process, allowing them to access global markets and capitalize on trade opportunities. Advanced countries such as Germany, Ireland and Thailand take approximately 5 days or less on average to clear imported inputs (Adom, 2022). According to the World Bank (2020a) Doing Business Report, Singapore, the US, and Denmark have less than a week of days to import.

3.8 Simulation of trade impacts

To determine the impact of improvements in trade facilitation indicators (time to export/import) on the trade of Africa in the Africa-global specification, we develop

three scenarios based on the computed AVEs as follows:

1. If all African countries reach the AVE of the best African country, namely South Africa, that has the lowest AVE cost of time to trade. This is the moderate scenario.
2. If all African countries reach the AVE of the best country in the sample, which is the US, which is the most ambitious scenario.
3. If all African countries reduce their AVE by 50%, which is the most realistic scenario.

The simulated trade facilitation under the three scenarios significantly impacts the trade cost of countries with high AVEs before the simulations. Essentially, a reduction in trade delays at the port strongly impacts those nations with long delays, as we also showed in the regression analysis (see Table A.10). Developing counties by income group and SSA by region classification followed by Asia-Pacific and Latin America and the Caribbean, benefit from cost reductions due to trade facilitation (Sorescu, 2023).

Among the countries with longer trade delays, African countries (see Table A.11 for the complete list of countries) are the most affected. Regarding the scenarios, the second most ambitious, yet unrealistic, scenario of improving African countries' time to trade delay to the world's best performer the US, has the highest impact. AVEs are also larger in the case of reducing the time delay to trade by half than in the case of improving to the level of the best African countries, except for a few countries like Chad, Zimbabwe, Central Africa, Congo Republic, Niger, and Burundi. These countries have the highest trade costs (AVEs) overall and in the simulations.

In the more ambitious and realistic scenario of African countries reducing their time delay by half, all African countries will have a positive export and import trade increase. However, as countries have different AVE-costs, the trade impact is also heterogeneous. South Africa currently sets a high bar for efficient trade (lowest AVE), and if other African countries could match that level, then there would likely be positive impacts across the board. Under this moderate scenario, countries that currently experience long delays in trade (such as Central Africa, Burundi, Libya, Liberia, and Zimbabwe) could see a significant increase in trade. However, other countries such as Lesotho, Benin, Burkina Faso, Chad, Kenya, Uganda, and Tunisia may experience less than 1% change in their trade. Some of these countries have better trade logistic performance such as Lesotho, Tunisia, and Uganda. In other words, these countries are among the lowest AVE-cost countries that are potentially reflected in the lower trade impact on the simulations. The higher impact on import trade than export trade in Africa may be due to the structure of African trade, where major exports have lower AVEs and major imports have higher AVEs, which aligns with

the estimation results that higher trade facilitation coefficients have a greater impact on imports than exports. In the most ambitious, but unrealistic, scenario of African countries reducing the trade delay to the US level, the trade impact is much higher than the remaining two scenarios in a range of 24-48 % impacts. Hinz et al. (2022) also find similar results using a CGE model assessing the impact of the AfCFTA, as EU exports to Africa will increase by 32% due to trade facilitation. Overall, Africa has great potential to enhance its trade by reducing delays and bureaucratic processes that have slowed trade.

3.9 Conclusion and policy implications

To better understand the effects of trade facilitation measures, this study revisits the impact of trade facilitation on African trade flows at the HS2 product level and computes the ad valorem tariff equivalents. Using a structural gravity approach, this paper simulates the impact of trade facilitation in African countries. Our results indicate that trade facilitation has a strong positive and significant impact on Africa-global and intra-African export and import trade flows. Specifically, we find that border delay, measured as time to trade, has a strong negative impact on intra-Africa and Africa-global trade, imports and exports. A one-day time delay corresponds to a 0.9% AVE. However, the impact of such costs is relatively higher for imports than exports, both in terms of estimated coefficients and AVE calculations.

Second, AVEs are calculated at the product level to shed light on the cost differences among countries and products that are crucial for policy implications. AVE costs are heterogeneous across countries and products, corroborating the need for specialized trade facilitation policies. Developing countries stand to benefit the most from trade facilitation, particularly by reducing time delays due to various factors. We also find that developing countries experience the most protracted trade delays and have the least trade-enabling, logistics and infrastructure. As a result, they benefit much more than developed countries from reducing time delays in trade. Our analysis also confirms the sectoral heterogeneity in the impacts of trade facilitation, with agricultural and processed or manufacturing products the most time-sensitive products. In contrast, energy and mining-related products dominate African countries' export share and are the least costly.

Third, our counterfactual simulations confirm the positive impact of trade facilitation on different countries, especially intra-African trade, which increases by 30.2% and 12.7% in imports and exports, respectively, from the realistic and ambitious scenario of reducing the African trade delay by half. Countries with higher AVEs may consider implementing trade facilitation reforms, such as simplifying administrative

procedures, investing in infrastructure development, and enhancing customs efficiency, to reduce trade barriers and improve their competitiveness in global trade. Identifying countries with high AVEs provides policymakers insights into areas requiring attention and improvements. By addressing the underlying challenges and implementing targeted reforms, countries can enhance their trade performance, remain resilient in shocks, promote economic growth, and contribute to regional and global integration.

From a policy perspective, our findings have important implications. First, African countries benefit most from trade facilitation improvements in infrastructure, logistics, and customs administration, particularly those with long delays and weak infrastructural and logistics performance. Second, this is of particular importance of the implementation of the AfCFTA. If the latter focuses only on trade liberalization, its effect will be limited. Third, however, it is important to note that our results overestimate the impact of trade facilitation given that we do not take the cost into consideration. Indeed, the investment cost of trade facilitation should be taken into account. Clearly, both governments and international donors will need to invest more in trade facilitation in African countries to reap the benefits of this initiative and increase intra-African trade. Finally, trade facilitation, in order to work, will also need deep institutional reforms to make trade rules more transparent, fairer and thus more effective.

Chapter 4

Dynamic Effects of Climate-Induced Agricultural Shocks on Ethiopia's Economy

4.1 Introduction

Agriculture remains the primary source of livelihood for many African countries, contributing to GDP, trade, employment, and income. Nevertheless, this sector faces several challenges, such as insufficient infrastructure, the lack of adequate policy attention, and the effects of climate change. Despite agriculture being the predominant economic activity on the continent, Africa grapples with some of the highest rates of malnutrition, hunger, and food insecurity globally (Reardon et al., 2021; Garrity et al., 2012). Over the past few decades, the African economy has experienced notable growth, with an average rate of 4.5% (African Development Bank, 2024b). However, some countries, such as Ethiopia, have continued this vicious cycle of poverty and food insecurity. Droughts lasting for extended periods in some areas of East Africa and floods in parts of Southern Africa, along with prolonged and intense violent conflicts in the Sahel zone and the Horn of Africa, have led to increased food insecurity (World Bank, 2024a). The World Bank (2024a) estimated an adaptation and mitigation cost of approximately USD27.6 billion (cumulative terms) until 2050 in agriculture, livestock, sustainable land management, urban infrastructure, roads and bridges, and water storage for Ethiopia. This cost is equivalent to 3.6% of the cumulative GDP until 2050, approximately USD 0.6–3.2 billion annually. According to reports of the UNDP and OPHI, 2024, 71.2% of Ethiopians have multidimensional poverty, ranking Ethiopia the first in Africa. As the single independent second-most-populous country on the continent, Ethiopia needs a holistic approach to address this sluggish, if not regressive, poverty trend.

The Ethiopian government has been implementing different macroeconomic and

sectoral reforms to transform its economy, such as the successive GTP I and II, Homegrown Economic Reform (HGR), and agriculture-focused policies such as the Sustainable Development and Poverty Reduction Program, Participatory Accelerated Sustainable Development to Eradicate Poverty, and Agriculture-Led Industrialization in the past few decades. In a recent and ongoing 10-year national development plan, the government targets a growth rate of 10% annually that will ultimately help reduce extreme poverty to 7% by 2030. However, the recent report of the UNDP and OPHI (2024) shows that extreme poverty is exacerbated by over 40% and multidimensional poverty is approximately 72% is overwhelming. The plan targets macroeconomic stability and sustainable development to address climate change challenges. To address the threats posed by climate change, Ethiopia has articulated a climate-resilient green economy strategy, establishing itself as a leader in climate action. The Ethiopian government has signaled its strong commitment to adaptation. In addition, it has set ambitious mitigation targets, as articulated in its updated nationally determined contribution in 2021 and the long-term low emissions development strategy in 2023. However, the share of agriculture in GDP declined from 54% in 2000 to 32.0% in 2023, accounting for 62.8% of employment in 2022, which declined from 90.2% in 1990 (African Development Bank, 2024a). The share of other sectors remains small. For instance, the share of the service sector is 30% of employment, which has grown from 7.8% in 1990, and stagnated at only 7% in 2022, which grew from 2% in 1990. Therefore, agriculture remains the main livelihood of the significant population in the country.

Economic policies that aspire to food security and poverty reduction should focus on the improvements needed and the resilience of the population. The majority of Ethiopian agriculture is smallholder farmers, where commercial farms account for nearly 5% of the production (ESS, 2022). Meanwhile, temporary crop production accounts for approximately 72% of the land, whereas grazing and permeant crops cover about 10% and 9% of the land (Hausmann et al., 2022). Cereals take a significant share of land area and production amount. According to Hausmann et al. (2022), in the 2021/2022 production year, the three major crops, namely, cereal, pulse, and oilseed, produced by private peasants accounted for about 88.13%, 9.64%, and 2.23% of the crop production, covering the land area shares of 81.03%, 15.07%, and 3.90%, respectively. This boldly indicates how a few crops dominate Ethiopia's agriculture and are susceptible to climate change.

Ethiopia has faced multiple shocks that affected nearly all households, with approximately 91% of the population affected by persistent droughts, floods, locust invasions, conflict, or a combination of these issues (World Bank, 2024d). In addition, the COVID-19 pandemic in 2020 further strained households. Ongoing conflicts result in displacement and infrastructure destruction. On a macroeconomic level, these overlapping challenges, combined with structural weaknesses in the state-led growth model of Ethiopia—marked by significant policy and regulatory

distortions—have resulted in slow economic growth, diminished external competitiveness, escalating inflation, and increasing macroeconomic and debt vulnerabilities. Consequently, living standards have declined for the first time in over 20 years, leaving around 15 million people reliant on food assistance (World Bank, 2024b).

In a fast-growing population and with environmental and man-made challenges threatening the economy, a multifaceted approach to curtail its adverse impacts is essential. According to projections by the UN, the Ethiopian population will grow from 133 million in 2024 to 225 million in 2050. Ethiopia is facing severe drought, the worst in 40 years, causing significant challenges in arid pastoral regions. Climate change could further diminish agricultural productivity, which employs two-thirds of the workforce, particularly affecting vulnerable populations, further threatening food security, increasing regional conflicts, worsening health issues such as malaria and dengue, reducing labor productivity, and hindering human capital development (World Bank, 2024d).

Several studies have attempted to assess the impacts of climate change on agricultural output and its repercussions in other sectors (Belford et al., 2023; World Bank, 2024a; Ouraich et al., 2019; Sifiso et al., 2017; Montaud et al., 2017; Gebreegziabher et al., 2016; Calzadilla et al., 2013; World Bank, 2008). Studies in most countries found that climate change adversely affected their economies compared with the counterfactual of no climate change. Moreover, the results indicate that the impact is heterogeneous across sectors and households (Solomon et al., 2021; World Bank, 2008; Robinson et al., 2012). The yield of the major crops, namely, maize, and sorghum, will decline by 25.4%, 21.8%, and 25.2%, respectively, by 2050 compared with the no-climate change baseline (Solomon et al., 2021). For a decline in crop net revenue per hectare of 15.4%, a 31.1% agricultural GDP at factor cost by 2050 was projected. The impacts on GDP in 2030 will progressively worsen as the climate change-induced shocks become harsh (World Bank, 2008). As a worst-case scenario, the real GDP in the final year would be 46% lower than in the base run. Although productivity shocks occur only in the agricultural sector, the negative impact spreads across the economy. Prior studies on the microeconomics of climate change have provided a limited view of its impacts, with some solely focusing on the agricultural sector and only reflecting partial equilibrium effects on the economy. Although most of these studies indicated that climate change negatively affects the Ethiopian economy and varies by sector and location, they often struggle with data limitations, making it challenging to analyze how these impacts are distributed among households for better policy implications.

This chapter aims to address the above gaps using yearly projected changes in agricultural productivity from a study by Waldhoff et al. (2020) and projected future overall economic effects at the national level and for 10 income quantile households categorised by rural and urban areas in Ethiopia.

This study contributes to using of yearly and product-level climate change-induced projections to evaluate how fluctuations in agricultural yield are driven by climate change. Utilize a recursive dynamic CGE model. In addition, this chapter presents the basis of the CGE model developed for further analysis of the Ethiopian economy in relation to climate change versus trade liberalization, specifically the AfCFTA. The recursive dynamic CGE model simulation results indicate that the agricultural productivity shock resulting from climate change has a negative ripple effect on other sectors. It highlights that the Ethiopian economy is vulnerable to the impacts of climate change. Rural and urban low-income households will be the most negatively affected, bearing the heavy burden of climate change and exacerbating the income inequality effect caused by climate change. However, poor urban households suffer significant welfare losses due to food price inflation and the erosion of their real incomes. Trade impacts indicate that Ethiopia's main agricultural exports, such as coffee, pulses, and sesame, will decline significantly in both climate scenarios. At the same time, the manufacturing sector is expected to realize some export gains due to enhanced competitiveness. However, the overall trade balance deteriorates. Food price inflation will further erode the purchasing power of households, reducing welfare and deepening poverty in both rural and urban areas. In summary, the results indicate that the Ethiopian economy is vulnerable to climate change, primarily through its impact on agriculture, which has a robust yet indirect connection with other sectors. The ripple effects of decreased agricultural productivity extend throughout the economy, thereby slowing growth and negatively impacting food security.

4.2 Literature review

4.2.1 Climate Change and Agriculture

The impacts of climate change on agriculture have been extensively studied using two key approaches, as highlighted by (Lobell et al., 2017). The first approach utilizes historical climate data, specifically temperature and precipitation records, to estimate the impact on agriculture through econometric methods. These estimations are then used in conjunction with the projected climate variables to simulate potential future impacts. The second approach utilizes process-based crop models, which track the physiological needs of crops in relation to their ambient environment and changing climate. This method uses systems of equations to simulate the effects of climate change on agricultural output. What makes crop-climate modeling unique is the integration of GCMs with crop models to project the consequences of future climate scenarios on crop yields and agricultural production. This holistic approach

enables researchers to assess the potential magnitude of climate change impacts and identify strategies to mitigate risks.

Despite remarkable developments, agriculture remains the backbone of Ethiopia's economy. It contributes approximately 35.2% of the GDP, accounts for 80% of exports, and employs approximately 75% of the labor force. Diao et al. (2023)) reported that this sector is heavily dependent on rain-fed farming systems and highly susceptible to climate variability, increasing rainfall variability, and extreme weather events such as frequent droughts and floods that disrupt agricultural production and rural livelihoods.

The average annual temperature in Ethiopia increased by approximately 1.7 °C between 1960 and 2020, indicating a significant warming trend. Additionally, significant decreases in rainfall have occurred, with a particularly pronounced impact on southern and western areas, exacerbating water shortages and agricultural challenges nationwide (World Bank, 2024a). These changes outline the urgent need for adaptive strategies to adopt drought-resistant crops, improve irrigation infrastructure, and enhance climate-resilient agricultural practices, which could help protect food security and the rural economy in Ethiopia from the adverse impacts of climate change.

Ethiopia is one of the countries most susceptible to climate change, as its agricultural production significantly depends on rainfall, which accounts for a substantial portion of its GDP and employs the majority of its population (Conway et al., 2011; Bouteska et al., 2024; Admassie et al., 2021). The diverse topography of Ethiopia, characterized by various climatic zones, renders the country highly susceptible to various climate-related impacts (Shukla et al., 2021). Climate change is currently adversely affecting agricultural productivity in the region. Declined crop yields and livestock production can be attributed to increasing average temperatures, erratic rainfall patterns, and increasing frequency of extreme weather events. According to the International Food Policy Research Institute, climate change could reduce agricultural production in Ethiopia by up to 10% by 2050, worsening food insecurity and poverty in the country.

Other studies have indicated that these climate changes affect either directly or indirectly: For instance, Deressa et al. (2009) estimated net crop revenue per hectare using the Ricardian approach. They showed that climate change impacts in Ethiopia are seasonal and vary across agroecological zones. Under a parallel climate model scenario, they predicted a net crop revenue loss of 15.4% by 2050 and a 103.39% loss by 2100.

The World Bank (2008) employed a stochastic dynamic CGE model for Ethiopia to simulate agricultural productivity shocks resulting from historical climate trends

and estimated a 46% reduction in GDP from the baseline in the worst-case scenario. Robinson et al. (2012) projected a 10% lower GDP by 2050 using a dynamic single-country CGE model without externally funded adaptive mechanisms. You et al. (2010) examined the possible impacts of water constraints and flood damage on poverty reduction, highlighting the significant economic impacts of extreme hydrological events.

In a related study, Bezabih et al. (2010) examined the Tanzanian economy and found that, although the effects of climate change-induced adjustments would be minimal in the early years, they are expected to increase significantly over time. However, some impacts can be mitigated via adaptation strategies. In their study in Ethiopia, Gebreegziabher et al. (2016) employed the Ricardian approach within their CGE simulations and projected that climate change would result in a 30% decline in agricultural productivity over the next 50 years.

To fully mitigate the impacts of climate change, complementary policies focusing on climate-smart agriculture, irrigation expansion, and investment in agricultural technology are essential. In modeling adaptations, Yalew et al. (2017) examined the cost of planned adaptation in Ethiopia, advocating for a more proactive government policy to enhance agricultural resilience through a CGE model. Solomon et al., 2021 employed a recursive dynamic CGE model to examine the adverse effects of climate change on various sectors and regions, with the highest sectoral loss projected by 2050. Aragie et al. (2023) projected the far-reaching impacts of climate change pressure variations on catchment water flow and energy outputs in agriculture, which have significant effects on the agricultural sector and poor rural households. In a different setup, Aragie (2013) examined the impacts of climate change on the Ethiopian agricultural sector, employing time-series econometric analysis to establish a relationship between rainfall variability and agricultural output, using data from national and regional sources. In a simulation to forecast future impacts, the results indicate that Ethiopia has already lost over 13% of its agricultural output due to declining rainfall, with potential future losses exceeding 6% annually if current trends continue. The paper concludes that climate change exacerbates poverty by directly affecting agricultural productivity, highlighting the need for significant adaptation measures.

A World Bank (2024b) assessment highlighted how the increased frequency and intensity of weather events could reduce crop yields and lead to inflation in food prices, thereby widening economic inequality. The policy simulations derived from these models indicate that climate adaptation, such as infrastructure development and policy reforms that promote climate-resilient agricultural practices, can help offset projected economic damages. Moreover, integrating renewable energy and climate-smart agriculture into Ethiopia's development strategies sustains growth while reducing vulnerability to climate change. Although the Ethiopian economy

is at significant risk due to climate change, strategic adaptive measures informed by CGE modeling insights can foster resilience and sustainable development pathways.

Annual-level crop projections in CGE models are a valuable tool for analyzing the economic impacts of climate change, particularly in agriculture-dependent economies. These models integrate biophysical crop yield responses to climate variables such as temperature and precipitation, providing a comprehensive framework for assessing the economy-wide impacts on growth, income distribution, and sectoral outputs. By simulating the impact of different climate change scenarios over time, CGE models yield fundamental insights into the trade-offs and synergies that various adaptation and mitigation strategies imply, making them a firm input for policymaking. However, much of the existing literature has focused on national or global trends, leaving a gap in understanding how such projections can inform region-specific policies tailored to vulnerable agricultural communities. Therefore, this study attempts to fill that gap by incorporating annual-level crop modeling into the CGE analysis to assess the economic impacts of climate change in Ethiopia. The next chapter presents a detailed exploration of the adaptation options of trade liberalisation.

4.2.2 Ethiopia's Trade Reforms and Regional Integration

Ethiopia has been pursuing import substitution strategies and industrialization driven by agriculture from a trade policy standpoint. Between 2010 and 2020, Ethiopia implemented the Growth and Transformation Plan (GTP I and II) in two 5-year phases. Ethiopia saw notable growth during this period. The current Prosperity Party government's domestic economic reform agenda supports domestic industries and prioritizes the implementation of an import substitution policy. Since the administration took office (reformed) on April 2, 2018, various steps have been taken to increase exports. The accession to the WTO process has been ongoing, and frequent discussions and negotiations have continued despite the doom and gloom surrounding the future of the WTO. While some measures, such as digitisation and the reduction of trade difficulties, are beneficial, frequent policy changes are said to have a detrimental impact on traders, resulting in high trade costs at the port and elsewhere resulting from the uncertainty.

In November 2023, the Ministry of Trade and Regional Trade Integration (MoTRI) released a draft of sectoral trade policy for public review for the first time. This draft aims to enhance private sector involvement in domestic and global value chains, promote regional and bilateral trade integration, facilitate e-commerce participation, and attract foreign investment (MoTRI, 2023). While its objectives are mainly consistent with those outlined in the earlier GTP (I & II) national plans, the effort to create and execute a national sectoral policy reflects the government's dedication to advancing and developing the sector. This continuous commitment to reform is

necessary for Ethiopia to navigate the complex trade landscape, better exploit the opportunities, and withstand the challenges of implementing AfCFTA and overall regionalisation. The upcoming sectoral trade policy under MoTRI is a significant step toward creating a more coherent and supportive trading environment.

In a small survey of Ethiopian policymakers, this section presents the country's recent trade development for a better economic modeling scenario and insight into the AfCFTA implementation. This survey targets Ethiopian policymakers involved in trade and investment, with the goal of evaluating the overall trade environment and trade facilitation efforts within the country. Our primary objectives are to identify significant trade barriers, evaluate measures to enhance trade, and examine reforms to promote investment. We analyse the data collected from the questionnaires completed by these policymakers to gain insights into the trends in Ethiopia's trade—exports and imports—over recent years to draw lessons for economic modeling. Furthermore, the survey will delve into the various initiatives implemented to support trade, pinpoint the main challenges encountered in trade and investment, assess the impact of the COVID-19 pandemic on trade activities, and evaluate whether there has been a recovery since the onset of the pandemic. Additionally, we explore the expectations of trade-related policymakers concerning the AfCFTA.

The survey encompasses five key areas: the effectiveness of trade policy and comparative advantages; the institutional framework and integration into trade; trade facilitation and infrastructure development; digital trade and competitive advantages; and the resilience and adaptation of trade policy. These areas will help us address critical specific questions regarding Ethiopia's trade landscape.

4.2.3 Ethiopia's Trade Landscape: Challenges and Strategic Directions

Ethiopia's trade landscape presents a combination of opportunities and challenges, stemming from domestic policies, regional integration efforts, and global disruptions. The country's trade policy has been highly influenced by the developmental state model, primarily focusing on import substitution and agricultural-driven industrialisation. Over the last decade, infrastructure development — especially in energy and transportation — has been the core focus of both GTP I and II, serving as the foundation for industrialisation and export growth. However, these efforts have been weak in broadening the country's narrow export base, dominated by agricultural products such as coffee, sesame, and livestock (Okereke et al., 2019).

Ethiopia's trade deficit has persisted due to reliance on capital goods, machinery, and essential inputs such as fertilizer and processed foods imports. As the manufacturing sector grows, it has not yet reached a point where it can significantly help

reduce the trade imbalance (UNCTAD, 2024). Intra-African exports have seen modest growth but remain highly concentrated in a few sectors and destinations, mainly within neighbouring countries.

The country has also been a key player in regional trade integration, being a member of COMESA and IGAD. However, it has had minimal participation in intra-African trade. High tariffs and non-tariff barriers, inadequate infrastructure, and limited policy harmonisation with trading partners have constrained Ethiopia's ability to fully exploit regional agreements. Ethiopia's failure to gain accession to the WTO highlights the challenges the country faces in aligning its trade practices and regulatory frameworks with the requirements and standards set by the WTO. The AfCFTA presents an opportunity to enhance trade integration; however, this poses a significant challenge in terms of readiness and actual implementation in Ethiopia.

External shocks, such as the COVID-19 pandemic and the Russia-Ukraine war, have highlighted Ethiopia's vulnerability to global supply chain disruptions. These crises have accelerated the government's focus on import substitution policies and efforts to strengthen trade facilitation measures, including port efficiency and digital trade initiatives. However, inconsistent policy changes and high trade costs at ports continue to challenge trade performance.

More recent developments in Ethiopia include the introduction of a sectoral trade policy draft in November 2023, which aims to spur renewed commitment to addressing these structural issues. This should be complemented by encouraging private sector participation, regional and bilateral trade integration, and engagement in digital trade. In this regard, these adjustments underscore the importance of coherence at the trade policy level with broader economic reforms, thereby reinforcing competitiveness from both global and regional perspectives.

4.2.4 Ethiopia's intra-Africa trade

Ethiopia's export basket - dominated by coffee, vegetables, and oil seeds, accounting for about 90 percent of total exports in 2023—evidences its heavy reliance on agriculture (African Export-Import Bank, 2024). Ethiopia's total intra-African trade amounted to approximately USD 2.48 billion in 2022, accounting for 12.64 percent of its total trade, below the regional average of 14 percent. Djibouti, Kenya, Somalia, and Sudan were the destinations of over 89 percent of Ethiopia's exports to Africa. Somalia alone accounted for more than 48 percent of Ethiopia's total exports to the continent in 2022. The main export products to Africa were edible vegetables, certain roots and tubers, coffee, tea, maté, and spices. On the other hand, the countries that provided the bulk of Ethiopia's imports in 2022 were Morocco, Egypt,

and Djibouti, with a combined share of approximately 80 percent. The primary imports were fertilizers (58.8 percent), animal, vegetable, or microbial fats and oils (19.4 percent), mineral fuels, mineral oils, and bituminous substances (6.4 percent) (UNCTAD, 2024; African Export-Import Bank, 2024). Expanding its traded commodities and establishing new trade partnerships through the implementation of the AfCFTA would serve as an effective adaptation mechanism to climate change, as well as the economic and trade benefits the agreement offers.

Ethiopian traders encounter various challenges that hinder their operations. The country's trade relations with African nations are affected by high tariff and non-tariff barriers. Despite being a member of COMESA and IGAD, the latter primarily focuses on political issues rather than trade facilitation. Ethiopia's trade with other African countries is limited in terms of both the variety of products and trading partners. Its main export partners include Somalia, Djibouti, Sudan, and Kenya, while it imports primarily from Morocco, South Africa, and Egypt as depicted in figures 4.1 and 4.2. In comparison to other nations, Ethiopia's active participation in trade agreements and efforts towards tariff liberalization remain relatively limited, resulting in low levels of intra-African trade involving only a handful of countries and product categories.

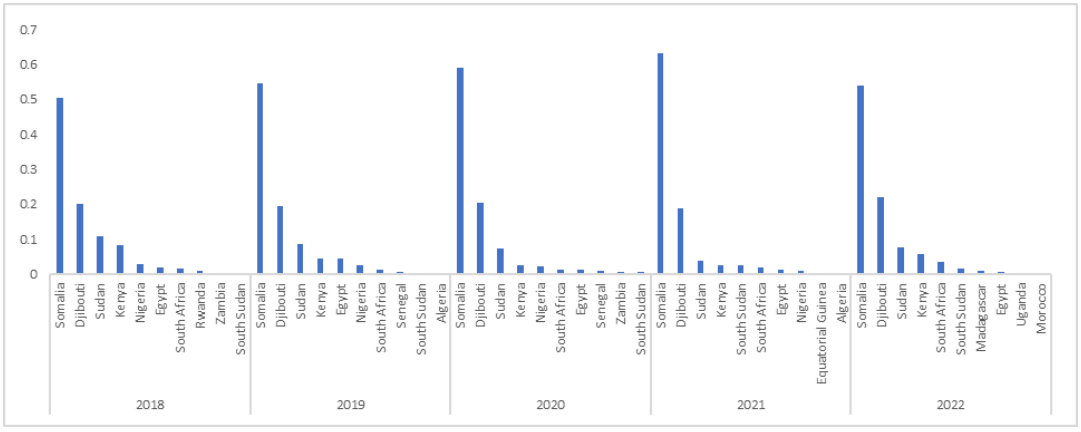

FIGURE 4.1: Top Ethiopia intra-Africa export destinations

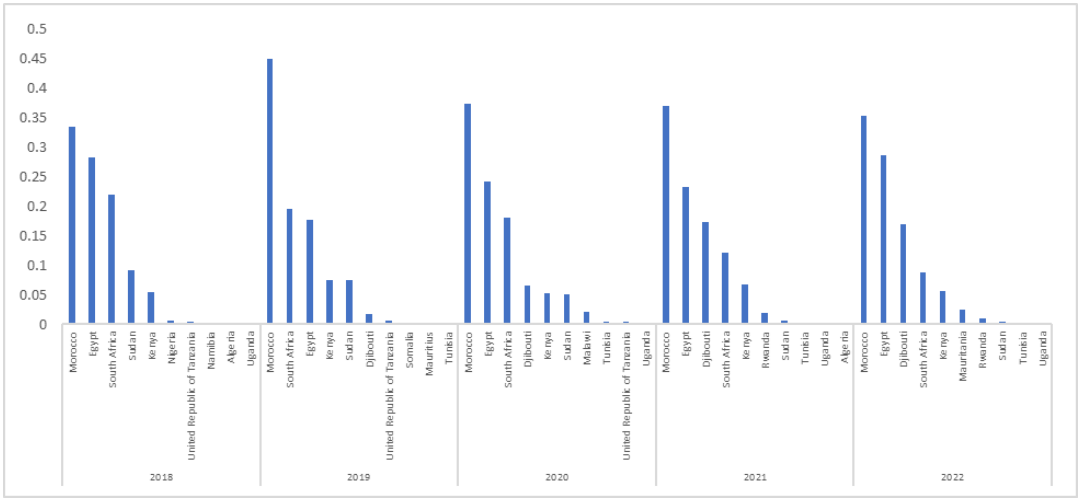

FIGURE 4.2: Top intra-Africa Ethiopia import

Despite the disruption caused by the Russia-Ukraine war in global trade, Ethiopia has turned to African countries, particularly Morocco, for fertilizer imports, a crucial agricultural input. The proportion of imports from Morocco, Ethiopia's top African trading partner, has decreased from 45% in 2019 to 35.3% in 2022. According to Figure 2.5 above, the five leading countries supply more than 90% of Ethiopia's imports from Africa. Conversely, Somalia is the primary recipient of Ethiopia's exports within Africa, followed by Djibouti. This concentration of countries as sources for exports and imports is characterized by a similar range of products, with vegetables and crops making up a significant portion of the trade.

This analysis is based on a survey of trade policymakers conducted from November 2023 to March 2024. The primary focus of the study is how the Ethiopian trade sector is evolving, the main obstacles identified by policymakers, and the expectations and frustrations regarding the AfCFTA implementation. The sampling strategy followed in this study is purposive sampling. First, offices participating in any trade and related sectors, as well as logistics in Ethiopia, are selected purposively. Even though there are regional trade and investment bureaus, this study focuses on the federal

offices only for the following reasons: 1) most of the activities and policies are designed and implemented at the federal level, and the regional mandates are limited; 2) the current political situation and difficulty travelling across all regions. Thus, six offices (see figure4.3) Ministry of Trade and Regional Integration, Ministry of Transport and Logistics, Ministry of Revenue, Ethiopian Customs Commission, Ethiopian Shipping and Logistics, and Ethiopian Maritime Authority in Addis Ababa were selected purposively. From these chosen offices, a high weight was given to the Ministry of Trade and Regional Integration, the central office responsible for the study question. Then, six samples from the Ministry of Trade and Regional Integration, five from the Ethiopian Customs Commission, four from Ethiopia Supply and Logistics, four from the Ethiopia Maritime Authority, three from the Ministry of Transport and Logistics, and two from the Investment Commission were selected. A total of 24 samples were included in the survey. Each office reached out first and discussed the research questions and objectives. The officials were selected based on discussions and the role of officials with experience and knowledge of the area. For instance, some officials are members of the AfCFTA negotiation and implementation committee.

The selected officials are clarified based on the research question, their direct or indirect involvement in the research area, and the neutrality of the study as an academic investigation, given the area's political sensitivity. The questionnaires are provided for completion after the discussion. Each official was given one week to complete the questionnaire and collect it within two or more weeks. Additionally, various reports and news from the offices are collected as supplementary information that is not available online or elsewhere. In the following section, the main finding of the study is presented in a descriptive manner.

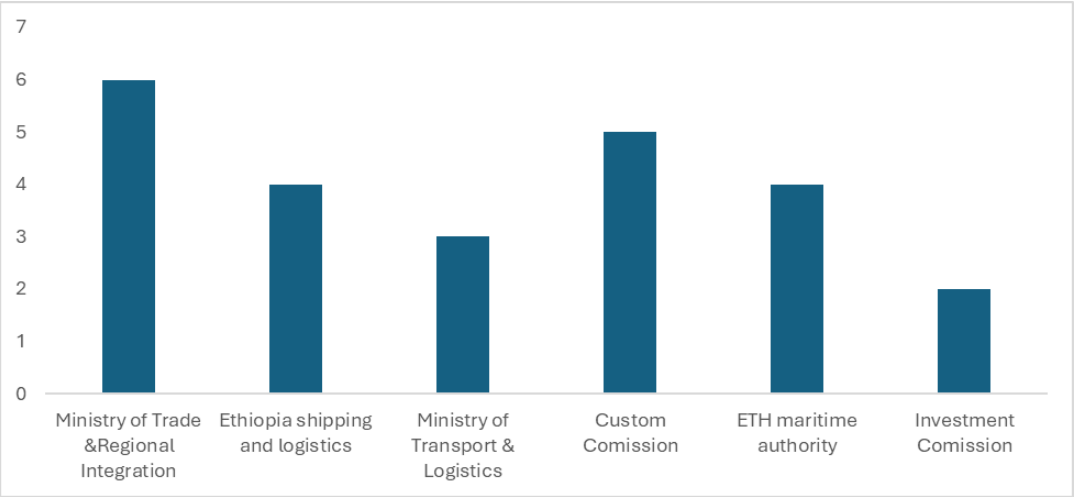

FIGURE 4.3: Distribution of surveyed offices

When examining the trends in trade in Africa over the past few decades, it is essential to consider the role of policies and institutions in shaping these changes. Policymakers have made consistent efforts to promote trade on the continent, including the establishment of several Regional Economic Communities (RECs). All African countries are members of at least one REC, with some being multiple RECs (Economic Commission for Africa, 2013). Ethiopia is a member of COMESA, IGAD, and AfCFTA.

Regarding the ease of trading, NTMs are relatively high in Africa (ElGanainy et al., 2023). Specifically, for intra-African trade, NTMs are estimated to be equivalent to an average import tariff of 18 percent, which poses a significantly larger obstacle to trade than traditional tariffs (ElGanainy et al., 2023). However, it is not just restrictive trade policies that hinder intra-African trade. The most significant factor affecting trade within Africa is the challenging trade environment. This includes transport infrastructure (including cross-border road, rail, port, and air transport networks, as well as border and customs procedures), telecommunications infrastructure, financial development, human capital, institutions, and regulations that restrict product and labor markets. While policies and institutions, such as the establishment of RECs, have aimed to enhance trade in Africa, there are still obstacles to overcome. Non-Tariff Measures (NTMs) and the overall trade environment, including various infrastructure and regulatory factors, continue to hinder intra-African trade. Therefore, this survey study aims to highlight these challenges and developments in Ethiopia from the policymakers' perspective.

The results of our survey show that there is an almost unanimous positive expectation regarding the benefits of AfCFTA implementation (see Figure). From the total sample, 95% expect a positive gain for Ethiopia from implementing the agreement, consistent with prior modeling results. However, there is a strong complaint regarding the preparation and implementation strategies despite the commitment

of government officials, who are unsatisfied with the progress of the reparation. In general, 81 percent of the surveyed officials perceive regional trade agreements such as COMESA and AfCFTA will significantly impact Ethiopian exports, 93.8 percent on exports, and 84 percent reported that it enhances the customs procedures and logistics of so-called trade facilitation. However, there is a suspicion of a significant gap in trade facilitation or nontariff barriers that would adversely affect participation gains. A recent survey study by International Trade Centre (2018) reported that 96 percent of the traders face difficulties applying and implementing nontariff measures.

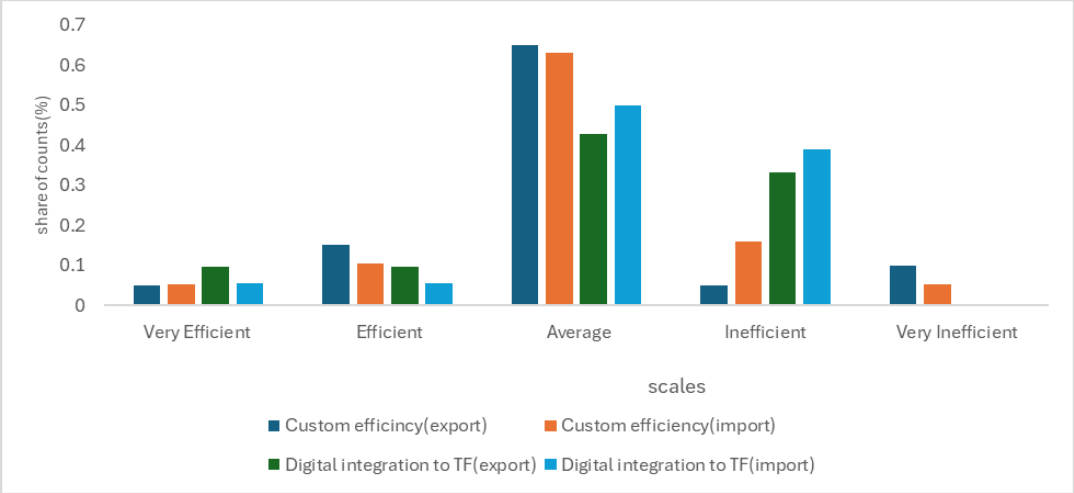

FIGURE 4.4: Custom efficiency and digitization in Ethiopia

The recent Covid-19 shock has been one of the greatest hits. Ethiopia's external demands of goods and services and exports were affected by the shock even though it showed a rebound in the firm's revenue and household income protracted impact (World Bank, 2021). The trade impacts of the shock were evident in Ethiopia's exports and imports, indicating a significant disruption. It is apparent in the survey that the effects of the COVID-19 shock trade are unanimously accepted. The most mentioned factors for shock are delays in orders, cancelling orders, quantity reductions on the export side, and time delay in importation because of the lockdown and workers' absence and shifting of services to the Covid-19 protection. 64.7 percent of the officials reported that Ethiopia has fully recovered from the shock. However, the shock created an opportunity to improve the overall trade environment, such as purchasing new containers, including those with weathered conditions, to overcome the shortages created by time and the digitization of various activities, including license renewal and order processing. A digitized trade has become common and more efficient. Most respondents agree that Ethiopia is on the right track in digitizing trade and related activities. However, trade policies and regulations remain less clear and accessible, according to the survey. On a scale of 1 to 5, regarding clarity to traders, officials' response is 3 on average.

The survey result (see Figure 4.4) also reveals a significant difference in the efficiency of customs procedures at port and border crossings for both export and import. This implies a higher cost of imports than exports. On a scale of 1 to 5, exports scored an average of 3.14, which is higher than imports at 2.95. In a comparison of Ethiopia's Logistics Performance Index (LPI) measures, the latest data available in 2016 Show that there is significant progress in all aspects of each LPI indicator, assuming the two datasets are comparable and taking into account the 7-year time difference. There is some consistency in the distribution of each indicator that follows the trend of the LPI of the World Bank. However, the absence of dramatic improvement in any indicators is worrisome.

FIGURE 4.5: LPI Measures for Ethiopia Based on Personal Survey and World Bank Data

Ethiopia suffers from a chronic shortage of foreign exchange (forex). The chronic shortage compels the government to prioritize sectors. The primarily prioritized sector is pharmaceutical products such as medicine and laboratory reagents. Inputs for Agriculture, such as fertilizers, seeds, pesticides, and chemicals, as well as inputs for manufacturing, including raw materials and chemicals, which are critical for the country's industrialization, are the second prioritized sectors. Motor oil, lubricants, and liquefied petroleum gas are the third priority, according to the National Bank of Ethiopia directive No. FXD/67/2020: Transparency in Foreign Currency Allocation and Foreign Exchange Management. The inability to reliably access foreign exchange for imports affects firm decisions on sourcing, capacity, and output (Hausmann et al., 2022). Our survey results confirm that over 61 percent of the officials reported that forex is the number one trade obstacle, especially for importers, followed by transport logistics and customs procedures.

The cost of transport or weak institutional performance, due to various factors, accounts for a significant share of the trade costs in Africa. African transportation costs are 63% higher than those of developed countries, and freight costs as a percentage

of import value are 11.4% for Africa compared to 6.8% for developed countries. According to the World Bank, customs transactions involve 20-30 different parties, 40 documents, and 200 data elements. Meanwhile, customs processing delays can cost USD 185 per consignment for each day of delay. Survey results show that a lack of coordination among the trade-involved bodies is a significant barrier to trade in Ethiopia. Even though a considerable number of officials report that there is a resource constraint, the lack of coordination exacerbates it. Thus, officials report that the Ethiopian government is prioritizing domestic infant industry protection, and they strongly suggest the need for special banks to finance prioritized sectors. In this regard, the leather and garment sector and the detergent-producing firms are given as good examples of well-done facilitation and import substitution production.

In brief, the survey conducted among Ethiopian trade policymakers sheds light on various aspects of the country's trade environment, including its challenges and opportunities. Despite facing obstacles such as high tariffs and non-tariff barriers, infrastructure limitations, and the impact of external shocks like the COVID-19 pandemic, policymakers have an overall positive outlook regarding Ethiopia's trade prospects, particularly with the implementation of the AfCFTA. It also indicates that while there is optimism surrounding AfCFTA, there are concerns about preparedness and strategies for its implementation. The COVID-19 pandemic significantly disrupted Ethiopia's trade, but there have been efforts to adapt and recover, with digitization playing a crucial role in enhancing trade efficiency and transparency. However, challenges in policy clarity, customs efficiency, and infrastructure development still need to be addressed.

4.3 Data and methodology

4.3.1 The recursive dynamic CGE model

The recursive dynamic CGE model captures the economy-wide impact of climate-induced shocks to agricultural production. The model is solved annually, with the initial year ranging from 2018 to 2035. However, the shock began in 2021, the year when AfCFTA liberalization started and was gradually implemented. The base year began in 2021, primarily for the purpose of our next chapter, which integrates it with the AfCFTA implementation. The model is solved annually by capturing the dynamic path for each year and updating the capital stock for each period, taking into account depreciation and investment. Additionally, the new values for the capital stocks are incorporated into the solution for the subsequent year. New capital is distributed among sectors based on each sector's initial share of aggregate capital income. Furthermore, population size and growth rates of the labor supply are updated annually. The population growth rate updates the total labor supply, i.e., as

the population grows, the total labor supply increases at the same rate.

4.3.2 Analytical model

The equations comprising the dynamic CGE model are a system of simultaneous, nonlinear equations that express the economic system[1] (Diao et al., 2012; Lofgren et al., 2002). The model uses the number of simultaneous equations that represent the economy. The model is based on the International Food Policy Research Institute's standard CGE model with a nested constant elasticity of substitution/transformation (CES/CET) in the production function. The production process begins with the combination of capital, skilled labor, unskilled labor, and land, which are partially interchangeable, to generate value added using a Cobb–Douglas production function. A Leontief-type production function is employed to generate the gross domestic product, which combines value-added and intermediate inputs. Subsequently, this output is transformed into composite exports and domestic goods using a CET production function. The composite exports are converted into exports to each destination country or region using another CET function. Similarly, imports from different source countries are combined with domestic goods to create composite imports. Composite imports, along with domestic goods, are then combined to form composite goods using Armington's (1969) approach. Throughout these aggregation processes, a CES function is assumed. The detailed structures, assumptions, parameters, and equations are presented in the appendix to Chapter 4.
Households maximize the utility derived from consumption, subject to budget constraints. Their income is derived from factor payments, such as wages, rents, transfers, and government subsidies. Savings are endogenously determined as the difference between disposable income and consumption. Firms maximize profits by employing factors such as production labor and capital to produce goods. Production decisions are represented using nested CES production functions, where intermediate and value-added inputs are combined at the top level, and factors are combined at the lower level. The government imposes taxes, which are equivalent to direct, indirect, import, and export taxes and pay transfers, and supplies public goods. The government's savings are the residual between revenues and expenditures. The demand for good consumption, government purchases, investment, and intermediate use for each household equals supply (domestic production and imports). With respect to factor markets, wages and rents are adjusted to equate the demand and supply of labor and capital. Changes in factor supply are modeled to occur dynamically across sectors. The basic block of equations for the household and trade is presented below; the details are provided in the appendix.

Major block of equations

[1]The details of the assumptions and structures of the model are presented in the appendix.

Income Equations Income can be categorized into two types. The first type comprises payments to factor accounts for the services provided to various activities, which represent the domestic value added. The second type comprises payments made to domestic factors utilized overseas, whose value is fixed in foreign currency terms. Thus, factor incomes (YF) are defined as the total income factors received across all activities:

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \tag{4.1}$$

where:
YF_f = income of factor f.
WF_f = average price of factor f.
$\overline{WFDIST}_{fa}$ = wage distortion factor for factor f in activity a.
QF_{fa} = quantity demanded of factor f from activity a. The Income Equations section outlines the factor payments within the economy and how they are distributed among households and other entities, such as tax contributions, savings, remittances, and other international transactions. In this framework, households primarily derive their income from labor, dividends, transfers among household members, government assistance, and remittances:

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i,gov} \cdot \overline{CPI} + trnsfr_{i,row} \cdot EXR \tag{4.2}$$

[Income of institution i] = [factor income] + [transfer from other domestic nongovernment institution] + [transfer from government] + [transfer from ROW]
where: YI_i = income of households.
YIF_{if} = income to domestic institution i from factor f.
$TRII_{ii'}$ = transfers from the government to households.
$trnsfr_{i,gov}$ = transfer from the government to households.
$trnsfr_{i,row}$ = transfer from the rest of the world (ROW) to households.
$\overline{CPI}$ = consumer price index.
EXR = exchange rate.

Household Consumption Expenditure

In addition, the production segment established equilibrium imports within the dynamic model. Given that imports are intermediate inputs, increasing wages results in a significant reliance on imports because companies opt to replace labor with imported goods. The conditions for achieving cost minimization, considering the two pricing factors and subject to the Armington function alongside a set quantity of the

composite commodity, produce the subsequent import-to-domestic demand ratio:

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih}\right) \cdot (1 - MPS_h) \cdot (1 - TINS_h) \cdot YI_h, \quad h \in H \tag{4.3}$$

(household income disposable for consumption) = f (household income, net of direct taxes, savings, and transfers to other nongovernment institutions

where: EH_h = household consumption expenditures.
$shii_{ih}$ = share of net income of i' with $i \quad (i' \in INSDNG'; i \in INSDNG)$.
MPS_h = marginal propensity to save for households.
$TINS_h$ = direct tax rate for institution $i \quad (i \in INSDNG)$.
YI_h = income of institution $i \quad$ (in the set INSDNG).
Trade Block Equations

Import

In addition, the production segment established equilibrium imports within the dynamic model. Given that imports are intermediate inputs, increasing wages results in a significant reliance on imports because companies opt to replace labor with imported goods. The conditions for achieving cost minimization, considering the two pricing factors and subject to the Armington function alongside a set quantity of the composite commodity, produce the subsequent import-to-domestic demand ratio:

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q}\right)^{\frac{1}{1+\rho_c^q}} \tag{4.4}$$

(Import-to-domestic demand ratio) = f (domestic demand-to-import price ratio)

where $\mathrm{PDD}_c andPM_c$

are import and domestic output prices, respectively. The equation defines the optimal mix between imports and domestic output. Thus, its domain is limited to imports with domestic production. The equation ensures that an increase in the domestic demand-to-import price ratio generates an increase in the import-to-domestic demand ratio, resulting in a shift away from the source that becomes more expensive.

Exports
Ethiopia, which has an insignificant global trade impact, acts as a price taker in its export markets. The volume of exports is sensitive to changes in the relative prices of these exports. Consequently, fluctuations in global economic growth can influence export levels by affecting foreign export prices. Other factors that impact export

supply are production input prices, wages, and import costs. A decrease in wages and import prices usually increases export supply. The following equation establishes the best balance between exports and domestic sales. When the ratio of export to domestic prices increases, it leads to a higher export-to-domestic supply ratio, shifting toward markets that provide great returns:

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1-\delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \tag{4.5}$$

(export-to-domestic supply ratio) = f (export-to-domestic price ratio)
where:
$PE_c and PDS_c$ are the export and domestic prices, respectively. This equation constitutes the first-order conditions for the maximization of producer revenues given the two prices and is subject to the CET function and a fixed quantity of domestic output. The equation ensures that an increase in the export-to-domestic price ratio results in an increase in the export-to-domestic supply ratio.

This study examines the effects of changing precipitation and temperature on crop productivity. First, we used the estimated shock by Waldhoff et al. (2020) [2], which is particularly effective for evaluating how climate change impacts alternative emission scenarios at the product, year, and country levels. In addition, Waldhoff et al. (2020) used the empirical modeling approach to estimate the impacts of climate change on agricultural yields in different countries and various crops, according to representative concentration pathways (RCP) [3] 4.5 and 8.5—the medium and high greenhouse gas concentration scenarios. The methodology builds up a set of reduced-form statistical models that estimate crop supplies using historical data for yields and weather patterns (temperature and precipitation). The country-specific crop yield responses of the model are linked to ESM outputs to project future impacts under the RCP 4.5 and 8.5 scenarios. For instance, yield losses for maize are projected to decrease by no more than 30% in RCP 8.5 within certain regions by the end of the 21st century, whereas in RCP 4.5, yield losses may be lower (approximately 10%–20%). Such projections are indispensable for integrating into integrated assessment models to study broader economic and food security impacts.

[2] The study uses empirical modeling to estimate crop yield responses to climate variables at the country level. Historical yield and weather data are used, incorporating temperature, precipitation, and economic controls in the estimation. Future yield projections are derived by integrating these models with Earth System Model (ESM) simulations under RCP 4.5 (moderate warming) and RCP 8.5 (high warming) scenarios.

[3] RCP4.5 and RCP8.5 refer to Representative Concentration Pathways (RCPs) used in climate modeling to project greenhouse gas emissions and their impact on the climate. RCP4.5 represents a moderate scenario in which global efforts stabilize emissions by 2100, resulting in a radiative forcing of 4.5 watts per square meter.
In contrast, RCP8.5 is a high-emission scenario characterized by minimal climate mitigation efforts, leading to a radiative forcing of 8.5 watts per square meter by the end of the century (IPCC, 2014). These scenarios are widely used for economic and environmental assessments to understand potential climate impacts and policy responses.

TFP (alphava in the CGE model) was used for the simulation shock as the efficiency loss of the climate change simulation. TFP is the portion of output that cannot be explained by the number of inputs used in production. Hence, the CES activity production function (alpha) shift parameter is used for the simulations, as shown in the following aggregate value-added production function. The equation states that, for each activity, the quantity of value added is a CES function of the disaggregated factor quantities. The implementation of the productivity shock is in the following equations on alpha for the agriculture sector:

$$QVA_a = \alpha_a^{va} \left(\sum_{f \in F} \delta_{fa}^{va} QF_{fa}^{-\rho_a^{va}} \right)^{\frac{1}{\rho_a^{va}}} \tag{4.6}$$

(Quantity of aggregate value added) = (CES factor inputs)

where: F = set of factors.
α_a^{va} = efficiency parameter in the CES value-added function.
δ_{fa}^{va} = CES value-added function share parameter for factor f in activity a.
QF_{fa} = quantity demanded of factor f from activity a.
$-\rho_a^{va}$ = CES value-added function exponent. The CGE model allows us to analyze welfare measures by tracking changes in key indicators such as consumer surplus, real income, equivalent variations (EV), and distributional outcomes across households and factors of production (Robson et al., 2018; Gohin, 2005; Robichaud, 2001). These measures allow us to simulate how policy reforms, in our case, trade liberalization, and climate change affect the overall well-being of a household and the economy. A CGE model ensures that all markets (labor, goods, and capital markets) are balanced and that total savings equal total investment. The model assures consistency between supply and demand throughout the economy (Lofgren et al., 2002). This closure ensures that all income (wages, profits, taxes, etc.) is either spent or saved and that the balance of payments is kept, making the model invaluable for evaluating the full macroeconomic impact of policy changes.

Consumer surplus is the difference between a consumer's willingness to pay for a good or service and the actual amount they pay. For instance, it can be an indicator of the benefits that consumers derive from market transactions. In a CGE model, changes in consumer surplus can be considered an assessment of the impact of policy reforms or market shocks on the welfare of households, driven by changes in prices. For instance, trade liberalization, which involves tariff cuts, typically implies that price levels decline, and therefore, the consumers' surplus increases, which can be reflected in their increased welfare.

The real income measure is another relevant welfare indicator. It tracks the purchasing power of households over time, reflecting changes in prices. Real income under a CGE model is subject to variations in wages, profits, and prices across sectors.

The model captures the interaction of the factor markets—land, labor, and capital product markets; thus, studying the impacts of policies on the prices and services in a household is possible. For instance, trade liberalization can raise real incomes through efficiency gains in the production process or by reducing the price of imports. EV measures the amount of income that households would need to receive before the policy change to achieve the same level of utility that they experience after the policy change. It reflects the welfare gains or losses associated with a policy reform or economic shock by comparing the utility levels between the initial and new equilibria.

This equilibrium condition places the CGE framework uniquely positioned to model general equilibrium accurately, capturing changes that diffuse through an economy well beyond the direct effects of reforms or shocks. For instance, the AfCFTA reduces tariffs, which directly affects import prices; however, this may also lead to resource reallocation, a shift in labor markets, and altered capital flows. These, in turn, have repercussions on production and consumption patterns, which manifest in welfare changes.

The CGE model helps capture distributional impacts by disaggregating households across different income groups, defined by 10 income quantiles, thus allowing a comprehensive investigation of how different segments of the population are affected by AfCFTA. This is of great significance in any equity assessment of reforms wherein welfare gains or losses are not evenly distributed among households. For instance, AfCFTA may lower the price level for consumers and benefit them, but may hurt specific industries or labor that lose out owing to increased import competition.

In summary, the CGE model integrates a series of welfare measures and posits that all markets are in equilibrium at any instant, regardless of policy changes or external shocks. Therefore, this presents a comprehensive framework for analyzing the economy-wide welfare impacts of trade, fiscal, and environmental policies. In addition, it allows to capture the direct and indirect effects, whereas important outcomes may be distributional. Therefore, it has become an essential tool for policymakers seeking to comprehend the far-reaching and long-term implications of economic reforms on social welfare.

4.3.3 The Macroeconomic Closure Rules

The basic CGE model requires three macroeconomic balances: the government's current balance, the external balance (which includes the current account of the balance of payments, specifically the trade balance), and the savings–investment balance. The latter has various closing options that have no effects on the solution to the base

simulation but will typically influence the results of other simulations (Lofgren et al., 2002).

Macroeconomic closure rules are essential in CGE modeling because they determine how the model equilibrates and how various economic variables adjust in response to policy shocks. This section discusses the chosen closures for key macroeconomic accounts: savings–investment, government, external balance, and factor markets. The chosen macroeconomic closure rules provide a coherent framework to analyze the dynamic interactions between climate change, trade liberalization, and economic performance in an Ethiopian context. By capturing the key adjustment mechanisms in savings, investment, government balance, external balance, and factor markets, the model offers robust insights into the potential long-term impacts of these policy interventions. This detailed closure specification ensures that the model remains grounded in economic theory while allowing for realistic simulations of policy scenarios.

The current account is typically fixed for almost all CGE models, and then either a savings-driven or investment-driven closure is chosen. This is because CGE models of developing economies and those involving foreign credit may be limited, so a fixed current account may simply reflect economic reality (Lofgren et al., 2002). The interpretation of the simulation results with such a closure represents the economic effect of a policy on a given level of foreign borrowing and investment in future consumption. Because borrowing foreign funds increases consumption in the current period and the model does not account for paying the debt, measures of economic welfare based on household consumption become invalid if the current account is free. Freedom of the current account implies that no frictions exist in borrowing or lending between a country and the rest of the world, which is not probable in most developing countries. In this situation, countries can borrow from foreign creditors to finance consumption, investment, or trade deficits without immediate limitations or repayment obligations during the period under consideration. This allows the perpetuation of current account imbalances. For instance, trade deficits can finance temporary increases in consumption or investment at the cost of accumulating external debt. The latter temporarily enhances economic activities and creates problems toward sustainability.

A free current account significantly affects the welfare measurement in economic modeling. Foreign borrowing temporarily raises household consumption and inflates welfare measures in the short run. These measures are complicated because they cannot account for future repayment obligations that may reduce future consumption and economic welfare. Most models, without borrowing constraints, often assume infinite borrowing, thus ignoring debt sustainability and the long-term trade-offs between current and future consumption. This produces an overly optimistic view of policy outcomes that stimulate short-term consumption or investment

without considering the potential long-term economic costs of foreign debt. A current account is effectively "free" when no restrictions exist on capital movements, such as borrowing from international creditors, and when the model does not impose intertemporal budget constraints requiring future debt repayment.

While this may yield welfare gains in the short term, it is conducive to unsustainable debt accumulation, exposing the economy to external shocks such as sudden stops in capital inflows, balance-of-payments crises, or currency devaluations. Moreover, although consumption may increase today, future welfare is often curtailed owing to high debt servicing obligations, increased taxes, or reduced government spending capacity.

Second, debt servicing costs-interest payments and principal repayments-must be introduced into the models to gauge their impacts on household consumption and welfare, which is impossible in our model. Introducing borrowing limits or penalties for sizeable current account deficits may also eliminate unrealistic welfare gains from unfettered foreign borrowing. Finally, although a free current account provides an avenue for short-term economic gain, sustainability and intertemporal considerations must be incorporated into the analysis to present a realistic, long-term view of economic welfare. The current account can be directly fixed when the exchange rate is used as the numeraire. By contrast, we set the consumer price index (CPI) as the numeraire and allow the exchange rate to vary, thereby maintaining the current account balance. Section 2.4 in Chapter 2 provides a detailed discussion of alternative closures, closure rules, and economic implications.

The simulations are based on the following closure rules:

- Savings-driven investment: This type of investment adjusts based on the fixed saving propensities of households and enterprises. It is ideal for short-run analysis.
- Semiflexible government spending: Any fiscal imbalance is addressed through government savings or borrowing adjustments while tax rates remain fixed.
- Capital: Capital is assumed to be partially mobile across sectors with sector-specific adjustment costs. This assumption captures the slow reallocation of capital in response to shocks.
- Fixed foreign savings and variable exchange rates.
- Producer price index (PPI) is the model numeraire, the reference price for all other price changes. Therefore, the CPI changes in relation to the PPI.
- Labor: Mobile labor and land across national activities. Labor is segregated (classified as unskilled, semiskilled, and skilled) and mobile across activities;

however, only skilled labor is fully employed. A fixed wage closure (allowing unemployment) that better reflects labor market frictions and rigidities is important.

4.3.4 Simulation Scenarios

To comprehensively assess the impacts of climate change on Ethiopia, two climate change scenarios (RCP 4.5 and 8.5) are simulated to capture a range of potential outcomes. RCP 4.5 represents a "moderate" scenario wherein global mitigation efforts stabilize greenhouse gas concentrations. This scenario allows for an analysis of the Ethiopian economy under relatively easy climate adaptation and less severe environmental stress. By contrast, RCP 8.5 assumes high greenhouse gas emissions with minimal mitigation efforts, representing an "extreme" scenario in which climate impacts are severe, exposing the economy to pronounced temperature increases, erratic rainfall, and increased vulnerability.

Scenarios: Climate change-induced productivity shocks

- Climate change scenario (RCP 4.5): Under the RCP 4.5 emission scenario, TFP shocks owing to climate change are introduced. Crop-specific shocks are from an annually projected source.
- Climate change scenario (RCP 8.5): Introduction of TFP shocks owing to climate change. A crop productivity shock at the annual level was projected from 2021 to 2035.

4.3.5 Data and calibration

The model is calibrated for the initial year, 2018, using the Ethiopian SAM, which accounts for all income and expenditure flows of the economy in that year. The Nexus SAM of 2018 has 42 activities, 45 commodities after further disaggregation, and 5 factors of production (Aragie et al., 2023). In addition, the SAM has different accounts, including taxes, saving–investment, enterprise, and rest-of-the-world accounts, to illustrate the interaction of various economic agents.

This study uses a dynamic CGE model to capture the economy-wide impacts of climate change on agricultural production. The model is a recursive dynamic model, beginning with the base year of 2021 and annually solved through 2035. The model allows the analysis of the path of transitional dynamics leading to a new steady state following an initial impact. This means that the model is solved for an individual year; the capital stock is modified for each period due to depreciation and

investment, and the new values for the capital stock are used in the solution for the subsequent year. New capital is distributed among sectors based on the initial share of aggregate capital income that each sector holds. Additionally, the population size and growth rate of the labor supply are updated annually. The total labor supply is updated by the population growth rate, i.e., as the population grows, the total labor supply increases at the same rate.

To analyze the intricate impacts of trade liberalization and climate change in Ethiopia, this study developed the following scenarios based on the actual tariff liberalization offer and the climate-induced changes in agricultural productivity. The baseline of the analysis is business as usual when no shock exists and climate change prevails. Shocks are introduced once the base is calibrated. Climate change-induced productivity changes are introduced as a crop-level productivity shock, and the macroeconomic and sectoral impacts on the entire Ethiopian economy are assessed.

Once the productivity change is simulated, tariff liberalization proceeds as part of the AfCFTA implementation. National trade facilitation follows the liberalization of tariffs. However, to compare the simulated impact as a difference across the simulations, a separate simulation from the baseline is computed and reported as percentage changes. Therefore, the reported results indicate the impact of climate-induced productivity changes and the implementation of the AfCFTA.

4.4 Results and discussion

4.4.1 Simulation of the economic impacts of climate change

According to the above discussion, the economic effects of climate change refer to the economy-wide and welfare effects of the agricultural productivity shock. The overall economy-wide and sectoral analysis indicates that these primary shocks in the agricultural sector have profound economic consequences for both the agricultural and non-agricultural sectors.

Agriculture, as the primarily affected sector, faces significant impacts of the shock. Given the significant role of agriculture within the economy, the impacts on agricultural output effectively capture the macroeconomic effects, including GDP at factor cost and market prices, trade, household welfare, output, and prices. However, the spillover effects on the remaining economic sectors are not as gigantic as anticipated. This can be attributed to the low factor reallocation effects, weak interindustry linkage, and low elasticities of household demand. Regarding the apparent reasons for the weak factor reallocation effects, most agricultural factors of production, such as cropland, livestock units, and agricultural labor, are used only in agriculture or

are at least less mobile. A weak interlinkage exists between agriculture and non-agricultural activities, or weak forward and backward linkages. By contrast, the two main intermediate inputs in agriculture are self-produced seeds and entirely imported, namely, fertilizer. Nor shall we expect strong effects through the relative commodity price change. Income elasticities are small because Ethiopia is a low-income country, and the LES demand system, with low own-price and cross-price elasticities, assumes that commodities are gross complements to each other (De Boer, 2009; Boer et al., 2023).

The shocks to agricultural activities ripple through the rest of nonagricultural activities[4]. The Macroeconomic Effects section examines the impacts of climate change-induced low productivity on GDP, absorption, exports, imports, and consumption. The climate-induced decline in productivity of major agricultural products is introduced as a short-run TFP shock in the CGE model. Agriculture, the dominant contributor to the economy and the most affected sector is the main channel through which climate change affects the economy. The overall GDP impact of climate change is an indication of the damage cost. Absorption, private consumption, total investment, and government consumption are projected to decrease by 15.7%, 13.3%, 13.7%, and 18.8% throughout the entire simulation period, respectively (Appendix to Chapter 4). Declined household income leads to decreased imports, whereas real exchange rate depreciation (a 5.3% depreciation in 2035) leads to decreased exports. The overall decline in exports and imports is expected to be 24.9% and 19.9%, respectively, by 2035.

In the RCP 4.5 and RCP 8.5 scenarios, households' real income declines by 0.07–0.15 and 0.05–0.18% across the 10 income quantiles, corroborating the previous studies by (Solomon et al., 2021; Yalew et al., 2017). Climate change will have negative consequences, and the sensitivity of Ethiopian household income will have far-reaching implications on consumption and poverty. The World Bank (2024d) projected a poverty surge of 0.5–1.7 percentage points by 2050 in the case of a dry and hot weather scenario. Household consumption is expected to decline by 1%–5% from the baseline by 2035. The price increase and output and the import decline are the primarily responsible factors for this decline. The overlapping crises in Ethiopia have contributed to the declining trend of household consumption in Ethiopia since 2019 and the slow pace of poverty reduction in recent times (World Bank, 2024d). Exports declined by 0.64% and 0.88% in the annual average growth throughout the simulation period, impeding the country's trade balance in both scenarios. The total GDP declined by 0.72% to 1.05%, which is larger than the total absorption decline (0.69%–1.01%). This indicates that imports may dampen the macroeconomic effects of climate change, affirming the claims of previous studies (Solomon et al., 2021; Robinson et al., 2012; World Bank, 2010).

[4]Detailed results are reported in the appendix to chapter 4.

4.4.2 Sectoral impacts of climate change

The impact of climate change on sectoral output varies across sectors, as shown in Figure 4.6. With increasing productivity shocks, we observe repercussions in some non-agricultural activities (e.g., services and processed food) that utilize agricultural commodities as intermediate inputs. In the agricultural sector, rice, other cereals, pulses, oilseeds, roots, vegetables, and sugarcane are expected to face the highest negative impact. Likewise, because agricultural commodities contribute significantly to the total traded output of the economy, we observe declines in wholesale and retail trade outputs in specific sectors. However, manufacturing output is expected to expand. The service sectors with negative repercussions are accommodation, communication, and finance. This moderate reduction suggests that while the sector is affected by climate shocks, it remains relatively resilient. This resilience may be due to the sector's lower dependence on climate-sensitive resources and ability to adapt to changing conditions. However, the decline indicates climate shocks can disrupt service delivery and economic activities within this sector.

The food and beverage sector is the next most severely affected, with output reductions reaching 2.9% to 3.3% in the two scenarios. Agricultural production, which is the foundation of this sector, is directly influenced by changes in weather patterns, water availability, and temperature. Climate shocks can lead to crop failures, reduced yields, and increased food prices, exacerbating food insecurity and economic instability. The agricultural sector has shown a dramatic decline of around 30% to 40%. This significant reduction suggests that this sector is highly vulnerable to climate shocks. The simulation results reveal varying vulnerability across different sectors in Ethiopia due to climate shocks.

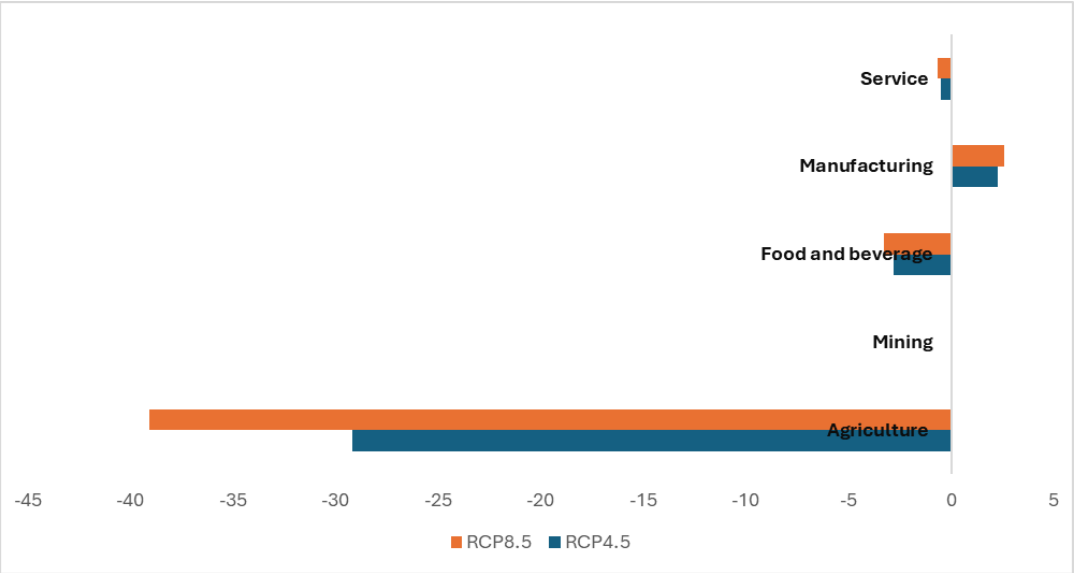

FIGURE 4.6: Climate change impact on output

This decline in various sectors was reflected in other economic indicators across different channels, as presented in the following sections. For instance, a decline in agricultural output increases domestic agricultural prices and eventually alters the ratio of domestic prices to export and import prices. This decline in agricultural exports and increase in agricultural imports will require increasing exports and reducing imports of nonagricultural commodities to maintain the balance of trade.

4.4.3 Household welfare impacts of climate change

The simulation results, which highlight output changes across key sectors due to climate shocks, provide critical insights into the broader economic implications for Ethiopia. CGE modelling leads to some results that would not be visible in partial equilibrium studies. For instance, these sectoral output declines, particularly in the agriculture and food and beverage sectors, are likely to have cascading effects on household consumption and welfare. Reduced output in these sectors can lead to higher prices for essential goods, decreased income for workers, and limited access to basic services, all of which directly impact household well-being. As households face increased economic pressures, their consumption patterns may shift, prioritizing immediate needs over long-term investments, which can further exacerbate poverty and inequality.

The combined effects of changes in real income and food prices determine the effect of climate change on household consumption. The consumption effects on urban poor households (–2.9% to –11.5%) are slightly worse than those on rural poor households (–3.7% to –6.8%). Furthermore, the effect is expected to be high in the

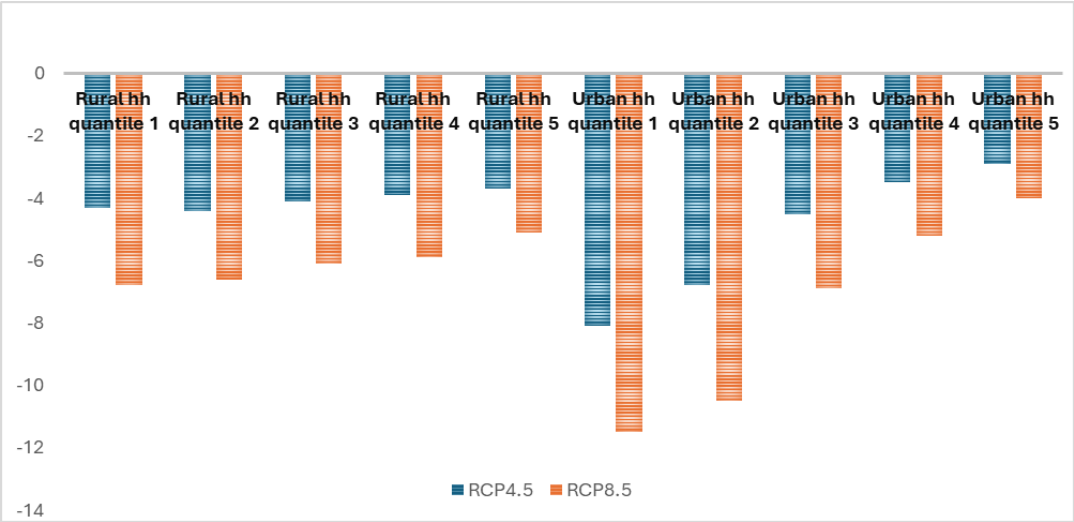

FIGURE 4.7: Impact of climate change on household consumption

high-emission scenario (i.e., the RCP 8.5 emission scenario) for all households (Figure 4.7). In the scenario of declining agricultural productivity, the negative consequences of climate change hit the consumption of rural households harder than that of rural non-farm and urban households. However, declining factor incomes (nonagricultural labor) and increasing agricultural (food) prices do affect the welfare of urban households. Climate change affects commodity supply, prices, and factors influencing wages and demand, ultimately impacting the consumption of rural and urban households differently. Climate change increases factor competition among agricultural activities. This drives up the wages (and income) of agricultural labor and land, which contributes to the total rural household income. However, increasing agricultural prices have a negative impact on the consumption of urban households.

The consumption impact of climate change on urban households is more regressive toward the rich than the rural population, indicating that climate change will exacerbate urban inequality. More robust modeling studies should further explore this topic, utilizing household-level microsimulation approaches. High-income quantile households' spending is less affected by changes in income and commodity prices compared with other countries and previous research. This indicates that households may use their savings and transfer funds to other institutions to help maintain consistent spending during difficult times. This aligns with the results of microstudies (Dercon, 2004; Braun et al., 1991), indicating that selling assets is a common strategy for smoothing consumption during periods of drought.

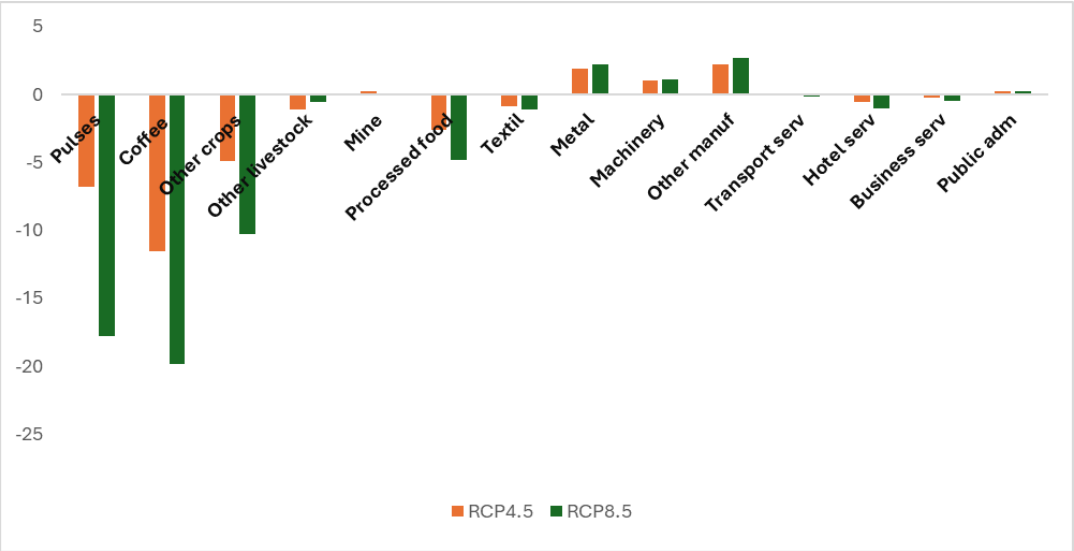

FIGURE 4.8: Export impact of climate change

4.4.4 Trade impacts of climate change

Domestic production in Ethiopia is expected to decline, while commodity prices are estimated to rise, as discussed in the above section. Indeed, climate-induced productivity changes result in cascading effects across sectors, influencing relative competitiveness and trade flows. In the first scenario, where the productivity of crop agriculture declined, the modeling results indicate that climate change has an adverse effect on exports and imports (Figures 4.8 and 4.9). These results highlight the vulnerability of several sectors and households, revealing possible variations in comparative advantage that may reshape the country's trade dynamics. Given that agricultural production is the primary sector expected to be affected by climate change in Ethiopia, it will indirectly impact trade. The projection results indicate that agricultural products, the sector primarily affected and the main export contributor, will be negatively impacted by the projected climate changes by 2035. Under the high emission scenario of RCP 8.5, the export of agricultural products declines the most. The major export crops of coffee, pulses, and other crops are expected to decline on average by 19.8%, 17.8%, and 10.3%, respectively, during the simulation period. As these are the major contributors to the country's exports, GDP, and foreign exchange, the impacts of climate change will be consequential to the Ethiopian economy. Coffee, sesame seeds, and kidney beans contribute to 55% of the total revenue from Ethiopian agricultural exports in 2023 (USDA, 2024). By contrast, the import of agricultural and food products increased the balance of the trade sector. As expected, the impact is lower in the RCP 4.5 emission scenarios, except for the food sector. However, the manufacturing sector showed an increase in exports. This highlights the dampening of domestic demand due to declining real income and the expansion of exports in non-agricultural sectors.

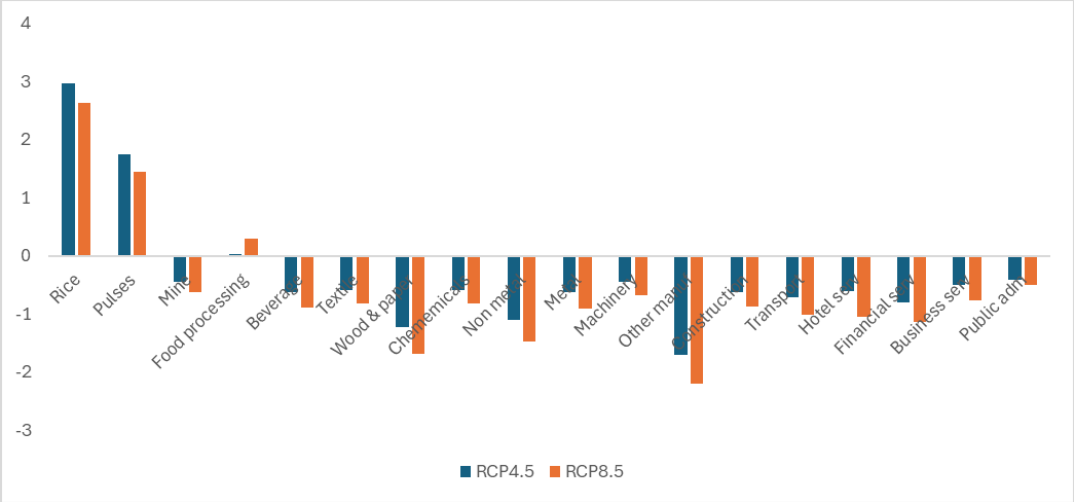

FIGURE 4.9: Import impacts of climate change

The overall projection indicates reduced Ethiopian exports and imports from the baseline in 2035 under the two climate emission scenarios. However, sector-wise results are mixed; although the agriculture sector shows a reduction in exports, the import of these products to fill the trade balance will increase, which supports the findings of Liu et al. (2023) that the occurrence of climate disasters in developing countries increased imports by about 6.7% and decreased exports by 0.65%.

The decreased supply of agricultural production will directly affect prices; hence, the prices of agricultural commodities will increase (Yalew et al., 2017). In addition, the increasing prices of agricultural goods result in changes in relative commodity prices, which in turn affect the overall price. The simulation results indicate that climate change-induced price increases for food decline household income and consumption. Moreover, a slowdown in national economic activity driven by climate change-related effects is likely to decrease the demand for agricultural products. Therefore, a significant reduction in crop output can quickly spread to other sectors of the economy. Consequently, it influences the purchasing capacity, thereby lessening the welfare of households.

The magnitude, rate, interaction, and prevailing local circumstances will determine the nature of these climate changes. In instances where the agricultural supply is reduced, farm commodity prices can increase because such a reduction in agricultural supply directly affects the prices. Additionally, high farm commodity prices affect the overall price levels and terms of trade between commodities. The surging food prices resulting from climate change will lower real household income and consumption, as indicated by the simulation results. The effects of climate change that contribute to a slowdown in national economic activity will likely further reduce the demand for crop output. Therefore, it may contribute to this large impact by trickling down and eventually reducing a household's welfare by impairing its purchasing power. The food security implications of these interactions are imperative

in the short run, and poverty implications are important in the long run.

4.4.5 Discussion and policy implications

The findings in this chapter highlight the profound and multifaceted impacts of climate-induced agricultural shocks on the Ethiopian economy, particularly in light of its significant reliance on agriculture for GDP, employment, and export earnings. The results align with and extend the existing literature on the economic consequences of climate change, particularly in low-income, agriculture-dependent economies. This discussion synthesizes the key findings, situates them within the broader literature, and explores the policy implications for Ethiopia and similar economies.

The results indicate that climate change has a significant impact on agricultural productivity, particularly for staple crops such as maize, pulses, and sorghum, which are crucial for food security and rural livelihoods in Ethiopia. Some of our findings are consistent with previous studies that have highlighted the vulnerability of rainfed agricultural systems to climate change (Diao et al., 2023; Conway et al., 2011). The projected yield losses of up to 25% for major crops by 2050 (Solomon et al., 2021) are corroborated by our results, which show a sharp decline in agricultural output under both RCP 4.5 and RCP 8.5 scenarios. This decline in agricultural productivity has cascading effects on the broader economy, including reduced GDP, household consumption, and investment, as well as increased food prices and imports.

The spillover effects of agricultural productivity shocks into non-agricultural sectors, such as food processing and retail trade, highlight the interconnectedness of the Ethiopian economy. However, the relatively weak inter-industry linkages and low elasticities of household demand mitigate some of these spillover effects, as noted in the results. Robinson et al. (2012) found that while agricultural shocks have significant macroeconomic impacts, their effects on non-agricultural sectors are often moderated by structural factors such as limited factor mobility and low demand elasticities.

The study also highlights the differential impacts of climate change on rural and urban households. Rural households, which are more directly dependent on agriculture for their livelihoods, experience significant declines in income and consumption. This aligns with the findings of Deressa et al. (2009), who noted that climate change disproportionately affects rural households, particularly those in low-income quantiles. Urban households, while less directly dependent on agriculture, are also adversely affected by rising food prices and declining real incomes. This exacerbates urban inequality, as low-income urban households, who are net food buyers, suffer more severe declines in consumption than wealthier households. The

World Bank (2024d) projection indicates that climate change could increase poverty by 0.5–1.7 percentage points in Ethiopia by 2050.

The welfare losses, as measured by EV, further underscore rural households' vulnerability to climate change. Our results indicate that rural households experience welfare losses of 3.7% to 6.6% under the RCP 4.5 and RCP 8.5 scenarios, respectively (Appendix to Chapter 4). This finding aligns with the work of Yalew et al. (2017), who emphasized the need for targeted adaptation strategies to protect the most vulnerable populations from the adverse effects of climate change.

The study also reveals significant trade implications of climate change, particularly for
Ethiopia's agricultural exports. The decline in exports of key crops such as coffee, pulses, and sesame seeds under both climate scenarios highlights the vulnerability of Ethiopia's export sector to climate-induced productivity shocks. Liu et al. (2023) found that climate disasters in developing countries tend to increase imports and reduce exports, thereby worsening trade balances. The increase in manufacturing exports, driven by changes in relative competitiveness and factor reallocation, offers a potential silver lining. However, the overall trade balance deteriorates, further constraining foreign exchange reserves and exacerbating economic vulnerabilities.

The findings of this study have several important policy implications for Ethiopia and other agriculture-dependent economies facing similar climate challenges:

- **Diversification of income sources**: To mitigate the adverse effects of climate change on rural households, policies should focus on diversifying income sources beyond agriculture. This could include promoting non-farm employment opportunities, supporting small-scale agro-processing industries, and enhancing rural entrepreneurs' access to credit and markets.

- **Social protection programs**: Given the disproportionate impact of climate change on low-income households, targeted social protection programs are crucial for safeguarding vulnerable populations. Cash transfer programs, food subsidies, and public works programs can help mitigate the immediate impacts of climate-induced income and consumption shocks.

- **Trade policy adjustments:** The decline in agricultural exports and the deterioration of the trade balance underscore the need for adjustments to trade policy. This could include diversifying export markets, promoting value-added agricultural products, and enhancing trade facilitation measures to reduce transaction costs and improve competitiveness, which is the objective of the next chapter, where we examine the extent to which trade liberalization compensates or exacerbates the impact of climate change.

- **Investment in climate adaptation and mitigation**: The projected economic losses from climate change highlight the importance of investing in climate adaptation and mitigation measures. This may include agricultural adaptation and investments in infrastructure, water storage, and renewable energy to reduce vulnerability to climate shocks. The estimated adaptation and mitigation cost of USD 27.6 billion until 2050 (World Bank, 2024d) underscores the scale of the challenge, as well as the potential benefits of proactive investment.

-**Strengthening inter-Sectoral linkages**: Given the weak interindustry linkages between the agricultural and non-agricultural sectors, policies should aim to strengthen these connections. This could include promoting agro-processing industries, improving rural infrastructure, and enhancing access to markets for agricultural products. Strengthening these linkages can help mitigate the spillover effects of agricultural shocks and promote more balanced economic growth.

While this study provides valuable insights into the economic impacts of climate change in Ethiopia, it is not without limitations. The reliance on a recursive dynamic CGE model, while useful for capturing economy-wide effects, may not fully account for the complex interactions between climate change, socio-economic factors, and policy responses. Future research could explore the use of more granular data and alternative modeling approaches to better capture these dynamics. Additionally, the study focuses on the short- to medium-term impacts of climate change, and further research is needed to understand the long-term implications, particularly in the context of Ethiopia's rapidly growing population and urbanization trends.

4.5 Conclusion

This chapter examines the dynamic effects of climate-induced agricultural shocks on the Ethiopian economy. An analysis of the Ethiopian economy using a recursive dynamic CGE model highlights the profound impacts of climate change on both its agricultural and non-agricultural sectors. Using the International Food Policy Research Institute's CGE model, the most recent 2018 nexus SAM of Ethiopia, and the crop-specific and yearly projections of temperature and precipitation changes in crops by Waldhoff et al. (2020) for Ethiopia under RCP 4.5 and RCP 8.5 emission scenarios. The simulation results indicate a sharp decline in agricultural output for the RCP 4.5 and RCP 8.5 scenarios, whereas the yields of staple crops, such as maize, pulses, coffee, and rice, are drastically reduced. The impact extended to the economy, resulting in decreased crop yields, rising domestic prices, reduced agricultural exports, and increased imports to cover the trade deficit. This has a general,

economy-wide impact, lowering GDP, household consumption, and welfare. Moreover, the spillovers of agricultural productivity shocks are cascading through non-agricultural sectors that, directly or indirectly, utilize agriculture as a source of intermediate input, such as food processing and services like retail trade. Some sectors, such as manufacturing, benefit from increased output and exports owing to changes in relative competitiveness and reallocation of factors. From a welfare standpoint, household consumption falls significantly, with rural poor households experiencing a 3.7% to 6.8% decline and urban poor between 2.9% and 11.5%, especially under RCP 8.5. These consumption losses reflect broader income contractions and rising food prices, which are particularly burdensome for the most vulnerable.

At the macro level, the results indicate significant GDP losses, absorption, and investment, with an increasing impact over time, particularly in the high-emission RCP 8.5 scenario. Meanwhile, households suffer from reduced income and consumption across rural and urban households. Urban inequality is intensified because poor households suffer more severe declines in consumption than high-quantile-income households. Trade impacts indicate that the main agricultural exports of Ethiopia, such as coffee, pulses, and maize, are expected to decline significantly in both climate scenarios. This decline in export earnings further constrains foreign exchange reserves, worsening the decline in GDP and household consumption. This occurs as the manufacturing sector realizes some export gains owing to dampened domestic demand; however, the overall trade balance deteriorates. In summary, the results indicate that the Ethiopian economy is vulnerable to climate change, primarily through its impact on agriculture, which has a robust yet indirect connection with other sectors. The ripple effects of decreased agricultural productivity extend throughout the economy, thereby slowing growth and negatively impacting food security. Without substantial policy interventions, such as adaptation measures and diversification of income sources, the Ethiopian economy will face escalating challenges in the coming decades. Addressing these issues requires a multifaceted approach, leveraging climate resilience strategies and structural reforms to mitigate the economic and social consequences of climate change.

Chapter 5

Trade Under Climate Pressure in Ethiopia: A Recursive Dynamic CGE Analysis

5.1 Introduction

Economic transformation and poverty eradication via broad-based, accelerated, and sustained growth have been at the forefront of Ethiopian policy priorities over the last few decades. In this regard, Ethiopia recorded impressive economic growth between 2000 and 2019 at an annual rate of 9%, which is higher than the average growth rate in sub-Saharan Africa (African Export-Import Bank, 2024). In addition, it is arguably the case that such growth stemmed from liberalization in the 1990s, substantial investments in public infrastructure, and policies oriented towards agriculture (Bachewe et al., 2018). However, looming challenges such as infrastructure gaps, climate change, and conflicts pose uncertainties and vulnerabilities to the sustainability of growth. Building a resilient economy is more critical than ever, necessitating the strengthening of LDCs' trade cooperation and revisiting international trade agreements to address global challenges, such as resilient supply chains, energy transition, and secure digital infrastructure (UNCTAD, 2023a). Ethiopia signed the AfCFTA in 2018, which aims to significantly boost intra-African trade, enhance regional inclusive growth, increase income and food security, and reduce external dependency. The AfCFTA liberalization schedules differ among countries according to their level of development (see Chapter 2). Ethiopia prepared and presented the country tariff offer to the secretariat in November 2023 to be commented on by member countries and concerned bodies of the secretariat and accepted in February 2024 (African Union, 2024). In this liberalization proposal, foodstuffs (over 60 products) and transportation services (50 product categories) represent the bulk of the excluded items at the HS8 product classification level. Ethiopia is a net importer of food products, and it exports transportation services, which could have significant

policy implications. Indeed, earlier estimates by various studies showed that the AfCFTA could increase trade within the African continent by 30%–80%, thus significantly improving economic income gains (World Bank, 2020b; Economic Commission for Africa and Africa Trade Policy Center, 2024; Abrego et al., 2019; Simola et al., 2021). Although these gains are not evenly distributed across sectors and countries, they could raise incomes for nearly 100 million people and lift 30 million out of extreme poverty by 2035, according to the World Bank (2020b) projection. This liberalization process will likely shift labor from agriculture to the public sector, service sector, and manufacturing industries.

Ethiopia is expected to be one of the largest beneficiaries of the AfCFTA, with significant gains in agriculture, processed foods, construction, and air transport services. However, the impacts on manufacturing and certain trade services are expected to be adverse. Nonetheless, the country faces binding constraints such as high population growth and inadequate infrastructure, especially in drought-prone areas (World Bank, 2021). Thus, the opportunities from the AfCFTA are seriously threatened by climate change, which may reduce the comparative advantage in agriculture, possibly causing spillover effects throughout the economy. Previous studies may underestimate the positive effects of intra-African trade liberalization, despite the impact of climate change. Climate change leads to reduced crop yields, increased food prices, and disruptions in agricultural productivity due to rising temperatures and adverse weather conditions (Braun et al., 1991; Godde et al., 2021; Ndlovu et al., 2020). Several studies (World Bank, 2008; World Bank, 2024a; Solomon et al., 2021; Gebreegziabher et al., 2016; Robinson et al., 2013) have estimated that climate change could reduce Ethiopia's GDP by approximately 8% to 10% by the middle of the 21st century. Food security can only improve when trade, nutritional, and social policies are integrated into the climate change framework.

Trade can play a crucial role in adapting to climate change by adjusting the production of vulnerable products (Brenton et al., 2022; Janssens et al., 2020; Leichenko et al., 2002; Huang et al., 2011; Reilly et al., 1993; Calzadilla et al., 2011). However, Africa faces significant challenges due to high tariffs and non-tariff trade barriers, which complicate international trade and economic growth. In addition, stringent regulation of carbon-intensive products reflects a growing commitment to environmental sustainability (Shapiro, 2021). In Ethiopia, implementing exogenous structural change policies plays a crucial role in mitigating the adverse impacts of climate change. These strategic policies are anticipated to offset approximately 20%–30% of the overall effects associated with climate change in the country (Yalew et al., 2017). This proactive approach addresses environmental concerns and promotes economic resilience and sustainability in the region.

Despite numerous studies on the impacts of climate change on the Ethiopian economy, the role of trade agreements in this context has been largely overlooked. This

study aimed to fill this gap by analyzing the impacts of the AfCFTA in light of climate change, providing a comprehensive assessment that encompasses sectoral, income level, and rural–urban dimensions. This study contributes to the literature and policy debate on the impacts of trade against climate change on developing countries in the following ways. First, this study projects the annual country-level economic and welfare effects of the product-level agricultural climate shock (rainfall and precipitation). This analysis better accounts for the differential crop sensitivity to climate change over different years (Waldhoff et al., 2020), improving the direct and indirect impact analyses of climate change in a CGE model. Second, the AfCFTA is modeled for Ethiopia using the actual tariff offer. In a full trade liberalization with African countries, the average actual tariff offer allows us to better understand the potential impacts and future implementation options and challenges of the agreement. Finally, this study used a trade liberalization vs. climate change simulation to better depict the economic and negotiation power of the country in the AfCFTA and can be further implied to the WTO accession. As an agrarian, fast-growing economy and the second-most populous country on the continent, the impacts of climate change are negligible. AfCFTA is one of the many ways to harness this negative shock by enhancing its competitiveness and comparative advantage.

Against this background, this study explores the possible effects of AfCFTA trade liberalization in climate affected Ethiopian economy. To achieve this, bilateral tariff liberalization with African countries and TF are simulated, and a single-country recursive dynamic CGE model is employed, for the period 2021 to 2035. The climate shock of the agriculture sector is implemented in the baseline, as discussed in Chapter 4. The simulation results indicate that the AfCFTA will significantly impact the Ethiopian economy by overcoming the negative impacts of climate change. At the sectoral and household level, agriculture, food processing, and some manufacturing sectors will benefit the most, while the rural and urban poor will recover from the climate shock significantly. At the macroeconomic level, these trade liberalization efforts foster growth in imports and exports, real income, and GDP. Moreover, AfCFTA significantly affects welfare, absorption, investment, and private consumption. However, the government's tariff revenue loss is moderate at 11.5% of the total revenue.

5.2 Trade liberalisation and climate change

Trade can be instrumental in resource allocation efficiency and promote development, and can facilitate the dissemination and transfer of technologies needed to address climate change (WTO, 2023; UNCTAD, 2023a; Hertel, 2018; Gouel et al., 2018; Truong, 2010). From an agricultural perspective, trade is a critical tool to mitigate climate change by optimising production systems, enhancing resilience, and

accelerating the adoption of climate-smart technologies. Agriculture, a sector both vulnerable to and responsible for 23% of global greenhouse gas emissions, stands at the intersection of climate action and trade policy (Food and Agriculture Organization, 2017). By leveraging their comparative advantages, countries can specialize in crops best suited to their ecological and climatic conditions, thereby reducing the need for resource-intensive practices. Agricultural trade and policies impact climate change adaptation and mitigation. Trade acts as a buffer against climate-induced crop shortages by stabilizing food supply and prices, but its effectiveness depends on trade policies, tariffs, and the nature of productivity shocks (Villoria et al., 2024). In the short term, trade helps mitigate disruptions, while in the long run, diversifying domestic production and improving supply chain resilience are more sustainable strategies.

Trade also facilitates access to climate-resilient technologies and practices, as well as potential solutions, through the use of cooperative trade agreements, technology transfer, or carbon tariffs against recalcitrant nations (Pienknagura, 2024; Brenton et al., 2022). The AfCFTA can lower tariffs on drought-tolerant seeds, solar-powered irrigation systems, and biofertilisers, enabling smallholders to adopt sustainable methods. Moreover, global value chains can incentivise low-carbon practices. Carbon pricing mechanisms, such as the EU's Carbon Border Adjustment Mechanism (CBAM), may soon penalise emissions-intensive agricultural imports, pushing exporters to adopt greener methods.

5.2.1 Trade liberalisation vs. climate change

Trade can significantly influence climate change via various mechanisms. Trade has become a key driver of economic growth and poverty reduction. Trade in goods has increased global incomes by 24% since 1990, while incomes for the poorest have increased from 40% to 50% (World Bank, 2023). However, trade is one of the most widely discussed factors contributing to global warming. Contrarily, trade can be part of the solution with the right policies to encourage cleaner production and trade in climate-friendly goods and services. Without adaptation through trade, the impacts of global climate change would increase the number of undernourished people to 73million (+33%). In contrast, a reduction in tariffs, as well as institutional and infrastructural barriers, would decrease the negative impact on 20 million (64%) people (Janssens et al., 2020).

Moreover, trade will be critical for greening, making the world resilient, and developing the world inclusively in the coming decades, particularly in light of climate change. It offers enormous opportunities for mitigating and adapting to a changing climate. Furthermore, trade facilitates the transition to cleaner methods of production by shifting production to countries that have a comparative advantage in

environmentally friendly technologies. The comparative export advantage will continue to shift as economies transition to low-carbon economies, which will pressure countries to adjust and seize new opportunities.

The developing world, by any count, is a minor contributor to emissions but remains highly vulnerable to the negative impacts of climate change. Therefore, they have much at stake in successfully adapting, especially to climate-sensitive sectors such as agriculture, which remains central to food security, employment, and trade. Shifting investment away from sensitive sectors can help build long-term resilience. How, then, can we achieve such gains? It is imperative to recalibrate trade policies, including the review and elimination of tariffs biased toward polluting sectors. For instance, facilitate access to environmental goods and services through multilateral negotiations. Another approach is to eliminate NTBs and enhance trade facilitation, thereby reducing delays, particularly in food supply chains, and thereby increasing food security. Moreover, tariffs and NTBs should be reduced for agricultural inputs and farmers' access to new technologies. However, the expansion of production and consumption through trade creates greenhouse gas emissions. The expansion of international trade generally enhances economic activities in more sectors of the economy, thereby predictably increasing greenhouse gas emissions. This phenomenon is known as the scale effect, which has a negative sign because an increase in economic activity is associated with higher emissions (Grossman et al., 1991; Copeland et al., 1994). Anti-globalization critics have largely highlighted the negative side of the scale effect, arguing that increased trade exacerbates environmental degradation and climate change (IPCC, 2023; WTO, 2018).

The second mechanism is through composition effects, which are understood in terms of how trade and climate policies shape patterns of production and consumption. As countries trade, they become wealthier, and theoretically, they increase their demand for goods and services, such as environmental goods. Wealthy countries will trade carbon-intensive goods, such as steel and cement, in favor of lower-carbon products and services, including technology and telecommunications. However, this shift would not have been realised without the trading partners' stringent enforcement of environmental regulations. In practice, without coordinated international policies, emissions could just be relocated or "leaked" from one country to another, as has been the case until now, detracting negatively from the overall positive contribution trade has made to climate change (WTO, 2021; Garsous, 2019).

The third mechanism is the technique effects. Technique effects refer to the changes in production techniques that occur due to trade liberalization and investment agreements, which may result in more energy-efficient production, thereby reducing greenhouse gas emissions per unit of output. The right policy can promote trade and the diffusion of cleaner technologies and best practices. Some EU climate policies, such as incentives for adopting renewable energy sources, have spurred innovation

and the development of clean technologies. Furthermore, international negotiations, such as those held at the WTO on the environmental goods and services sector, work toward liberalizing the trade of climate-friendly technologies and thus may enhance the positive technique effects further (WTO, 2022).

Finally, the interlinking mechanism is the direct effect. Trade has immediate effects on climate change, particularly related to the increased demand for international freight, which is one of the carbon-intensive sectors. The high dependence on combustible fossil fuels results in an incremental increase in greenhouse gas (GHG) emissions (WTO, 2021; IPCC, 2023). This aspect of trade has a consistently negative impact on the environment, as most emissions are released through the transport sector, which is one of the most detrimental to the atmosphere (International Energy Agency (International Energy Agency, 2021). On the contrary, these direct effects should be weighed against the trade benefits in the context of promoting economic growth and development. For instance, these efforts involve reducing the adverse direct impacts by promoting low-carbon means of transport, such as electrified shipping and aviation, and participating in within-country-initiated carbon pricing mechanisms applied in the transportation industries of countries exporting to the importing country (Organization for Economic Cooperation and Development, 2021; WTO, 2022).

5.2.2 AfCFTA and climate change: Ethiopian context

AfCFTA will be a landmark initiative for a single continental market of goods and services across Africa, with the free movement of businesspersons and investments, as briefly discussed in Chapter 2. Ethiopia is one of the signatory countries, and this subsection provides a brief overview of the AfCFTA case in Ethiopia. Particularly, the deal is likely to facilitate an expansion of trade by eliminating tariffs and other trade barriers, thereby increasing market access for goods and services in Ethiopia. According to the Economic Commission for Africa and Africa Trade Policy Center (2024), the AfCFTA is expected to increase intra-African trade by over 50% by 2040. This implies an increase in exports, particularly in manufacturing and agriculture, for Ethiopia, which are crucial sectors of the economy.

AfCFTA pushes Ethiopia toward industrialization. It is for this reason that its contribution to the deal can lead to value-added industries, breaking the country's cycle of a mono-economy that relies too heavily on exporting agriculture-based products (Stuart, 2022; Fusacchia et al., 2022; African Union Commission/Organization for Economic Cooperation and Development, 2022). The country will, therefore, be able to leverage AfCFTA to FDI in manufacturing and also accelerate its industrial development strategy to ensure that it becomes a middle-income country by 2025, as envisioned in a report by the African Development Bank (2024a). It is prudent to

note that the cost reductions associated with trade integration into a larger market are crucial to Ethiopia's aspirations of becoming a manufacturing hub in Africa.

On the downside, however, some impediments are standing in the way of growth in the industrial sector in Ethiopia, which has primarily been less competitive owing to infrastructural bottlenecks, energy constraints, and logistical challenges (UNDP, 2023; FDRE Ministry of Industry, 2021; Gebrehiwot et al., 2020; Oqubay, 2019; Gebreeyesus, 2013; Ciuriak, 2010; Luther et al., 2009). The World Bank (2024d) emphasized that unless these areas are seriously overhauled, they will make it challenging for Ethiopian manufacturers to make a mark in the more established industries of other African countries. Added to this is the risk of trade diversion and pressure on local industries from competing with imports from more competitive markets in the AfCFTA. In fact, according to several studies (Economic Commission for Africa and Africa Trade Policy Center, 2024; World Bank, 2020b; Abrego et al., 2019; Economic Commission for Africa and the Centre for International Research and Economic Modelling (CIREM(CEPII)), 2021), this risk must be cautiously managed.

On the contrary, Ethiopia is among those most vulnerable to climate change, as agriculture heavily relies on rainfall for a significant portion of its GDP contributions and employs a large proportion of the population in the sector (Conway et al., 2011; Bouteska et al., 2024; Admassie et al., 2021). Moreover, the nation's topography varies significantly across climatic zones, making it vulnerable to nearly all forms of climate-related impacts (Shukla et al., 2021). Climate change is already contributing to the decline in agricultural productivity in Ethiopia. Such a situation has resulted in decreased crop yields due to increasing average temperatures, erratic rainfall patterns, and an increasing frequency of extreme weather events. The International Food Policy Research Institute Robinson et al. (2013) estimated that potential climate change in Ethiopia may reduce GDP by as much as 10% before 2050, thereby increasing food insecurity and poverty.

The interactions between AfCFTA and climate change in Ethiopia highlight both the opportunities and challenges. In turn, AfCFTA trade opportunities may provide Ethiopia with economic means and technological transfers to help it better adapt to and mitigate climate change. For instance, the revenues generated from increased trade flows can be effectively utilized through the development of climatically resilient infrastructure, sustainable agricultural practices, and renewable energy initiatives. Regional cooperation, as envisaged under the AfCFTA, can promote Ethiopia's capacity to develop climate adaptation strategies by sharing technologies and knowledge (African Union, 2024).

On the contrary, climate change may be one of those scenarios in which Ethiopia cannot maximize the benefits of the AfCFTA. For instance, climate-related disruptive

events affecting agricultural production will have negative implications for the export potential of leading commodities, such as Coffee, Sesame, and oil crops, which are sensitive to climate change. In addition, in the absence of effective adaptation measures, the anticipated economic gains from the AfCFTA could be delayed by losses resulting from climate change, particularly those affecting agriculture and other water-related sectors.

The more challenging issue is the low-carbon economy pathway that Ethiopia must take, given its global commitments on climate change. AfCFTA can bring industry growth; however, this industrial growth should be in sync with sustainable practices to avoid further environmental degradation and greenhouse gas emissions. In addition, the Africa Climate Policy Center suggested that the AfCFTA implementation program should mainstream green growth strategies to ensure that the growth driven by trade for Ethiopia and any other African countries is resilient and sustainable in the event of climate change.

However, with regard to the economic impacts resulting from trade policies and climate change, Ethiopia corresponds to one of the most studied countries; however, many of the studies are using either econometric or CGE models. A significant gap exists in the literature regarding the complex implications of the AfCFTA and climate change-induced changes in productivity. This study conducted an ex ante analysis of these impacts, focusing on studies that employ CGE models.

Despite numerous studies on the impacts of climate change and available adaptation choices, the role of trade in mitigation has not been given much emphasis. Under the AfCFTA, trade can play a significant role in mitigating the impact of climate change. Indeed, AfCFTA is predicted to increase intra-African trade by 30%–80% (Abrego et al., 2019; Economic Commission for Africa and the Centre for International Research and Economic Modelling (CIREM(CEPII)), 2021; World Bank, 2020b; Saygili et al., 2018) with economic gains of additional income of approximately 7% by 2035 (World Bank, 2020b). Labor will be reallocated sectorally from agriculture to manufacturing and services, with varying overall effects across countries and sectors.

Ethiopia is one of the tops benefiting countries, with a real income effect of approximately 9% of the measures on nontariff and trade facilitation; however, the sectoral results vary. Agriculture, food processing, and construction benefit the most, while reductions in employment can be felt in manufacturing and a few other service sectors.

Several studies have examined the effects of climate change on the Ethiopian economy, highlighting significant challenges across various sectors. Using the Ricardian approach, Deressa et al. (2009) estimated net crop revenue losses of 15.4% by 2050 and over 100% by 2100 under a Parallel Climate Model scenario, indicating severe

seasonal and agroecological vulnerabilities. The World Bank (2008) simulated historical climate shocks using a stochastic dynamic CGE model and predicted that the worst-case scenario would result in a 46% reduction in GDP. Similarly, Robinson et al. (2012) projected that GDP will be 10% lower by 2050 using a dynamic CGE model without external adaptive funding. In addition, water constraints and flood damage (You et al., 2010) resulted in substantial economic impacts. Moreover, Gebreegziabher et al. (2016) combined the Ricardian approach with CGE simulations, estimating that agricultural productivity will decline by 30% over a 50-year period. Other regional studies, such as those by Bezabih et al. (2010) on Tanzania, have indicated that although impacts in the early period are relatively moderate, long-term impacts may be devastating, highlighting the need for adaptation strategies. These findings underscore the urgent need for comprehensive mitigation and adaptation mechanisms in Ethiopia's climate-vulnerable economy.

To fully mitigate the impacts of climate change, complementary policies focusing on climate-smart agriculture, irrigation expansion, and investment in agricultural technology are essential. In modeling adaptations, Yalew et al. (2017) investigated the cost of planned adaptation in Ethiopia, calling for more proactive government policy to enhance agricultural resilience using a CGE model. Solomon et al. (2021) employed a recursive dynamic CGE model to examine the adverse effects of climate change on various sectors and regions, with the highest sectoral loss projected by 2050. Aragie et al. (2023) projected the far-reaching impacts and pressures of climate change variations on catchment water flow and energy outputs in agriculture, which have significant effects on the agriculture sector and poor rural households. In a different study, Aragie (2013) examined the impacts of climate change on Ethiopia's agricultural sector, employing time-series econometric analysis to establish a relationship between rainfall variability and agricultural output, using data from national and regional sources. A simulation to forecast future impacts reveals that, owing to declining rainfall, Ethiopia has already lost more than 13% of its agricultural output. If trends continue, potential future losses could increase to over 6% per year. Their study shows that climate change, through its impact on lowered agricultural productivity, increases poverty and thus requires considerable adaptation measures.

Although interest has been growing in the economic impacts of trade liberalization and climate change, there has been little work focusing on how the combined impact affects the Ethiopian economy. For instance, Kahsay et al. (2018) examined this relationship within the broader Nile Basin context using a multisector CGE model within the GTAP-W framework. Their findings suggest that trade liberalization promotes economic growth and enhances welfare. However, water conservation is negligible, whereas climate change is a complex problem that influences both positive and negative changes in water availability. Most of these studies focus on a single resource, such as water, without thoroughly investigating the broader economy of

Ethiopia or the dual challenges and interplays of trade reforms and climate shocks.

Most of the earlier studies focused on the independent impacts of climate change on Ethiopia and were less likely to focus on how trade liberalization may interact with these climate-induced effects. While ample documentation exists on the implications of rising temperatures and unpredictable rainfall patterns for agriculture, analyses of how trade policies could further exacerbate or mitigate these challenges are scarce. Given Ethiopia's agriculture-based economy, the increasing emphasis on regional and global market integration requires an understanding of the interplay between these drivers and the country's economic resilience.

This chapter fills these knowledge gaps by applying a multisectoral CGE model to comprehensively study the nexus between climate change and trade liberalization in an Ethiopian context. It achieves this by providing insights into how these two forces jointly impact key sectors, household welfare, and overall economic performance. Moreover, this study aimed to identify pathways for policy intervention that can provide recommendations for achieving a balance of trade-driven growth in the face of climate shocks. This approach addresses a critical knowledge gap and contributes to the development of integrated policies that align economic development with environmental sustainability.

5.3 Data and Methodology

This section is based on the previous chapter's model [1] development and extended to analyze the intricate impacts of trade liberalization and climate change in Ethiopia. Chapter 4 presents a detailed discussion of the model description and SAM data used in this model. Climate change is the baseline for this chapter's analysis. Once the base is calibrated, shocks are introduced. Climate change-induced productivity changes are introduced as a crop-level productivity shock, and the macroeconomic and sectoral impacts on the Ethiopian economy are assessed. Productivity change is simulated at the baseline, and tariff liberalization is implemented as the AfCFTA proceeds. The national tariff offer[2] is used to determine the liberalization rate and schedule. National trade facilitation proceeds with tariff liberalization as a reduction in iceberg trade costs. However, to compare the simulated impact as a difference across the simulations, a separate simulation from the baseline is computed and reported as percentage changes. The AfCFTA impacts are on top of the

[1] The basic model and data applied in this chapter are developed in chapter 4, where the detailed model development and data description are presented. In this section, some specific AfCFTA data and applications are discussed.

[2] Ethiopia is in the LDCs group and will liberalize the tariff in accordance with the AfCFTA schedule. In November 2023, it submitted the tariff offer detail, which was accepted in the February 2024 meeting. The detailed HS8 level tariff offer received from the Ministry of Trade and Regional Integration.

climate change-affected base economy. Therefore, the results indicate the impacts of climate-induced productivity change and AfCFTA implementation.

Activities and commodities have a one-to-one mapping based on a concordance between the International Standard Industrial Classification of All Economic Activities industries and HS Version 2012 products (Aragie et al., 2021). For our application of trade liberalization, the rest of the world is divided into the Rest of Asia (ROA) and the Rest of the World (ROW), using different national reports and IMF balance of payments data. For instance, the Comtrade export and import data are used to allocate total exports and imports to the ROA and ROW. The rest of Africa (ROA) and the rest of the world (ROW) transact with the domestic economy via imports, exports, and capital flows. The imperfect substitution between domestic and foreign varieties is modeled within the Armington framework.

Many studies have shown that reduced trade costs, resulting from improved port handling of goods, fast and transparent customs procedures, standard inspections, simplified document requirements, lower transportation costs, and enhanced communication and information technologies, can have significant economic and welfare effects. Wilson et al. (2004) used classified country-level indicators of port efficiency, the customs environment, the regulatory environment, and e-business usage. They found that port-efficient management has a higher impact than customs and e-business in the Asia Pacific Economic Cooperation countries. The fact that trade transaction costs can be as much as 15% of the value of shipment suggests that reducing such costs can raise trade volumes and GDP, similar to the effect of reducing tariffs (Organization for Economic Co-operation and Development, 2003). The trade costs, as a transport margin paid by each producing activity, are calculated based on their purchase price transaction values. These sectoral transport margins are then incorporated into the calculation of the domestic sales price. Changes in transportation margins directly impact domestic sales prices, which in turn influence all other prices due to their interconnected nature. As sectoral prices fluctuate, resources are reallocated across different production activities. AVEs of the World Bank Doing Business time to trade are used (Wassie et al., 2024). In an updated product- and country-level AVE computation for Ethiopia, the cost is simulated as a reduction in trade margin.

5.3.1 Macroeconomic closure rules

The chosen macroeconomic closure rules provide a coherent framework to analyze the dynamic interactions between climate change, trade liberalization, and economic performance in the context of Ethiopia. By capturing the key adjustment mechanisms in savings, investment, government balance, external balance, and factor markets, the model offers robust insights into the potential long-term impacts of these

policy interventions. This detailed closure specification ensures that the model remains grounded in economic theory while allowing for realistic simulations of policy scenarios. Chapter 2, section 2.4, provides a detailed discussion of the alternative closure rules and their economic implications.

The simulations are based on the following closure rules:

- Savings-driven investment: Investment adjusts based on the fixed saving propensities of households and enterprises.
- Semi-flexible government spending: Any fiscal imbalance is addressed through adjustments in government savings or borrowing, while tax rates remain fixed.
- Capital: Capital is assumed to be partially mobile across sectors with sector-specific adjustment costs. This assumption captures the slow reallocation of capital in response to shocks.
- Fixed foreign savings and variable exchange rates.
- The PPI is the model numeraire, the reference price for all other price changes. Therefore, the CPI changes to the PPI.
- Labor: Mobile labor and land across national activities. Labor is segregated (classified as unskilled, semiskilled, and skilled) and mobile across activities; however, only skilled labor is fully employed.

5.3.2 Simulation scenarios

The following scenarios were simulated to evaluate the interplay and separate effects of climate change and AfCFTA trade liberalization in Ethiopia. The experiments demonstrate how the AfCFTA implementation will impact the Ethiopian economy in the context of climate-affected agriculture.
Case 1: Climate change impact:

- Climate change scenario (RCP 4.5): Introduction of TFP shocks owing to climate change under the RCP 4.5 emission scenario.
- Climate change scenario (RCP 8.5): Introduction of TFP shocks owing to climate change under the RCP 8.5 climate scenario.
  Case 2: Impact of climate change with trade liberalization
- Climate change 1 and tariff liberalization scenario (RCP 4.5 tariff): TFP shock from the RCP 4.5 scenario and implementation of the AfCFTA liberalization. A gradual full liberalization of tariffs for African countries is only implemented based on the actual yearly promised liberalization. Based on the actual offer

of tariff liberalization, the yearly tariff reduction is calculated as the average of the offer.

- Climate change 2 and tariff liberalization scenario (RCP 8.5 tariff): TFP shock from the RCP 8.5 scenario and implementation of AfCFTA liberalization measures.

- Climate change 1 and tariff and trade facilitation (RCP 4.5 tariff and TF): Joint implementation of the TFP shock scenario RCP 4.5, AfCFTA liberalization, and trade facilitation. The implementation of AfCFTA features a trade facilitation section that aims to reduce unnecessary trade barriers and hassles, including border and customs cooperation by half. According to a structural gravity study (Wassie et al., 2024), the AVE of the World Bank's time to trade for import and export, which accounts for 28.5% (14.25%) and 25.2% (12.6%), respectively, is used in our simulation. This was implemented as a trade margin reduction in the CGE model.

- Climate change 2 and tariff and trade facilitation (RCP 8.5 tariff and TF): Joint implementation of the TFP shock scenario RCP 8.5, AfCFTA liberalization, and trade facilitation. AfCFTA implementation features a trade facilitation section that aims to reduce unnecessary trade hurdles and barriers, such as border and customs cooperation. From a structural gravity study by Wassie et al. (2024), half of the 28.5% and 25.2% AVE of the World Bank time to trade for import and export are used in our simulation, which was implemented as a trade margin reduction in the CGE model.

Simulation experiments

Table 5.1 presents the specific application procedures of the simulation experiments.

TABLE 5.1: Simulation experiments

Climate scenarios AfCFTA Liberalization	*Baseline with climate RCP 4.5*	*Baseline with climate RCP 8.5*
AfCFTA tariff	*YES*	*Yes*
AfCFTA tariff and TF	*YES*	*Yes*

5.4 Simulation results and discussions

The economy-wide and sectoral effects of climate change-induced shocks to agricultural productivity in Ethiopia, as presented in Chapter 4, highlight the significant economic implications for both the agricultural and non-agricultural sectors. The high dependence of Ethiopia on agriculture amplifies the adverse effects of climate

change on the broader economy, showing vulnerabilities beyond the agricultural sector. This section examines how the implementation of AfCFTA addresses these challenges. Our results indicate interactions between the tariff and trade facilitation reforms of AfCFTA and the agricultural productivity shocks induced by climate change under the RCP 4.5 and RCP 8.5 scenarios. The key findings have implications for the impacts of trade policy on trade performance, price adjustment, sectoral resource allocation, and income distribution in the context of a climate-affected Ethiopian economy.

5.4.1 Economic impacts of AfCFTA with climate change

This section discusses whether the implementation of the AfCFTA can mitigate the negative impacts of climate change in Ethiopia. Two scenarios are used—tariff reductions only and tariff reductions plus trade facilitation—to assess the impacts on GDP, trade, employment, and household welfare. The findings suggest that implementing the AfCFTA can stimulate trade, industrialization, and development through enhanced market access and regional integration. However, the magnitudes of these gains are mitigated by the severity of climate change, especially under RCP 8.5, which results in substantial losses in agricultural productivity.

5.4.2 Sectoral output impacts: Agriculture vs. Industry and Services

Several factors explain the impacts of changes in output [3]. When import prices decrease in the standard Armington framework, a higher expenditure on imports compared to domestic production is observed across different sectors. Without exports, production overall decreases. However, exports increased owing to real exchange rate depreciation, reduced production cost from low-priced imported intermediate goods, assumed enhancements in trade facilitation for Ethiopian exporters, and improved market access in Africa and globally.

The Ethiopian economic structure, which is heavily reliant on agriculture, makes it particularly vulnerable to the impacts of climate change. However, the AfCFTA enables regional market access, encouraging export diversification and industrial development, particularly in the manufacturing and services sectors. Although agriculture remains a critical component of the economy, it is experiencing negative effects due to climate change, including declines in the output and exports of key agricultural products such as maize, poultry, vegetables, and coffee.

[3] These results are tariff liberalization and TF on a climate change base economy. Sectors are aggregated according to the products concordance in the modelling and for a simple presentation purpose.

However, the manufacturing and services sectors benefit from increased demand in African markets driven by tariff reductions and TF, as shown in Figure 5.1. Textiles, processed foods, and manufactured products are among the sectors poised for significant growth. This shift helps mitigate losses in agricultural exports, contributing to a gradual improvement in Ethiopia's trade balance over time.

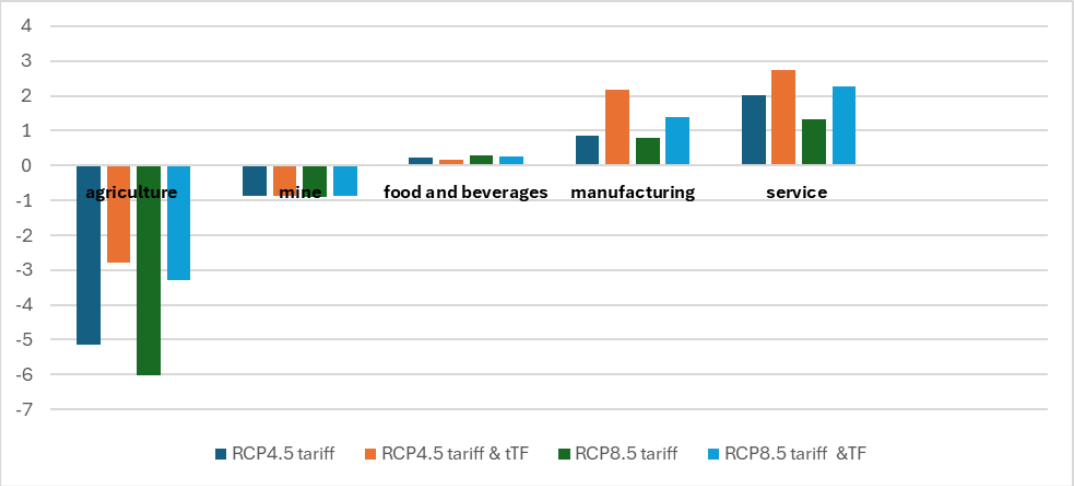

FIGURE 5.1: Annual average Output impact of AfCFTA tariff and TF with climate change

Figure 5.1 presents the sectoral results from implementing the two policy instruments (tariffs and trade facilitation) under two climate scenarios (RCP 4.5 and RCP 8.5). According to the estimates, agriculture suffers the highest loss in all scenarios, with the loss being substantial in the RCP 4.5 and 8.5 scenarios of tariff liberalization. This highlights the vulnerability of Ethiopian agriculture, a major contributor to the country's GDP and employment, to climate change and trade policy. Given the sector's reliance on rain-fed farming and limited adaptive capacity, these results underscore the risks to food security and rural livelihoods. Similarly, while the mining sector is a minor component of Ethiopia's economy, it also has consistent but minor negative impacts, reflecting potential challenges to global competitiveness and resource demand. By contrast, the food and beverage sector has relatively minor impacts, which may indicate resilience, likely owing to its linkage with domestic demand.

On the contrary, the manufacturing sector appears to be largely unaffected, reflecting the country's low level of industrialization and limited exposure to international trade dynamics. Moreover, the service sector shows a positive impact across all scenarios, with more substantial gains under the RCP 4.5 scenarios. This suggests that the service sector, which is becoming increasingly important in the Ethiopian economy, could experience a relative gain from trade facilitation reforms and growing urban demand. Similarly, other service sectors have revealed marginally positive outcomes, supporting the relative robustness of nonclimate-sensitive activities. For Ethiopia, these results underscore the urgent need to address the vulnerabilities of

the agriculture sector through targeted investments in climate adaptation measures.

Trade facilitation measures, although beneficial for services, must be designed to enable primary sectors, such as agriculture, to integrate more effectively into value chains and reduce export revenue losses. The muted response from manufacturing highlights the importance of accelerating industrialization and value while diversifying the economy and reducing the dependency on agriculture. Furthermore, the resilience of the service sector suggests an opportunity to leverage urbanization and technological advancements to drive growth.

5.4.3 Macroeconomic effects

One of the key findings is the differentiated impacts on trade performance under the two climate scenarios of RCP 4.5 and RCP 8.5. Although the implementation of AfCFTA generally boosts Ethiopia's trade volume, the gains are constrained by the severity of agricultural productivity shocks. Under RCP 4.5, with moderate climate shocks, Ethiopia enjoys a modest increase in agricultural exports owing to improved market access and lower trade costs facilitated by the AfCFTA. However, the productivity loss in agriculture under RCP 8.5 significantly diminishes agricultural exports, preventing Ethiopia from fully exploiting its trade benefits. This result suggests that climate change could substantially reduce the trade benefits of regional agreements for economies that rely on the exports of climate-sensitive products, such as agriculture. These results further indicate that Ethiopia's trade balance is shifting toward greater reliance on manufacturing and processed food imports. This highlights the need for supportive policy measures to promote agricultural export diversification and value addition.

As discussed in Chapter 4, climate change has a negative impact on the economy. Figure 5.2 presents the impact of implementing AfCFTA on tariffs and TF according to the RCP 4.5 and RCP 8.5 climate scenarios for key macroeconomic variables in Ethiopia using a CGE model simulation. The results indicate a significant increase in exports and imports under all scenarios, with the combined tariff and trade facilitation scenario under RCP 4.5 exhibiting the highest increase, thereby underscoring the crucial role of improved trade facilitation in enhancing Ethiopia's trade performance despite climate-induced agricultural productivity shocks. In addition, private consumption and fixed investment increased; however, the impacts are more substantial under the RCP 4.5 scenarios than in the RCP 8.5 scenarios, reflecting a better recovery of domestic demand and milder economic shocks under a less severe climate scenario. Aggregate absorption, representing total economic spending, GDP at market prices, and factor cost, shows marginal but positive growth across all scenarios, with more substantial increases if trade facilitation measures are included. These findings suggest that the implementation of AfCFTA, particularly

through trade facilitation measures, mitigates the adverse economic effects of climate shocks and promotes economic integration and growth in Ethiopia. However, the magnitude of these gains depends on the level of climate change impacts, as shown by the differences between the RCP 4.5 and RCP 8.5 scenarios. The annual

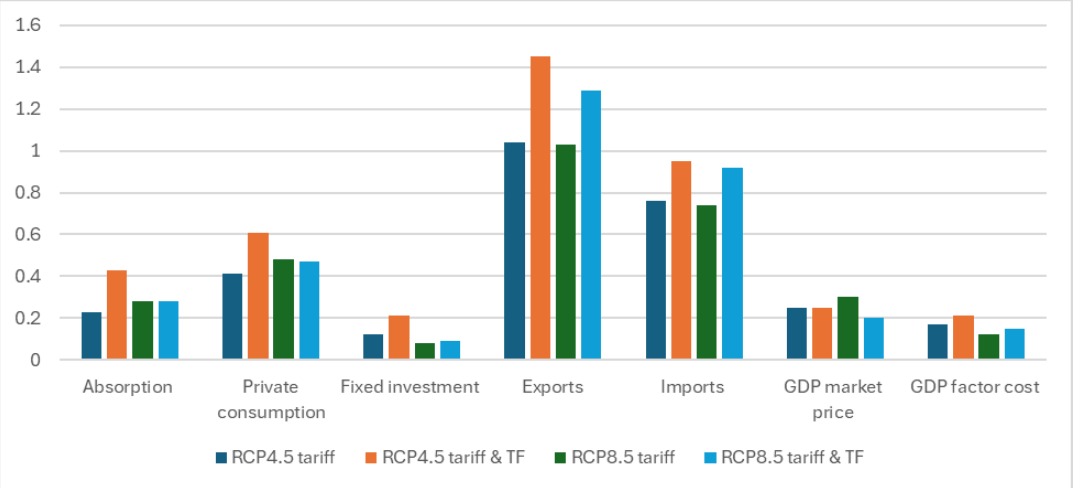

FIGURE 5.2: Percentage annual change on major economic variables at the national level due to AfCFTA with climate change.

growth rate of detailed sectoral exports exhibits a varied trend over the simulation period. As an economy reliant on rain-fed agriculture, Ethiopia's future sectoral export growth rate is expected to be volatile due to climate change shocks and turbulent trade dynamics. Despite the anticipated boost in intra-African trade with the implementation of the AfCFTA (Appendix to Chapter 5), our simulation results suggest that Ethiopia's export growth rate is limited. Specifically, agricultural products (maize, poultry, and vegetables), coffee, fish, meat, and cattle, as well as food, indicate negative export growth rates. This could be attributed to the increasing impact of climate change on the country's exports. Deressa et al. (2009) and Solomon et al. (2021) have suggested that the regressive impact of climate change will intensify in the future.

In fact, the value of manufacturing output is higher under the AfCFTA in 2035 than under the baseline scenario, and the output of several manufacturing sectors expands at a slower rate than that of other sectors. Similarly, for agriculture, the volume of output for most activities under the combined tariff and TF scenarios by 2035 is higher than under the baseline and lower in the climate change path, whereas for services, the volume is higher under the baseline and AfCFTA, indicating the less vulnerable status of the services sector relative to the agriculture sector.

5.4.4 Household consumption effects

The household consumption expenditure simulation of the AfCFTA implementation scenarios with tariff and TF measures, across RCP4.5 and RCP8.5 climate scenarios, reveals notable insights into consumption patterns across rural and urban quantiles. The results demonstrate a general increase in household consumption across all quantiles when trade facilitation measures are included, with more pronounced gains under the RCP4.5 scenario. These findings align with previous studies that have highlighted the positive impacts of regional trade agreements and improved TF on household welfare in sub-Saharan Africa.

In rural areas, households in the lowest consumption quantile (quantile 1) exhibit the highest expenditure growth, reaching a 5.95% increase under the RCP4.5 tariff and trade facilitation scenario. This suggests that trade facilitation measures help reduce market inefficiencies and improve access to affordable goods, which benefits poorer rural households disproportionately. Consumption gains gradually decline across higher rural quantiles, with rural quantile 5 seeing only a modest 1.30% increase under the same scenario. This pattern reflects the tendency for lower-income households to experience greater relative improvements in welfare from trade liberalization. Urban households also exhibit positive expenditure changes, though the impact is slightly less pronounced compared to rural households. Urban quantile 1 shows a significant increase of 4.94% under RCP4.5 with trade facilitation, underscoring the importance of AfCFTA in enhancing market access and reducing the cost of living for urban low-income families. Higher urban quantiles experience diminishing consumption gains, with urban quantile 5 registering only a 1.12% increase under RCP4.5 with trade facilitation. Interestingly, the consumption expenditure response is less favorable under the RCP8.5 scenario, particularly without trade facilitation measures, where urban quantile 5 records a negligible 0.30% increase. Our simulation results are consistent with prior studies that emphasize the role of trade agreements in boosting household welfare, particularly in rural regions where market fragmentation and high transportation costs often limit access to affordable goods. The findings also highlight the vulnerability of household consumption patterns to climate risks, as evidenced by the lower growth in expenditure under different scenarios. Trade facilitation measures appear critical for mitigating these climate-related impacts by improving supply chain efficiency and reducing trade costs. Overall, Ethiopia's implementation of AfCFTA, particularly with trade facilitation measures, holds the potential to significantly enhance household consumption and welfare, especially for low-income households.

However, this net effect is highly dependent on sectoral linkages, government policies, and household heterogeneity in terms of income sources and consumption patterns. Prior studies projected consumption gains for Ethiopia to be positive. However, although the World Bank (2020b) found a higher rate than the African average,

TABLE 5.2: Annual average percentage change on household consumption due to afcfta with climate change.

	RCP4.5 tariff	RCP4.5 Tariff &TF	RCP8.5 tariff	RCP8.5 tariff & TF
Rural quantile 1	3.90	5.95	1.91	3.90
Rural quantile 2	2.36	4.36	1.55	2.57
Rural quantile 3	2.39	3.41	1.67	2.67
Rural quantile 4	2.12	2.14	1.33	2.33
Rural quantile 5	0.79	1.30	0.53	0.94
Urban quantile 1	2.39	4.94	1.52	2.85
Urban quantile 2	2.32	3.41	1.15	2.43
Urban quantile 3	1.19	2.26	1.32	1.29
Urban quantile 4	1.10	1.46	1.02	1.20
Urban quantile 5	0.80	1.12	0.30	0.91

Abrego et al. (2019) found a rate lower than the African average for Ethiopia.

5.4.5 Factor allocation

Our results indicate that unskilled labor benefits significantly from the implementation of AfCFTA, particularly under the RCP4.5 moderate scenario with trade facilitation. The service sector is expected to show the highest allocation of unskilled labor, increasing by over 9% by 2035 under RCP8.5 conditions (Figure 5.3). Agriculture also experiences robust growth, with unskilled labor increasing by approximately 8% under RCP4.5 with trade facilitation. Although the manufacturing sector benefits, the gains are smaller compared to services and agriculture. These trends suggest that the service and agricultural sectors in Ethiopia will become key absorbers of unskilled labor as trade and logistics improve.

For semi-skilled labor, the manufacturing and service sectors are expected to see strong growth across all scenarios. Under RCP8.5 with trade facilitation, the service sector is expected to experience a nearly 7% increase in semi-skilled labor allocation, while manufacturing follows closely with a 6% rise. The agriculture sector shows more modest gains, which are more pronounced under RCP4.5 scenarios. This growth in demand for semi-skilled labor highlights the importance of Ethiopia's manufacturing and service sectors as engines of employment under improved trade conditions. The allocation of skilled labor presents a mixed picture. Under RCP4.5 scenarios, skilled labor allocation remains relatively stable in manufacturing and agriculture but shows negative changes in the service sector, with declines of up to 3% under RCP4.5 with trade facilitation. Conversely, RCP8.5 scenarios with trade facilitation show marginal positive increases in skilled labor allocation for manufacturing and agriculture, while the service sector continues to exhibit minor negative shifts. The decline in the service sector's skilled labor allocation may reflect a shift

toward less labor-intensive or more automated services. The findings suggest that Ethiopia's implementation of AfCFTA with trade facilitation under varying climate scenarios will have differentiated impacts on labor allocation across skill levels and sectors. The service sector emerges as a dominant absorber of both unskilled and semi-skilled labor, driven by trade expansion and improved logistics. Agriculture continues to play a crucial role in employing unskilled labor, particularly under scenarios with moderate climate impacts. The manufacturing sector shows consistent demand for semi-skilled and skilled labor, reinforcing Ethiopia's ambition to industrialize and participate more actively in regional value chains.

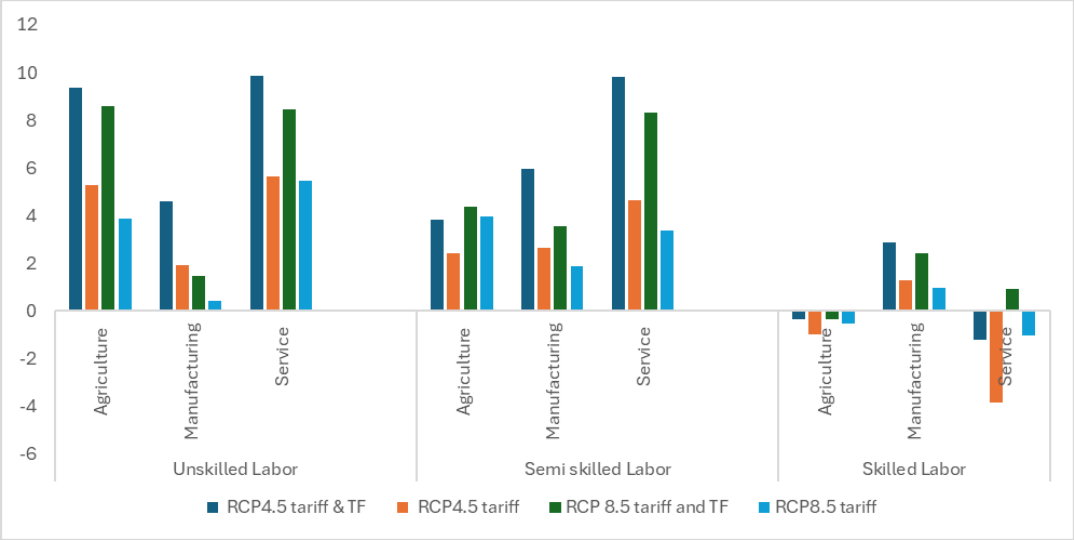

FIGURE 5.3: Factor employment effects AfCFTA with climate change

5.4.6 Price effects

The price simulation results provide significant insights into the potential impacts of AfCFTA implementation under climate change scenarios (RCP4.5 and RCP8.5) on Ethiopia's economy. Sectoral price changes indicate varying outcomes depending on whether trade liberalization is limited to tariff reduction or accompanied by trade facilitation measures. Our findings are particularly important for Ethiopia, where the economy is highly dependent on agriculture and is increasingly focused on growth in the manufacturing and service sectors.

The agricultural sector, which forms the backbone of Ethiopia's economy, exhibits notable price declines under a moderate climate shock scenario (RCP4.5) with tariff-only and trade facilitation measures, suggesting potential supply challenges or increased foreign competition under improved trade conditions. Conversely, under a severe climate shock, such as RCP8.5, agricultural prices rise, possibly due to constrained supply driven by harsher climate impacts. These results highlight the need for climate-resilient agricultural practices and adaptations. On the other hand, the mining sector demonstrates relatively modest price changes across all scenarios, reflecting its resilience and potential to benefit from AfCFTA's tariff liberalization. However, without proper climate adaptation measures, mining operations may face long-term environmental risks, particularly under the more severe RCP8.5 scenario. Meanwhile, the food and beverage sector exhibits modest positive price changes, particularly under RCP8.5 with trade facilitation, indicating enhanced demand and opportunities for trade expansion. Ethiopia's agro-processing industry could benefit from improved logistics and trade efficiencies, provided climate risks to raw material supply are addressed.

The service sector exhibits a strong and positive response across all scenarios, particularly with trade facilitation measures under RCP8.5, underscoring the potential for Ethiopia's digital economy and logistics services to thrive under liberalized trade conditions and enhanced infrastructure. Furthermore, the price increases in the manufacturing sector are notable when trade facilitation measures are implemented, particularly under the RCP8.5 scenario. This underscores the importance of complementary actions in logistics and regional value chain integration to enhance Ethiopia's competitiveness as a manufacturing hub. In brief, the findings highlight several key economic implications for Ethiopia. Climate resilience must be a top priority, particularly for the agricultural sector, where adverse impacts and price volatility are most apparent, and its implications for food security are of great importance. Investments in trade facilitation infrastructure and customs efficiency are crucial to maximizing the benefits of the AfCFTA across all sectors. Tailored support policies should be developed to bolster vulnerable sectors, such as agriculture, while fostering growth in manufacturing and services.

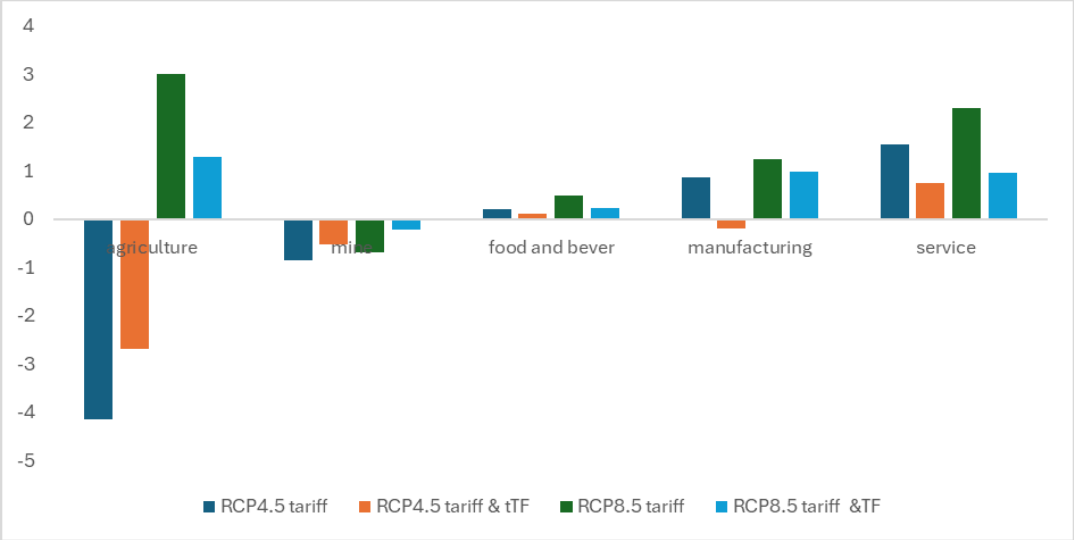

FIGURE 5.4: Price effects of the AfCFTA with climate change

5.5 Discussion of results

The successful implementation of the AfCFTA is expected to have positive economic and welfare effects on Africa as a whole, as well as for Ethiopia in particular (Simola et al., 2021; Fofack et al., 2021; World Bank, 2020b; Abrego et al., 2019; Economic Commission for Africa and Africa Trade Policy Center, 2024). If successfully implemented, Ethiopia's real income gains from tariff and nontariff measures, including TF, will exceed the African average (World Bank, 2020b). Thus, the AfCFTA will have a counterbalancing effect on the negative impacts of climate change. Our simulation results indicate mixed net macroeconomic and sectoral impacts on tariff-only liberalization and a net positive impact on TF implementation under climate change scenarios. The indirect effects of climate change on the macroeconomy, non-agricultural economic activities, and household consumption become relatively minor in the scenario of RCP 4.5 emissions.

The AfCFTA, by eliminating tariffs and reducing non-tariff barriers (NTBs), will enable Ethiopia to access large regional markets. This creates opportunities for export diversification and industrial development (World Bank, 2020b). Although agriculture remains critical, the industrial and service sectors benefit from increased demand from other African countries, driving GDP growth and compensating for the negative impacts on agriculture resulting from climate change. With reduced tariffs and TF, Ethiopia will experience a significant increase in exports to African markets. Manufactured goods, textiles, and food processing benefit most from the tariff reductions. This helps to mitigate the decline in traditional agricultural exports caused by climate change, improving the trade balance over time. Moreover, AfCFTA creates new employment opportunities, particularly in industries and services, partially offsetting agricultural job losses. Expanding regional trade promotes

job creation in transportation and various industries, thereby improving household welfare in both urban and rural areas. Although climate change severely reduces incomes in poor rural and urban areas, the increased economic activity spurred by the AfCFTA helps raise incomes in non-agricultural sectors, thereby dampening the negative impacts.

Diversification of activities in implementing the AfCFTA stimulates growth in sectors less vulnerable to climate risks, such as manufacturing and services. However, the agricultural sector, which employs a large portion of the Ethiopian population, mainly rural households, remains vulnerable to the negative effects of climate change. While diversification into industry is essential for long-term resilience, short-term impacts on food security and rural livelihoods may persist without targeted climate adaptation measures. The effectiveness of the AfCFTA in overcoming climate-induced economic shocks also depends on the overall resilience of other African countries to climate change. If neighboring countries face similar climate challenges, regional markets may not be as robust in absorbing Ethiopian exports. This underscores the need for broader climate adaptation strategies across the continent to ensure that the trade gains of AfCFTA are not undermined by climate change, which requires a significant and continent-wide modeling that addresses the climate adaptation options. This is beyond the scope of this dissertation, and future studies should address this limitation.

For AfCFTA to fully mitigate the impacts of climate change, complementary policies focusing on climate-smart agriculture, irrigation expansion, and investment in agricultural technology are essential. Yalew et al. (2017) simulated various alternative adaptation options and assessed the effectiveness of the government in this context. However, modeling such alternative adaptation mechanisms is beyond the scope of this study. These measures will make the country less vulnerable to climate risks and enable it to fully capitalize on the new market opportunities presented by the AfCFTA, thereby achieving more balanced and inclusive economic growth. Although specific mechanisms of adaptation have not been modeled in this study, broader debates about funding climate adaptation, such as those highlighted during recent COP29 negotiations, underscore the growing impetus for urgency in climate adaptation financing, particularly in developing nations like Ethiopia, which face disproportionate climate risks despite making minimal contributions to global emissions. For instance, Yalew et al. (2017) discussed the potential of alternative adaptation options, such as state-led adaptation programs, to be generally more effective.

Integration into CGE modeling entails significant scenario development and data inputs that extend beyond the scope of this study. However, recognizing the role of climate policy in trade-related analyses is important. Climate adaptation funding,

through programs such as the Green Climate Fund or regional initiatives, can directly support the implementation of complementary policies that will allow Ethiopia to thrive under the AfCFTA. The AfCFTA is likely to increase regional output by enhancing competition and prompting countries to specialize in sectors where they have a comparative advantage. However, as Winters et al. (2004) noted, trade liberalization is also a process of creating winners and losers.

Less competitive sectors are likely to experience declines in production, whereas more advantageous sectors grow. In Ethiopia, agriculture and manufacturing are expected to experience modest declines in output relative to the baseline by 2035, ranging from -5% to 1.3% and -0.18% to 1.38%, respectively. Similarly, mining output may decline by 0.8%, whereas services, processed foods, and beverages may increase slightly (World Bank, 2020b). The AfCFTA will view East African economies as regional aggregates, specializing in agricultural and service products. Nevertheless, these must be combined with climate adaptation mechanisms to avoid setbacks caused by specific climate shocks that may occur within the agricultural sector. Without this intervention, the advantages accruable from trade liberalization will be outweighed by the negative effects of climate change on output and availability. Targeted adaptation investments may yield enormous opportunities for Ethiopia and other East African economies via sustainable land management, crop diversification, and water resource management World Bank, 2024d).

Furthermore, this gap could be bridged through international climate finance and mechanisms for technology transfer, which could be elaborated upon within the context of COP29. In fact, the integration of climate policy considerations into trade frameworks will continue to be at the heart of how AfCFTA catalyzes sustainable and inclusive growth across the region.

5.6 Implications for food security and poverty

Trade plays a crucial role in mitigating the adverse effects of climate change on poverty and food security in general and in Ethiopia in particular. While climate variability disrupts agricultural production, trade serves as a stabilizing mechanism by facilitating access to food supplies, diversifying income sources, and enhancing economic resilience. Given Ethiopia's heavy reliance on rain-fed agriculture, climate-induced yield declines pose a direct threat to rural livelihoods and national food security. However, strategic trade policies and market integration can alleviate these pressures by ensuring food availability, stabilizing prices, and generating alternative employment opportunities.

The findings of this study suggest that expanding export markets and enhancing trade logistics through the AfCFTA can help mitigate climate-induced agricultural

losses. By leveraging the AfCFTA, Ethiopia can offset domestic production shortfalls through imports while sustaining foreign exchange earnings through diversified exports. This approach reduces the vulnerability of both producers and consumers to climate shocks, preventing sharp fluctuations in food supply and prices. Furthermore, trade-driven investments in agricultural technology, infrastructure, and value chain development can enhance productivity and strengthen food security by reducing post-harvest losses and improving distribution efficiency. The AfCFTA further amplifies Ethiopia's ability to use trade as a climate adaptation tool. The agreement is expected to boost income by up to 9% for Ethiopia and lift as many as 30 million people out of extreme poverty in Africa by 2035 (World Bank, 2020b). Given Ethiopia's agrarian economy, reductions in non-tariff barriers and increased intra-African agricultural trade under the AfCFTA could significantly enhance food security (Economic Commission for Africa and the Centre for International Research and Economic Modelling (CIREM(CEPII)), 2021). The agreement is projected to drive a 20% to 30% increase in intra-African trade in agricultural and food products, ensuring greater availability of staple goods even in times of climate-induced production shortfalls.

At the household level, increased trade openness provides access to a wider variety of food products, mitigating the nutritional risks associated with climate-induced crop failures. Additionally, trade-related employment opportunities in non-agricultural sectors help reduce rural poverty by offering alternative income streams to those affected by climate stressors. This study's findings underscore that well-structured trade policies can serve as an adaptation tool, ensuring that climate change does not exacerbate existing socio-economic inequalities.

Despite these advantages, challenges remain in ensuring equitable benefits from trade. Smallholder farmers, who are most vulnerable to climate change, often face barriers in accessing export markets and adapting to shifting trade dynamics. Strengthening institutional support, enhancing trade infrastructure, and promoting inclusive policies are essential to ensure that the benefits of trade-driven climate adaptation are accessible to all segments of the population. By aligning trade strategies with climate resilience efforts, Ethiopia can enhance food security and reduce poverty, transforming climate challenges into economic opportunities.

5.7 Conclusion

Ethiopia signed the AfCFTA in 2018 and has since been actively participating in negotiations and implementing measures to ensure the beneficial implementation of the agreement. This study aimed to examine the economic impacts of AfCFTA in a

climate change-induced shock economy. The AfCFTA tariff liberalization is implemented as full liberalization for African countries, whereas TF is implemented as an iceberg trade cost reduction based on the estimated AVEs of time to trade. Results highlight the multifaceted impacts of AfCFTA liberalization and climate change on its economy. The gradual elimination of tariffs and TF under the AfCFTA would significantly enhance Ethiopian trade, particularly in mining, manufacturing, processed food, textiles, transportation, and financial sectors. On the macroeconomic level, these trade liberalization efforts foster growth in imports and exports, real income, and GDP. GDP is expected to grow at 0.3% and 0.21% in the tariff and TF implementation periods. Rural households in the lowest income quantile (Q1) experience an average consumption increase of 5.95% under the RCP 4.5 scenario with trade facilitation. Urban households in quantile 1 similarly benefit, with a 4.94% increase in consumption. These results indicate that the gains from trade liberalization are pro-poor, helping to reduce vulnerability and improve resilience among the most affected populations. Furthermore, sectoral employment is more focused on unskilled labor in the manufacturing and service sectors. However, the government's tariff revenue loss is moderate, at 11.5 percent of the total revenue.

From a policy perspective, Ethiopia's strategy should focus on leveraging the trade benefits of the AfCFTA to sustain economic growth and enhance resilience against the impacts of climate change. This balanced approach is crucial for achieving long-term economic stability and enhancing the welfare of its growing population. Specifically, the Ethiopian government should strengthen the reduction of tariff and non-tariff barriers to ensure the efficient implementation of AfCFTA, which can amplify the positive effects of the agreement, particularly in enhancing exports and economic integration while offsetting negative climate impacts. It should also accelerate industrialization by fostering value addition in agro-processing and encouraging investment in sectors like textiles, manufacturing, and services. This includes leveraging AfCFTA for regional market access and attracting foreign direct investment (FDI) into priority industries.

Beyond economic growth, the successful implementation of AfCFTA has direct implications for poverty reduction and food security, particularly in light of Ethiopia's vulnerability to climate change. By facilitating regional food trade, reducing trade costs, and improving agricultural supply chains, AfCFTA can help stabilize food markets and ensure greater availability of essential commodities. This is particularly important in rural areas where climate-induced shocks disproportionately impact smallholder farmers and low-income households. The shift of labor from agriculture to manufacturing and services also presents an opportunity to diversify rural incomes, reducing dependency on climate-sensitive agriculture and enhancing economic resilience. Moreover, food security improvements will depend on Ethiopia's

ability to align trade policy with climate adaptation strategies, investing in climate-smart agriculture, irrigation, and sustainable farming practices. If properly integrated, trade liberalization under the AfCFTA could enhance Ethiopia's capacity to withstand climate shocks, improve food affordability, and contribute to reducing poverty and malnutrition.

Chapter 6

General Conclusion and Policy Implications

The objectives of the concluding chapter are threefold. First, it summarizes the main results from the analytical chapters in a way that underscores the various connections among them and creates a coherent narrative. Second, it synthesizes the main messages from the chapter conclusions and develops policy recommendations firmly grounded in action-oriented, evidence-based findings. Finally, reflection on the study's limitations also forms the basis for future research areas that may advance and extend the work presented in this study.

6.1 Summary of main findings

The path of Africa toward economic integration and development is a long-term endeavor fraught with challenges but also brimming with potential. The interplay of trade, infrastructure, and resilience is central to this process. Although significant progress has been made in some areas, substantial challenges remain. Therefore, addressing infrastructural deficits, improving governance, enhancing institutional quality, and building resilience to various shocks are crucial to unlock the full economic potential of Africa. Moreover, a more holistic approach to regional integration, which goes beyond simply liberalizing trade and considers the multifaceted nature of the challenges, is essential.

In the review section, a summary of the simulations of the different impacts of AfCFTA is presented. The World Bank's extensive study on economic inequality (2020b) found a positive impact on trade, income, and production for most African countries. The trade impacts are projected to range from 30% to 85% under different scenarios and regional coverage (Economic Commission for Africa and Africa Trade Policy Center, 2024; World Bank, 2020b; Abrego et al., 2019). However, these

studies emphasize the significant adjustment costs associated with reallocating resources across sectors and implementing the agreement, as it creates both winners and losers. The World Bank (2020b) found a positive real income growth (7% average) for most African countries, particularly in cases where nontariff and trade facilitation were complemented by tariff liberalization. The manufacturing sector is expected to boost intra-African trade significantly. By 2035, manufacturing exports within Africa are expected to increase by over 81%, driven by reduced tariffs and non-tariff barriers (NTBs).

This will create new opportunities for industrial growth and value chain development, aligning with the continent's industrialization plan. This will reduce the primary product exports of African countries, which are blamed for the poor value chain and processing. More trade in industrial goods and services is critical for economic transformation. Meanwhile, the agriculture and natural resources sectors are expected to benefit, but to a lesser extent than the manufacturing sector. Trade facilitation measures, such as improved infrastructure and reduced compliance costs, are vital to unlocking their potential. AfCFTA is expected to reduce the gender gap. The World Bank (2020b) projected that the AfCFTA would enhance the wages of women and unskilled labor, whereas Bouët et al. (2022) suggested that it would ease the formalities and trade procedures, thereby facilitating the formalization of informal traders, in which women are often participants. Consequently, poverty reduction actions are expected to lift 30 million people out of extreme poverty and another 68 million out of moderate poverty by 2035. These gains can be attributed to low trade costs and increased economic opportunities.

However, except for a few studies, other studies have projected the impacts of tariff liberalization-only scenarios that potentially undermine the effects of the AfCFTA. This is not consistent with the recent deepening of the RTA. The first empirical chapter examined the impact of the TF measure on Africa, which is crucial for understanding the general equilibrium effects of TF analysis. Using the World Bank Doing Business, LPI, and WEF data, the trade impacts of TF in the Africa-global and intra-African setups are estimated. A strong negative trade impact of time to trade (measured by the number of days to export or import) exists on both exports and imports. However, these impacts are slightly higher for imports than exports and for intra-African trade than for African–global trade. The AVE costs are heterogeneous across sectors and commodities, with higher costs for sensitive and manufactured products and lower costs for most primary commodities and energy, which are the primary export items of African countries. African countries have a significant trade-enhancing potential from reducing trade delays. The realistic scenario of reducing time to trade by half in all countries could increase African exports and imports by nearly 12% and 32%, respectively.

The second quantitative chapter examined the impacts of climate change on the

Ethiopian economy using a recursive dynamic single-country CGE model, which reveals the significant effects of climate change on both the agricultural and non-agricultural sectors. In a model development as a basis for further analysis of the intricate effects of AfCFTA under climate change, this study projected sharp declines in agricultural output, particularly in staple crops such as teff, maize, and sorghum, owing to climate-induced productivity shocks. These agricultural declines lead to high domestic prices, reduced exports, and increased imports, resulting in lower GDP, household consumption, and overall welfare. The adverse effects ripple through nonagricultural sectors, particularly food processing and retail, whereas some manufacturing sectors may benefit from increased competitiveness. At the macro level, the impacts are more pronounced over time, especially under the RCP 8.5 scenario. Rural and urban households experience significant reductions in income and consumption, disproportionately affecting the rural poor. Urban poor households face steep declines in consumption. Key agricultural exports, such as coffee, oilseeds and pulses, are expected to decline, further straining foreign exchange reserves and worsening the economic situation. Ethiopia's economy is highly vulnerable to climate change, primarily owing to agricultural impacts that affect food security. The economy will face growing challenges without substantial policy interventions and adaptation measures. A multifaceted approach that incorporates climate resilience strategies and structural reforms is essential to mitigate these effects.

Finally, the fourth chapter simulates the Ethiopian economy under climate change using a recursive dynamic CGE model and shows that while there is a high risk owing to climate change, especially within the agricultural sector, leading to declines in staple crop output and the agriculture share of GDP, the implementation of AfCFTA offers counterbalancing benefits. Poor (lower quantile) rural and urban households are highly vulnerable to climate impacts; thus, adaptation measures are urgently needed. However, AfCFTA trade liberalization, through the elimination of tariffs and facilitation of trade, significantly enhances the performance of Ethiopian trade in sectors such as mining, manufacturing, textiles, and financial services. Moreover, gains are reflected at the macroeconomic level, with increased imports and exports, improved welfare, private consumption, and investment. Although losses to tariff revenue, which account for 11.5% of government tariff revenue, will put fiscal pressures on the government, these could be mitigated by long-term expansions in the tax base resulting from increased trade and adjustments in economic production. Therefore, the AfCFTA is a crucial mechanism for economic resilience, enabling growth despite the enormous challenges posed by climate change.

6.2 Policy implications

Based on the empirical and quantitative modeling results, the following policy recommendations are drawn. For a better understanding of the AfCFTA and trade integration in Africa, the findings, based on a strong empirical analysis, are critical and are elaborated as follows. As my first two chapters focus on the African level, and the other two on Ethiopia, the policy generalization accordingly follows.

First, the results from the various simulation studies on implementing the AfCFTA require cautious interpretation and policy input due to the wide array of methods and assumptions used in these studies. Although the results are heterogeneous across countries, regions, sectors, households, and genders, most studies indicate that it will have a positive impact on trade, income, welfare, and other related outcomes. This necessitates various adaptive mechanisms for countries to implement. Studies similar to those of the World Bank (2020b) found a strong positive real income gain for various countries, with this gain being particularly high for the unskilled, specifically for people with low incomes and women in wage employment. Another study by the IMF (Abrego et al., 2019) boldly stresses the adjustment costs of the agreement, noting that smaller economies and less competitive industries may struggle to compete with more developed African economies, such as South Africa, Nigeria, and Egypt. This could further increase regional and income inequality if proper redistributive policies are not implemented to complement the marginalized sectors and regions. Although most studies have found positive aggregate impacts, the major obstacle to pursuing the more equitable implementation of AfCFTA is uneven development in trade-related infrastructure across the continent. Poor logistical capacity, low levels of infrastructure, and weak institutional frameworks in various countries will limit the extent to which countries can leverage this agreement, thereby widening the chasm between more and less developed economies, as illustrated in Chapters 2 and 3.

Smallholder farmers in agriculture-dependent economies will also risk being outcompeted by more industrialized producers within and outside the African continent. Without safeguards, these producers may be driven out of local markets, leading to a worsening of poverty in rural areas. This process requires appropriate and context-specific policy and supporting mechanisms. Importantly, policy design should be cautious and adaptive, considering the variability in outcomes observed across countries and sectors. Policymakers should avoid overreliance on theoretical model predictions and instead use these tools as part of a broader decision-making framework. African countries should couple trade liberalization with investments in complementary policies to maximize the potential for trade integration and mitigate the potential adverse impacts of rapid population growth, climate change, and emerging geopolitical fragmentation on African countries.

Second, to enhance inter- and intra-African trade, policymakers must prioritize investments that can significantly reduce the time to trade. Despite the higher impacts on imports than exports, improvements in infrastructure and digital connectivity to reduce transaction costs and time can ultimately enhance market access, as discussed in the findings in Chapter 3. The result is consistent with prior studies and highlights the need for export-promoting facilitations because costs are high, and addressing these costs will boost exports. Second, a concerted effort should be made to harmonize regulations and improve infrastructure to shorten trade times, thereby fostering a more seamless trading environment among African countries. This approach could help address the continent's low trade share.

Third, the Ethiopian agricultural and non-agricultural sectors face significant challenges from climate change, necessitating a robust adaptation strategy to mitigate these impacts. Its approach should prioritize leveraging the trade opportunities presented by the AfCFTA while implementing comprehensive climate adaptation policies to ensure sustainable economic growth and resilience, as corroborated by the results from the fourth and fifth chapters. These measures are crucial for addressing the immediate and long-term threats posed by climate change and enhancing the overall welfare of Ethiopia's growing population.

Implementing the AfCFTA brings opportunities and challenges, generating winners and losers across various sectors and households. While specific industries and groups will benefit from increased market access, trade facilitation, and economic diversification, others may experience adjustment costs, such as revenue losses or reduced competitiveness. To address these disparities, Ethiopia needs to implement targeted policies that support the agricultural and selected service sectors, as well as the rural and urban poor, who have been negatively impacted by the trade reforms. By integrating the advantages of the AfCFTA with inclusive and adaptive strategies, Ethiopia can more effectively confront the intertwined challenges of trade liberalization and climate change, thereby establishing a solid foundation for equitable and sustainable economic growth.

6.3 Limitations and future research suggestion

In this final subsection, the limitations of this dissertation are explored to make future research suggestions. Despite significant progress, gaps remain in the literature and models on African trade integration analysis.

Trade integration between South–South and North–South regions often yields different outcomes. South–South integration, such as the AfCFTA, has a more significant impact on Total Factor Productivity (TFP) in low-tech industries. However, it is criticized for being less effective in helping LDCs catch up economically with DCs.

Despite the optimistic findings on the impacts of the AfCFTA in Africa and globally, implementation challenges are also apparent. Significant challenges exist in implementing the AfCFTA concerning policy and institutional barriers, bottlenecks, and capacity gaps. One of the major challenges, perhaps, is the lingering NTBs, such as inefficient customs procedures, bureaucratic delays, and mismatched technical standards across countries. These factors contribute to increases in trade costs and serve as impediments to cross-border trade. Poor trade facilitation measures, such as the limited adoption of digital technologies, further worsen the delays in customs clearance. Therefore, addressing NTBs is crucial to realizing the full potential of the agreement. Another crucial challenge is the infrastructure deficit in Africa. The transport infrastructure, including less-developed road, rail, and port systems, complicates the cross-border transport of goods. Similarly, inadequate energy supplies and poor logistics, such as insufficient storage facilities and inadequate freight services, lead to increased production and transaction costs for businesses. Without significant investment in infrastructure, the AfCFTA will likely fail to reap its full benefits.

The difficulty of institutional and policy coordination also complements this. Most countries face difficulties in harmonizing their trade policies because national priorities often vary with regional integration imperatives. Additionally, weak institutional capacity hinders the effective implementation of AfCFTA agreements in areas such as dispute resolution and monitoring. The overlapping mandates of existing RECs lead to redundancies and conflicts that hinder the progress of AfCFTA implementation. Moreover, unilateral trade negotiations and agreements with countries and regions outside Africa complicate the policy and procedural coordination. Although informal trade accounts for a considerable share of economic activities in many African countries, it remains underexplored in the trade literature, such as under the AfCFTA. This type of trade mostly bypasses formal channels and is not easily captured by conventional data collection methods. Therefore, further research should aim to quantify the magnitude of informal trade and identify its drivers, such as regulatory barriers, taxation policies, and cultural or historical trade patterns. Furthermore, understanding the role of informal trade in livelihoods, particularly for women and marginalized groups, will significantly contribute to the formulation of inclusive trade policies. Research in this area should also explore how informal trade interacts with formal regional trade agreements and what measures could facilitate its formalization without undermining livelihoods.

Another challenge is the lack of productive capacity in most African economies. Most countries are highly dependent on a few primary commodities and exhibit a weak manufacturing base, which limits their ability to exploit increasing market access. In addition, climate change poses a severe threat to economic activities across Africa; however, much of the research has focused narrowly on agriculture. The

skills gap exacerbates this issue, as the limited availability of skilled labor negatively impacts the competitiveness of firms in regional and global markets. Moreover, small and medium enterprises are significant in African economies, and such businesses often lack the resources and capacities to fully engage in regional trade. Financial and investment constraints represent other major stumbling blocks. These constraints bind the capacity of most African economies to invest in essential trade-related infrastructure. Similarly, high credit costs for enterprises hinder expansion in production, preventing them from participating in regional value chains. Without targeted interventions, these financings are likely to constrain trade growth further. Furthermore, the implementation of the AfCFTA is further complicated by political and governance challenges. The lack of political will by some governments to prioritize regional integration over domestic issues delays the policy alignment. Political instability and armed conflict in certain regions disrupt supply chains and hinder trade flows, while corruption at border points and within customs systems increases costs and discourages formal trade.

The digital divide and technological barriers also present significant challenges. Limited adoption of digital trade platforms and unstable Internet connections across countries create obstacles to streamlining trade processes under the AfCFTA. In addition, inadequate digital connectivity and low digital literacy hinder the adoption of e-commerce and other digital trade solutions. Despite the underdeveloped digital infrastructure and the lack of accessible and affordable connectivity in SSA, great strides toward digital transformation have been observed, with hundreds of millions of people gaining access to the Internet (a 115% increase between 2016 and 2021) and productively using a wide array of digital services, from mobile payments to online learning platforms (World Bank, 2024c). Another challenge to the implementation is the resistance of stakeholders. Some domestic industries in various countries feel threatened by increased competition, especially from more advanced economies within the African continent. Such threats have sparked political resistance due to the potential for job losses in specific sectors. Similarly, the meager public awareness of the benefits of the AfCFTA reduces support for the agreement at the business and community levels.

Another concern is trade imbalances and inequalities within the region. Larger economies, such as South Africa, Nigeria, and Kenya, may eventually dominate trade flows under the AfCFTA, potentially exacerbating inequality among member countries. Small and less developed economies will struggle to compete, raising concerns about uneven development outcomes. The weak monitoring and dispute resolution mechanisms further challenge the enforcement of AfCFTA agreements. Most countries are not well equipped to handle trade disputes or enforce compliance with trade rules. This is further exacerbated by a general lack of credible and consistent trade data to monitor and evaluate progress and, therefore, evidence on

the impact of the agreement. Lastly, timely implementation is essential for the effective exploitation of benefits, as time-sensitivity matters (e.g., gradual benefits from trade facilitation or long-term impacts of climate change on trade).

Bibliography

Bibliography

Abrego, L., M. A. Amado, T. Gursoy, G. P. Nicholls, H. Perez-Saiz (2019). *The African Continental Free Trade Agreement: Welfare Gain Estimates from a General Equilibrium Model*. Tech. rep. WP/19/124. International Monetary Fund.

Admassie, A., D. Abebaw (2021). *Ethiopia: Land, climate, energy, agriculture and development: A study in the Sudano-Sahel Initiative for Regional Development, Jobs, and Food Security*. Tech. rep. 198. ZEF Working Paper.

Adom, I. M. (2022). "Time delays at the border: Macroeconomic consequences for Sub-Saharan African economies". In: *SSRN Electronic Journal*. DOI: 10.2139/ssrn.4095802.

Africa Agriculture Trade, Monitor, AATM (2018). *Africa agriculture trade monitor 2018*. Washington, DC: International Food Policy Research Institute (IFPRI). DOI: 10.2499/9780896293496.

– (2021). *Africa agriculture trade monitor 2021*. AKADEMIYA2063. DOI: 10.54067/9781737916406.

Africa Union (2022). *Creating one Africa market*. Africa Trade House, Ambassadorial Enclave, Liberia Road, Ridge, Accra Ghana. URL: https://au-afcfta.org/wp-content/uploads/2022/01/AfCFTA-8th-Councilof-Ministers-Press-Statement-Official.pdf.

African Development, Bank, AfDB (2019). *African economic outlook 2019: Macroeconomic performance and prospects; Jobs, growth, and firm dynamism; Integration for Africa's economic prosperity*. Tech. rep. African Development Bank.

– (2024a). *African Economic Outlook 2024: Driving Africa's Transformation: The Reform of the Global Financial Architecture*. Tech. rep. African Development Bank.

– (2024b). *Making a difference: The African Development Bank @60 report*. Tech. rep. African Development Bank.

African Export-Import, Bank, AFREXIMBANK (2022). *Leveraging the power of culture and creative industries for accelerated structural transformation in the AfCFTA era*. Tech. rep. Cairo, Egypt: African Export-Import Bank. URL: http://www.afreximbank.com/.

– (2024). *Ethiopia country brief: Transforming Africa's trade*. Tech. rep. African Export-Import Bank.

African Union (2018). *Agreement establishing the African continental free trade area*. African Union.

African Union (2012). "Action plan for boosting intra-African trade". In: *Synthesis Paper on Boosting Intra-African Trade and Fast Tracking the Continental Free Trade Area* 25.

African, Union, AU (2024). "Thirty-Seventh Ordinary Session of the Assembly of the Union: Decisions, declarations and resolutions". In: Addis Ababa, Ethiopia.

African Union Commission/Organization for Economic Cooperation and Development (2022). *Strengthening regional value chains in Africa's Development Dynamics 2022: Regional value chains for a sustainable recovery*. Tech. rep.

Agnosteva D. E. Anderson, J. E., Y. V. Yotov (2014). *Intra-national trade costs: Measurement and aggregation*. Tech. rep. 19872. NBER Working Papers.

– (2019). "Intra-national trade costs: Assaying regional frictions". In: *European Economic Review* 112. DOI: 10.1016/j.euroecorev.2018.11.008.

Andersen, T. M. (2003). "European integration and the welfare state". In: *Journal of Population Economics* 16, pp. 1–19.

Anderson, J. E. (2011). "The gravity model". In: *Annual Review of Economics* 3, pp. 133–160.

Anderson, J. E., E. Van, Wincoop (2004). "Trade costs". In: *Journal of Economic Literature* 42.3, pp. 691–751.

Anderson, K. (2022). "Agriculture in a more uncertain global trade environment". In: *Agricultural Economics* 53.4, pp. 563–579. DOI: 10.1111/agec.12726.

Anderson J. E. Larch, M., Y. V. Yotov (2015). *Estimating general equilibrium trade policy effects: GE PPML*. Tech. rep. 5592. CESifo Working Paper Series. URL: http://www.repec.org/.

Aragie, E., J. Thurlow (2021). *2018 Social Accounting Matrix for Ethiopia: A Nexus Project SAM*. Tech. rep. International Food Policy Research Institute.

Aragie, E. A. (2013). *Climate change, growth, and poverty in Ethiopia*. Tech. rep. 3. CCAPS Working Paper.

Aragie, E. A., Y. Gebretsadik (2023). *Modeling the economywide effects of water and energy interventions in the face of climate shocks in Ethiopia*. Tech. rep. IFPRI Discussion Paper.

Arkolakis, C., A. Costinot, A. Rodríguez-Clare (2012). "New trade models, same old gains?" In: *American Economic Review* 102.1, pp. 94–130. DOI: 10.1257/aer.102.1.94.

Bacchetta, V., C. Beverelli, O. Cadot, M. Fugazza, J. Grether, M. Helble, A. Nicita, R. Piermartini (2012). *A Practical Guide to Trade Policy Analysis*. WTO and UNCTAD Publications. URL: http://vi.unctad.org/tpa.

Bachewe F. N. Berhane, G. Minten, B., A. S. Taffesse (2018). "Agricultural transformation in Africa? Assessing the evidence in Ethiopia". In: *World Development* 105, pp. 286–298. DOI: 10.1016/j.worlddev.2017.05.041.

Baier, S. L., J. H. Bergstrand (2007). "Do free trade agreements actually increase members' international trade?" In: *Journal of International Economics* 71.1. DOI: 10.1016/j.jinteco.2006.02.005.

Balistreri, E., F. Baquedano, J. C. Beghin (2022). "The impact of COVID-19 and associated policy responses on global food security". In: *Agricultural Economics* 53.6, pp. 855–869. DOI: 10.1111/agec.12749.

Bartholomae, F., C. W. Nam (2023). "A Critical Discussion on the Reasons and Impacts of International Decoupling". In: *Intereconomics* 58.2, pp. 92–95.

Baumüller H. von, Braun, J. Admassie A. Badiane O. Baraké E. Börner J. Bozic I. Chichiabelu B. Collins J. Daum T. Gatiso T. Gerber N. Getahun T. Glatzel K. Hendriks S. Kirui O. Kornher L. Kubik Z. Lüdeling E. ... Walakira, J. (2020). *From potentials to reality: Transforming Africa's food production - Investment and policy priorities for sufficient, nutritious and sustainable food supplies*. Tech. rep. research4agrinnovation.org.

Beghin, J. C., H. Schweizer (2021). "Agricultural trade costs". In: *Applied Economic Perspectives and Policy* 43.2. DOI: 10.1002/aepp.13124.

Behar, Alberto, Laia Cirera-i Crivillé (2013). "Does it matter who you sign with? comparing the impacts of n orth–s outh and s outh–s outh trade agreements on bilateral trade". In: *Review of International Economics* 21.4, pp. 765–782.

Belford C. Huang, D. Ahmed Y. N. Ceesay, E., L. Sanyang (2023). "An economic assessment of the impact of climate change on the Gambia's agriculture sector: A CGE approach". In: *International Journal of Climate Change Strategies and Management* 15.3, pp. 322–352. DOI: 10.1108/IJCCSM-01-2022-0003.

Beverelli C. Gourevich, I. Heiland I. Keck A. Larch, M., Y. V. Yotov (2023). *Trade and welfare effects of the WTO trade facilitation agreement*. Tech. rep. WTO Staff Working Paper ERSD.

Bezabih M. Chambwera, M., J. Stage (2010). *Climate change, total factor productivity, and the Tanzanian economy: A computable general equilibrium analysis*. Tech. rep. Environment for Development Discussion Paper Series. URL: http://www.efdinitiative.org/.

Bezuneh, Mesfin, Zelealem Yiheyis (2014). "Has Trade Liberalization Improved Food Availability in Developing Countries? An Empirical Analysis". In: *Journal of Economic Development* 39.1, pp. 63–78.

Bhorat, Haroon, Karmen Naidoo (2017). *Drivers of inequality in the context of the growth-poverty-inequality nexus in Africa: An overview of key issues: "Income inequality trends in sub-Saharan Africa: Divergence, determinants and consequences"*. Tech. rep. AgEcon Search.

Boer, P. de, J. van Daal, J. F. D. Rodrigues (2023). "Consumer preferences in CGE models when data are scarce: comparing the linear expenditure and the indirect addilog systems". In: *Economic Systems Research* 35.1, pp. 1–29. URL: https://doi.org/10.1080/09535314.2021.1964440.

Bond, E. W. (2008). "Adjustment costs and the sequencing of trade liberalisation". In: *World Economy* 31.1, pp. 97–111. DOI: 10.1111/j.1467-9701.2007.01083.x.

Bouët, A., D. Laborde, F. Traoré (2022). *Africa Agriculture Trade Monitor 2022 Report: The AfCFTA – The Need for Ambitious Implementation (Chapter Five)*. Tech. Report.

International Food Policy Research Institute (IFPRI). URL: https://www.ifpri.org/publication/africa-agriculture-trade-monitor-2022.

Bouteska A. Sharif, T. Bhuiyan, F., M. Z. Abedin (2024). "Impacts of the changing climate on agricultural productivity and food security: Evidence from Ethiopia". In: *Journal of Cleaner Production* 449. DOI: 10.1016/j.jclepro.2024.141793.

Bouët, A. (2008). *Does Africa trade less than it should, and if so, why? The role of market access and domestic factors*. Tech. rep. International Food Policy Research Institute. URL: http://www.ifpri.org/.

Bouët, A., David Laborde (2017). *Agriculture, development, and the global trading system: 2000-2015*. Washington, DC: International Food Policy Research Institute.

Bouët, A., S. Odjo, C. Zaki (2020). *Africa Agriculture Trade Monitor 2020*. Washington, DC: International Food Policy Research Institute (IFPRI).

Bouët, Antoine, Fatoumata Traoré, David Laborde (2019). *Africa Agriculture Trade Monitor Report 2019*. Washington, DC: International Food Policy Research Institute (IFPRI).

Braun, Joachim von, Rajul Pandya-Lorch (1991). *Income Sources of Malnourished People in Rural Areas: Microlevel Information and Policy Implications*. IFPRI working paper, IFPRI.

Brenton, P., G. Isik (2012). *De-fragmenting Africa: Deepening regional trade integration in goods and services*. Washington, DC: The World Bank.

Brenton, P., V. Chemutai, M. Pangestu (2022). "Trade and Food Security in a Climate Change-Impacted World". In: *Agricultural Economics* 53.4, pp. 580–591. DOI: 10.1111/agec.12727.

Bueno Rezende De, Castro, A., L. Kornher (2023). "The effect of trade and customs digitalization on agrifood trade: A gravity approach". In: *Q Open* 3.1. DOI: 10.1093/qopen/qoac037.

Cadot O. Himbert, A. Jouanjean M.-A. Tyson J. Balchin N. Calabrese, L., A. Lemma (2015). *Shaping policy for development: Trade facilitation and concentration - Evidence from Sub-Saharan Africa*. Tech. rep. ODI Report.

Caliendo, L., F. Parro (2015). "Estimates of the Trade and Welfare Effects of NAFTA". In: *The Review of Economic Studies* 82.1, pp. 1–44. URL: https://about.jstor.org/terms.

Calzadilla A. Rehdanz, K., R. S. J. Tol (2011). "Trade liberalization and climate change: A computable general equilibrium analysis of the impacts on global agriculture". In: *Water* 3.2, pp. 526–550. DOI: 10.3390/w3020526.

Calzadilla A. Zhu, T. Rehdanz K. Tol R. S. J., C. Ringler (2013). "Economywide impacts of climate change on agriculture in Sub-Saharan Africa". In: *Ecological Economics* 93, pp. 150–165. DOI: 10.1016/j.ecolecon.2013.05.006.

Carrico, C., E. Corong, D. Van Der, Mensbrugghe (2020). *The GTAP 10A multi-region input-output (MRIO) data base*. Tech. rep. Purdue University, Center for Global Trade Analysis.

Carrère, C., J. De, Melo (2011). "Non-tariff measures: What do we know, what might be done?" In: *Journal of Economic Integration* 26.1.

Chauvin, N. D., M. P. Ramos, G. Porto (2017). "Trade, Growth, and Welfare Impacts of the CFTA in Africa". In: Oxford, United Kingdom. URL: https://www.gtap.agecon.purdue.edu/databases/v8/default.asp.

Chidede, T., R. Sandrey (2018). *Intra-African trade - Focusing on trade within regional economic communities*. Tech. rep. URL: http://www.tralac.org|info@tralac.org|Twitter@tradelawcentre.

Choudhri, E. U., H. Faruqee, S. Tokarick (2006). "Trade Liberalization, Macroeconomic Adjustment, and Welfare: Unifying Trade and Macro Models". In: *IMF Working Papers* 06.304, p. 1. URL: https://doi.org/10.5089/9781451865646.001.

Ciuriak, D. (2010). *Supply and Demand Side Constraints as Barriers for Ethiopia Exports-Policy Options*. Trade and Development Discussion Paper (02). URL: http://ssrn.com/abstract=1659655.

Cockburn, J., E. L. Corong, C. B. Cororaton (2008). "Poverty effects of the Philippines' tariff reduction program: Insights from a computable general equilibrium analysis". In: *Asian Economic Journal* 22.3, pp. 289–319. URL: https://doi.org/10.1111/j.1467-8381.2008.00279.x.

Collier, P. (2007). "Africa's economic growth: Opportunities and constraints". In: *African Development Review* 19.1, pp. 6–25. URL: https://doi.org/10.1111/j.1467-8268.2007.00153.x.

Collier, P., J. Venables (2008). "Trade and Economic Performance: does Africa's fragmentation matter?" In: *Annual World Bank Conference on Development Economics*.

– (2010). *Natural Resources and State Fragility*. EUI Working Papers. Robert Schuman Center for Advanced Studies European Report on Development, RSCAS 2010/36. URL: https://www.researchgate.net/publication/46447399.

Conway, D., E. L. F. Schipper (2011). "Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia". In: *Global Environmental Change* 21.1, pp. 227–237. URL: https://doi.org/10.1016/j.gloenvcha.2010.07.013.

Copeland, B. R., Scott, M. Taylor (1994). "North-South Trade and the Environment". In: *The Quarterly Journal of Economics* 109.3, pp. 755–787. URL: https://www.jstor.org/stable/2118421.

Cordoba, F., S. Laird, J. Maur, J. Serena (2006). *Adjustment Costs and Trade Liberalization*. Palgrave Macmillan, pp. 66–85.

Crivelli, P. (2023). *Advancing regional trade integration through regional trade agreements in Asia and the Pacific*. Bangkok: Asian Development Bank.

Davidson, C., S. J. Matusz (2006). "Trade liberalization and compensation". In: *International Economic Review* 47.3, pp. 723–747. URL: https://doi.org/10.1111/j.1468-2354.2006.00394.x.

De, Boer, P. (2009). *Modeling household behavior in a CGE model: linear expenditure system or indirect addilog?* Econometric Institute Report. Econometric Institute, Erasmus University Rotterdam.

De, Melo, J., Y. Tsikata (2013). *Regional integration in Africa: Challenges and prospects: A contribution to the Handbook of Africa and Economics*. FERDi working paper.

De, Melo, J., Z. Sorgho, L. Wagner (2021). *Implementing the Trade Facilitation Agreement (TFA): estimates of reduction in time at customs for the United Nations' vulnerable economies*. FERDI Working Paper (296). URL: https://hal.science/hal-04478013.

De, Melo, Jaime, Zakaria Sorgho, Laurent Wagner (2024). "Implementing the Trade Facilitation Agreement should boost trade among African Continental Free Trade Area members". In: *FERDI Notes brèves/Policy briefs*.

Dercon, S. (2004). "Growth and shocks: Evidence from rural Ethiopia". In: *Journal of Development Economics* 74.2, pp. 309–329. URL: https://doi.org/10.1016/j.jdeveco.2004.01.001.

Deressa, T. T., R. M. Hassan (2009). "Economic impact of climate change on crop production in Ethiopia: Evidence from cross-section measures". In: *Journal of African Economies* 18.4, pp. 529–554. URL: https://doi.org/10.1093/jae/ejp002.

Devarajan, S., D. S. Go, C. Lakatos, S. Robinson, K. Thierfelder (2018). *Traders' dilemma: Developing countries' response to trade wars*. World Bank Policy Research Working Paper 8640, World Economy 44(4). URL: https://doi.org/10.1111/twec.13062.

Diao, X., J. Thurlow, S. Benin, S. Fan (2012). *Strategies and Priorities for African Agriculture, Economywide Perspectives from Country Studies*. International Food Policy Research Institute issue brief.

Diao, X., J. Thurlow (2023). *Impacts of Global Shocks on Poverty, Hunger, and Diets*. International Food Policy Research Institute.

Disdier, A.-C., S. F. Stone, F. Van, Tongeren (2019). "Trade and Economic Effects of IRC Further Empirical Evidence from SPS and TBT Provisions". In: *OECD Economic Studies*. URL: https://doi.org/10.1787/8648b6ca-en.

Dixit, A., V. Norman (1980). *Theory of International Trade: A Dual, General Equilibrium Approach*. Cambridge Economic Handbooks. Cambridge University Press.

– (1986). "Gains From Trade Without Lump-Sum Compensation". In: *Journal of International Economics* 21.1, pp. 111–122.

Dixon, P. B., R. B. Koopman, M. T. Rimmer (2013). "The MONASH style of computable general equilibrium modeling: A framework for practical policy analysis". In: *Handbook of Computable General Equilibrium Modeling*. Vol. 1. Elsevier, pp. 23–103. URL: https://doi.org/10.1016/B978-0-444-59568-3.00002-X.

Djankov, S., C. Freund, C. S. Pham (2010). "Trading on time". In: *Review of Economics and Statistics* 92.1. URL: https://doi.org/10.1162/rest.2009.11498.

Dollar, D., A. Kraay (2004). "Trade, Growth, and Poverty". In: *The Economic Journal* 114.493, F22–F49.

Donaubauer, J., A. Glas, B. Meyer, P. Nunnenkamp (2018). "Disentangling the impact of infrastructure on trade using a new index of infrastructure". In: *Review of World Economics* 154, pp. 745–784.

Duval, Yann, Chorthip Utoktham (2022). *Trade, Investment and Innovation: Has the WTO Trade Facilitation Agreement helped reduce trade costs? An ex-post analysis*. UNESCAP. URL: http://www.unescap.org/kp.

Economic Commission for Africa, ECA (2013). *Trade facilitation from an African Perspective*. ERD Working Paper Series (Issue 78).

Economic Commission for Africa and Africa Trade Policy Center (2024). *Country-level Implications of Implementation of the African Continental Free Trade Area Agreement on Inequality and Poverty*. Annual Conference paper on Global Economic Analysis.

Economic Commission for Africa and the Centre for International Research and Economic Modelling (CIREM(CEPII)) (2021). *Takeaways from the expected impact of AfCFTA's implementation*. Unpublished document.

Egger, P., S. Nigai (2015). "Effects of deep versus shallow trade agreements in general equilibrium". In: *Trade Cooperation: The Purpose, Design and Effects of Preferential Trade Agreements*. Cambridge University Press. URL: https://doi.org/10.1017/CBO9781316018453.018.

ElGanainy, A., S. Hakobyan, F. Liu, H. Weisfeld, A. Abbas, C. Allard, H. Balima, C. Bteish, R. Giri, D. Kanda, S. Meleshchuk, G. Ramirez, R. Zymek, V. Arora, S. Lall, B. Kett, M. Pohl (2023). *Trade Integration in Africa: Unleashing the Continent's Potential in a Changing World*. International Monetary Fund, Washington, DC, U.S.A.

Engel, J., D. Kokas, G. Lopez-Acevedo, M. Maliszewska (2021). *The Distributional Impacts of Trade Empirical Innovations, Analytical Tools, and Policy Responses*. World Bank report, Washington D.C.

Espitia, A., A. Mattoo, N. Rocha, M. Ruta, D. Winkler (2022). "Pandemic trade: COVID-19, remote work and global value chains". In: *World Economy* 45.2, pp. 561–589. URL: https://doi.org/10.1111/twec.13117.

ESS (2022). *Report on Area, Production and Farm Management Practice of Belg Season Crops for Private Peasant Holdings*. Statistical Bulletin (578).

European Commission (2021). *Trade Policy Review–an open, sustainable and assertive trade policy*. Strategic Foresight Report, Belgium, Brussels.

Evenett, S. (2004). "The Sequencing of Regional Integration". In: *Aussenwirtschaft* 59.4.

FDRE Ministry of Industry (2021). *Ethiopian Industrial Development Institutional Setup (2013–2025)*. Policy Report. Addis Ababa, Ethiopia: Federal Democratic Republic of Ethiopia, Ministry of Industry.

Fofack, H., R. Dzene, O. A. M. Hussein (2021). "Estimating the Effect of AfCFTA on Intra-African Trade using Augmented GE-PPML". In: *Journal of African Trade* 8.2 (Special Issue), p. 62. URL: https://doi.org/10.2991/jat.k.211122.001.

Fontagné, L., G. Orefice, R. Piermartini (2016). *Making (Small) Firms Happy. The Heterogeneous Effect of Trade Facilitation Measures*. WTO Staff Working Papers ERSD-2016-03, World Trade Organization (WTO), Economic Research and Statistics Division. Available at http://www.cepii.fr.

Fontagné, L., H. Guimbard, G. Orefice (2022). "Tariff-based product-level trade elasticities". In: *Journal of International Economics* 137. URL: https://doi.org/10.1016/j.jinteco.2022.103593.

Food and Agriculture Organization, FAO (2017). *The future of food and agriculture and challenges*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Food and Agriculture Organization, UN (2024). *World Food and Agriculture – Statistical Yearbook 2024*. Rome. URL: https://doi.org/10.4060/cd2971en.

Food and Agriculture Organization and Africa Union Commission (2021). *Framework for Boosting Intra-African Trade in Agricultural Commodities and Services*. Addis Ababa, Ethiopia. URL: https://doi.org/10.4060/cb3172en.

Food and Agriculture Organization of the United Nations (2020). *Intra-Africa Trade in Food and Agriculture*. Tech. rep. ARC/20/INF/10. FAO. URL: https://openknowledge.fao.org/server/api/core/bitstreams/56c8b951-5624-4f37-9c8c-c04c8685a4a3/content.

Francois, J. B. (2019). *Behind-the-Border Policies: Assessing and Addressing Non-Tariff Measures*. Cambridge University Press.

Frankel, J. A., D. Romer (2017). "Does Trade Cause Growth?" In: *The American Economic Review*, pp. 255–275. URL: https://doi.org/10.4324/9781315254166-11.

Fusacchia, I., J. Balié, L. Salvatici (2022). "The AfCFTA impact on agricultural and food trade: A value added perspective". In: *European Review of Agricultural Economics* 49.1, pp. 237–284. URL: https://doi.org/10.1093/erae/jbab046.

Garrity, D., J. Dixon, J. M. Boffa (2012). *Understanding African farming systems*. Food Security in Africa: bridging research and Practice, pp. 1-50.

Garsous, G. (2019). *Trends in policy indicators on trade and environment*. OECD Trade and Environment Working Papers (1). URL: https://doi.org/10.1787/b8d2bcac-en.

Gebreegziabher, Z., J. Stage, A. Mekonnen, A. Alemu (2016). "Climate change and the Ethiopian economy: A CGE analysis". In: *Environment and Development Economics* 21.2, pp. 205–225. URL: https://doi.org/10.1017/S1355770X15000170.

Gebreeyesus, Mulu (2013). *Industrial policy and development in Ethiopia: Evolution and present experimentation*. Tech. rep. WIDER working paper.

Gebrehiwot, Berihu, Assefa, Mulu Gebreeyesus, Alebel, Bayrau Weldesilassie (2020). *Chinese investment in Ethiopia: contribution, challenges, opportunities and policy recommendations*. PSI Research Report 34.

George, C. (2010). *The truth about trade: The real impact of liberalization*. Bloomsbury Publishing.

Gereffi, G., K. Fernandez-Stark (2011). *Global Value Chain Analysis: A Primer*. Center on Globalization, Governance & Competitiveness (CGGC), Technical Report. URL: https://www.researchgate.net/publication/265892395.

Glaeser, E. L., J. E. Kohlhase (2004). "Cities, regions and the decline of transport costs". In: *Papers in Regional Science* 83.1, pp. 197–228. URL: https://doi.org/10.1007/s10110-003-0183-x.

Glauber, J. W., D. Laborde, Debucquet (2023). *The Russia-Ukraine conflict and global food security*. Washington, DC: International Food Policy Research Institute. URL: https://doi.org/10.2499/9780896294394.

Godde, C., D. Mason-D'Croz, D. Mayberry, P. Thornton, M. Herrero (2021). "Impacts of climate change on the livestock food supply chain; a review of the evidence". In: *Global Food Security* 28. URL: https://doi.org/10.1016/j.gfs.2020.100488.

Gohin, Alexandre (2005). *Decomposing Welfare Effects of CGE models: an Exact, Superlative, Path Independent, Second Order Approximation*. GTAP Annual Conference on Global Economic Analysis. URL: https://www.gtap.agecon.purdue.edu/events/conferences/default.asp.

Goldberg, P. (Penny), T. Reed (2023). *Is the Global Economy Deglobalizing? And If so, Why? And What is Next?* SSRN Electronic Journal. URL: https://doi.org/10.2139/ssrn.4413852.

Gouel, C., D. Laborde (2018). "The Crucial Role of International Trade in Adaptation to Climate Change". In: *Journal of Environmental Economics and Management* 106. URL: http://www.nber.org/papers/w25221.

Grossman, Gene, M., Alan, B. Krueger (1991). *Environmental Impact of A North American Free Trade Agreement*. NBER Working Paper Series.

Gul, N., J. Iqbal, M. Nosheen, M. Wohar (2023). "Untapping the role of trade facilitation indicators, logistics and information technology in export expansion and diversification". In: *Journal of International Trade and Economic Development*. URL: https://doi.org/10.1080/09638199.2023.2182606.

Gumede, V. (2019). "Revisiting Regional Integration in Africa: Towards a Pan-African Developmental Regional Integration". In: *Africa Insight* 49.1. URL: https://www.researchgate.net/publication/340395996.

– (2020). *Examining the African Continental Free Trade Area in the Context of a Political Federation for Africa-Towards a United African States*. UNISA working paper. URL: https://doi.org/10.25159/64.

Hartzenberg, T. (2019). *The African Continental Free Trade Area Agreement - what is expected of LDCs in terms of trade liberalisation?* Available at: URL: https://www.un.org/ldcportal/content/african-continental-free-trade-area-agreement-what-expected-ldcs-terms-trade-liberalisation.

Hausmann, R., T. O'brien, T. Cheston, N. Taniparti, I. W. Hassen, C. Soylu, L. Lamby, P. A. Neumeyer (2022). *A Survey of Importers Results of a Survey Conducted in Collaboration with the Ethiopian Economics Association*. Center for International Development at Harvard University Working Papers.

Head, K., T. Mayer (2014). "Gravity Equations: Workhorse, Toolkit, and Cookbook". In: *Handbook of International Economics 4*. Elsevier, pp. 131–195. URL: https://doi.org/10.1016/B978-0-444-54314-1.00003-3.

Heid, B., M. Larch, Y. V. Yotov (2021). "Estimating the effects of non-discriminatory trade policies within structural gravity models". In: *Canadian Journal of Economics* 54.1, pp. 376–409. URL: https://doi.org/10.1111/caje.12493.

Hendy, R., C. Zaki (2021). "Trade facilitation and firms exports: Evidence from customs data". In: *International Review of Economics and Finance* 75. URL: https://doi.org/10.1016/j.iref.2021.03.023.

Hertel, T. (2018). *Climate change, agricultural trade and global food security: Background paper for The State of Agricultural Commodity Markets (SOCO) 2018*. FAO, Rome, Italy.

Herz, B., M. Wagner (2011). "The dark side of the generalized system of preferences". In: *Review of International Economics* 19.4, pp. 763–775. URL: https://doi.org/10.1111/j.1467-9396.2011.00980.x.

Hinz, J., S. Chowdhry, A. Jacobs, R. Thiele (2022). *PEGNet Policy Brief: Potential Economic Benefits of the African Continental Free Trade Area for Africa and the EU*. Kiel Institute for The World Economy. URL: http://www.pegnet.ifw-kiel.de/.

Hoekman, B., A. Nicita (2011). "Trade policy, trade costs, and developing country trade". In: *World Development* 39.12, pp. 2069–2079. URL: https://doi.org/10.1016/j.worlddev.2011.05.013.

Huang, H., M. von Lampe, F. van Tongeren (2011). "Climate change and trade in agriculture". In: *Food Policy* 36. URL: https://doi.org/10.1016/j.foodpol.2010.10.008.

Hummels, D (1999). *Have International Transportation Costs Declined?* University of Chicago, Graduate School of Business, Chicago, USA.

– (2007). "Transportation Costs and International Trade in the Second Era of Globalization". In: *Journal of Economic Perspectives* 21.3, pp. 131–154. URL: http://www.bea.gov/.

Hummels, D, A Skiba (2004). "Shipping the good apples out? An empirical confirmation of the Alchian-Allen conjecture". In: *Journal of Political Economy* 112.6. URL: https://doi.org/10.1086/422562.

Hummels, D, L., G Schaur (2013). "Time as a trade barrier". In: *American Economic Review* 103.7, pp. 2935–2959. URL: https://doi.org/10.1257/aer.103.7.2935.

International Chamber of Commerce, ICC (2023). *2023 Trade report: A fragmenting world*. Available at. URL: https://iccwbo.org/news-publications/policies-reports/icc-2023-trade-report-a-fragmenting-world/.

International Energy, Agency, IEA (2021). *Energy Efficiency 2021*. IEA report. URL: http://www.iea.org/t&c/.

International Trade Centre (2018). *Ethiopia: Company Perspectives. An ITC Series on Non-Tariff Measures*. ITC, Geneva.

IPCC (2023). *Summary for Policymakers. In Climate Change 2021 – The Physical Science Basis*. URL: https://doi.org/10.1017/9781009157896.001.

Ismail, Normaz, Wana, Jamilah, Mohd Mahyideen (2015). *The Impact of Infrastructure on Trade and Economic Growth in Selected Economies in Asia*. ADBI Working Paper Series. URL: http://www.adbi.org/.

Jacks, D. S., C. M. Meissner, D. Novy (2011). "Trade booms, trade busts, and trade costs". In: *Journal of International Economics* 83.2, pp. 185–201.

Jafari, Y., H. Engemann, A. Zimmermann (2024). "The multiple dimensions of resilience in agricultural trade networks". In: *Q Open* 4.2. URL: https://doi.org/10.1093/qopen/qoae024.

Janssens, C., P. Havlík, T. Krisztin, J. Baker, S. Frank, T. Hasegawa, D. Leclère, S. Ohrel, S. Ragnauth, E. Schmid, H. Valin, N. Van, Lipzig, M. Maertens (2020). "Global hunger and climate change adaptation through international trade". In: *Nature Climate Change* 10.9, pp. 829–835. URL: https://doi.org/10.1038/s41558-020-0847-4.

Jensen, H. G., R. Sandrey (2015). "African agricultural trade: Recent and the future". In: *African Journal of Agricultural and Resource Economics* 10, pp. 146–157.

Johns, M. B., C. Busch, G. McLinden (2016). "Implementing Trade Facilitation Reform in Africa". In: *African Perspectives on Trade and the WTO*. URL: https://doi.org/10.1017/cbo9781316795873.017.

Kahsay, T. N., O. Kuik, R. Brouwer, P. van, der Zaag (2018). "The Transboundary Impacts of Trade Liberalization and Climate Change on the Nile Basin Economies and Water Resource Availability". In: *Water Resources Management* 32.3, pp. 935–947. URL: https://doi.org/10.1007/s11269-017-1847-7.

Kappel, R. (2021). *Redefining Europe-Africa Relations*. Friedrich-Ebert-Stiftung, Berlin. URL: http://www.ssoar.info/.

Karakoc, D. B., M. Konar (2021). "A complex network framework for the efficiency and resilience trade-off in global food trade". In: *Environmental Research Letters* 16.10. URL: https://doi.org/10.1088/1748-9326/ac1a9b.

Kareem, I. O. (2019). *Border Measures and Africa's Agri-Food Trade: Export Markets Comparative Analysis*. WTO agricultural Symposium paper.

Kee, H. L., A. Nicita, M. Olarreaga (2009). "Estimating trade restrictiveness indices". In: *Economic Journal* 119.534, pp. 172–199. URL: https://doi.org/10.1111/j.1468-0297.2008.02209.x.

Kee, H. L., A. Nicita (2022). *Trade Fraud and Non-Tariff Measures*. Policy Research Working Paper 10112. World Bank. URL: http://www.worldbank.org/prwp.

Kim, K., P. Mariano (2020). *Trade impact of reducing time and costs at borders in the Central Asia Regional Economic Cooperation region*. ADBI Working Paper Series, No. 1106, Asian Development Bank Institute (ADBI), Tokyo. URL: https://www.adb.org/publications/trade-impact-.

Kindo, M. D., A. A. Adams, J. Mohammed (2024). "The impact of trade on environmental quality and sustainable development in Ghana". In: *World Development Sustainability* 4, p. 100134.

Kornher, L., J. von Braun (2020). "EU Common Agricultural Policy - Impacts on Trade with Africa and African Agricultural Development". In: *SSRN Electronic Journal*. URL: https://doi.org/10.2139/ssrn.3613628.

Kornher, L., D. Sakyi, L. L. Tannor (2024). ""When you need it quick, let us ship it right": on the importance of port efficiency and service quality to comply with

food trade standards in Ghana". In: *Review of World Economics*. URL: https://doi.org/10.1007/s10290-024-00549-1.

Krugman, P. (1991). "1991-The Move Toward Free Trade Zones". In: *Economic Review* 76, pp. 5–25.

– (1995). "Growing World Trade: Causes and Consequences". In: *Brookings Papers on Economic Activity*.

– (2008). "Trade and Wages, Reconsidered". In: *Brookings Papers on Economic Activity*.

Leichenko, R. M., K. L. O'brien (2002). "The Dynamics of Rural Vulnerability to Global Change: The Case of Southern Africa". In: *Mitigation and Adaptation Strategies for Global Change* 7, pp. 1–18.

Limão, N. (2016). *Preferential Trade Agreements*. Working Paper 22138. National Bureau of Economic Research.

Lin, Faqin, M. Liu, M. Zhou (2023). "COVID-19 and the distance effect". In: *The World Economy* 47.3, pp. 1297–1323. DOI: 10.1111/twec.13479.

Liu, F., V. Tawiah, A. Zakari, N. Alessa (2023). "The Impact of Climate Disaster on International Trade: Evidence from Developed and Developing Countries". In: *Journal of Environmental Management* 342, p. 118308. DOI: 10.1016/j.jenvman.2023.118308. URL: https://doi.org/10.1016/j.jenvman.2023.118308.

Lobell, D. B., S. Asseng (2017). "Comparing estimates of climate change impacts from process-based and statistical crop models". In: *Environmental Research Letters* 12. URL: https://doi.org/10.1088/1748-9326/015001.

Lofgren, Hans, R. Lee Harris, Sherman Robinson (2002). *A standard computable general equilibrium (CGE) model in GAMS*. Tech. rep. International Food Policy Research Institute.

Lopes, C. (2024). *The Self-Deception Trap Exploring the Economic Dimensions of Charity Dependency within Africa-Europe Relations*. Palgrave Macmillan.

Luke, D., S. Mevel (2020). *EU-Africa Trade Arrangements at a Crossroads Securing Africa's External Frontier*. Global Governance Spotlight.

Luther, D., M. Simone, D. Cook, B. Lynch, P. Stone, D. Heuschel, J. Fry, L. Bloodgood (2009). *Sub-Saharan Africa: Effects of Infrastructure Conditions on Export Competitiveness, Third Annual Report*. Tech. rep. USITC. URL: http://www.usitc.gov/.

Macheng, C. (2021). *Women without borders: What the AfCFTA can do for Botswana's informal cross border traders*. Africa Portal, South Africa. URL: https://coilink.org/20.500.12592/hxk64n.

Martin, W., P. Messerlin (2007). "Why is it so difficult? Trade liberalization under the Doha Agenda". In: *Oxford Review of Economic Policy* 23.3, pp. 347–366. URL: https://doi.org/10.1093/oxrep/grm026.

McCulloch, N., B. Baulch, M. Cherel-Robson (2001). *Poverty, Inequality and Growth in Zambia during the 1990s*. Discussion Paper 2001/123. United Nations University WIDER.

Mealy, P., A. Teytelboym (2022). "Economic complexity and the green economy". In: *Research Policy* 51.8, p. 103948.

Melagne, D., B. Ehuitché (2021). *Trade Policies for Improved Food Security*. Washington D.C.

Mensah, E., S. Owusu, N. Foster-McGregor, A. Szirmai (2023). "Structural Change, Productivity Growth and Labour Market Turbulence in Sub-Saharan Africa". In: *Journal of African Economies* 32.3, pp. 175–208. URL: https://doi.org/10.1093/jae/ejac010.

Mevel, S., S. Karingi (2012). "Deepening Regional Integration in Africa: A Computable General Equilibrium Assessment of the Establishment of a Continental Free Trade Area followed by a Continental Customs Union". In: *African Economic Conference, Kigali, Rwanda*. African Economic Conference.

Minor, Peter (2013). *Time as a Barrier to Trade: A GTAP Database of ad valorem Trade Time Costs*. Second Edition. ImpactEcon.

Mirito, C. (2022). *The SADC Trade Facilitation Agenda: Lessons for the African Continental Free Trade Area*. Trade Report G22TR01/2022. Stellenbosch: tralac.

Mold, A. (2021). "Proving Hegel Wrong: Learning the Right Lessons from European Integration for the African Continental Free Trade Area". In: *Journal of African Trade* 8.2 (Special Issue), p. 115. URL: https://doi.org/10.2991/jat.k.210908.001.

– (2022). *The economic significance of intra-African trade: Getting the narrative right*. Africa Growth Initiative at Brookings.

Mold, A., R. Mukwaya (2017). "Modelling the economic impact of the tripartite free trade area: Its implications for the economic geography of Southern, Eastern and Northern Africa". In: *Journal of African Trade* 3.1–2, p. 57. URL: https://doi.org/10.1016/j.joat.2017.05.003.

Montaud, J. M., N. Pecastaing, M. Tankari (2017). "Potential socio-economic implications of future climate change and variability for Nigerien agriculture: A country-wide dynamic CGE-Microsimulation analysis". In: *Economic Modelling* 63, pp. 128–142. URL: https://doi.org/10.1016/j.econmod.2017.02.005.

MoTRI (2023). *Draft trade policy of Ethiopia*. Unpublished document.

Moyer, J. D., A. Kabandula, K. Bohl, T. Hanna, I. Mayaki, M. Bwalya (2021). *Conditions for Success in the Implementation of the African Continental Free Trade Agreement*. Tech. rep. African Union Development Agency-NEPAD and Frederick S. Pardee Center for International Futures. URL: https://ssrn.com/abstract=3941470.

Moïsé, E., S. Sorescu (2015). *Contribution of Trade Facilitation Measures to the Operation of Supply Chains*. OECD Trade Policy Papers.

Ndlovu, Everson, Barend Prinsloo, Tanya le Roux (2020). "Impact of climate change and variability on traditional farming systems: Farmers' perceptions from south-west, semi-arid Zimbabwe". In: *Journal of Disaster Risk Studies*.

Nicita, A. (2018). *Nontariff measures. Economic Assessment and Policy options for Development*. Working Papers P218. FERDI.

Nicita, A., M. Olarreaga, G. Porto (2014). "Pro-poor trade policy in Sub-Saharan Africa". In: *Journal of International Economics* 92.2, pp. 252–265. DOI: 10.1016/j.jinteco.2014.01.001.

Nilsson, L. (2018). "Reflections on the economic modelling of free trade agreements". In: *Journal of Global Economic Analysis* 3.1. URL: http://ec.europa.eu/trade/policy/policy-making/analysis/\#_bilateral-regional.

Nordås, H. K., R. Piermartini (2004). *Infrastructure and trade*. WTO Staff Working Paper 4. WTO.

Oberhofer, H., M. Pfaffermayr, R. Sellner (2021a). "Revisiting time as a trade barrier: Evidence from a panel structural gravity model". In: *Review of International Economics* 29.5, pp. 1382–1417. URL: https://doi.org/10.1111/roie.12547.

– (2021b). "Revisiting time as a trade barrier: Evidence from a panel structural gravity model". In: *Review of International Economics* 29.5, pp. 1382–1417. URL: https://doi.org/10.1111/roie.12547.

Ochieng, Sharman (2004). *Trade traps: Why EU-ACP Economic Partnership Agreements pose a threat to Africa's development*. Actionaid International. URL: http://www.actionaid.org/.

Odjo, S., F. Traoré, C. Zaki (2024). *Africa Agriculture Trade Monitor 2024*. Ed. by S. Odjo, F. Traoré, C. Zaki. Kigali and Washington, DC: AKADEMIYA2063 and International Food Policy Research Institute.

Okereke, Chukwumerije, Alexia Coke, Mulu Geebreyesus, Tsegaye Ginbo, Jeremy, J Wakeford, Yacob Mulugetta (2019). "Governing green industrialisation in Africa: Assessing key parameters for a sustainable socio-technical transition in the context of Ethiopia". In: *World Development* 115, pp. 279–290.

Olafuyi, M. (2019). *The Informal Economy and the African Continental Free Trade Agreement: Making Trade Work for the Often Overlooked*.

Oqubay, A. (2019). *Industrial Policy and Late Industrialization in Ethiopia*. Working Paper Series 303. Abidjan, Côte d'Ivoire: African Development Bank.

Organization for Economic Co-operation and Development, OECD (2003). *Quantitative Assessment of the Benefits of Trade Facilitation*. OECD Working Paper. URL: https://doi.org/http:/www.oecd.org/trade.

Organization for Economic Cooperation and Development, OECD (2021). *Transport Strategies for Net-Zero Systems by Design*. OECD Publishing, Paris. URL: https://doi.org/10.1787/0a20f779-en.

Organization for Economic Cooperation and Development, OECD, African Development Bank (AfDB), United Nations Development Programme (UNDP), United Nations Economic Commission for Africa (UNECA) (2013). *Trade policies and regional integration in Africa*. Paris. DOI: 10.1787/888932807360.

Ouraich, I., H. Dudu, W. E. Tyner, E. H. Cakmak (2019). "Agriculture, trade, and climate change adaptation: a global CGE analysis for Morocco and Turkey". In: *Journal of North African Studies* 24.6, pp. 961–991. URL: https://doi.org/10.1080/13629387.2018.1463847.

Pasara, M. T., N. Diko (2020). "The effects of AfCFTA on food security sustainability: An analysis of the cereals trade in the SADC region". In: *Sustainability* 12.4. URL: https://doi.org/10.3390/su12041419.

Pavcnik, N. (2017). *The Impact of Trade on Inequality in Developing Countries*. URL: http://www.nber.org/papers/w23878.

Peet, R. (1987). "Industrial Devolution, Underconsumption of the Third World Debt Crisis". In: *World Development* 15.6, pp. 777–788.

Persson, M. (2012). "From trade preferences to trade facilitation: Taking stock of the issues". In: *Economics* 6. URL: https://doi.org/10.5018/economics-ejournal.ja.2012-17.

Pienknagura, Samuel (2024). *Trade in Low Carbon Technologies: The Role of Climate and Trade Policies*. IMF Working Paper. International Monetary Fund.

Piermartini, R., Y. V. Yotov (2016). *Estimating Trade Policy Effects with Structural Gravity*. WTO Working Paper ERSD-2016-10.

Piermartini, R., S. Rubínová, L. A. Jackson, F. Maggi (2022). "Monitoring agriculture policy at the WTO: Insights from a new quantitative database". In: *Journal of International Economic Law* 25.4, pp. 548–567.

Porteous, O. (2019). "High trade costs and their consequences: An estimated dynamic model of african agricultural storage and trade". In: *American Economic Journal: Applied Economics* 11.4. URL: https://doi.org/10.1257/app.20170442.

Portugal-Perez, A., J. S. Wilson (2009). "Why trade facilitation matters to Africa". In: *World Trade Review* 8.3, pp. 379–416. URL: https://doi.org/10.1017/S147474560900439X.

Reardon, Thomas, David Tschirley, Lenis Saweda, O Liverpool-Tasie, Titus Awokuse, Jessica Fanzo, Bart Minten, Rob Vos, Michael Dolislager, Christine Sauer, Rahul Dhar, et al. (2021). "The processed food revolution in African food systems and the double burden of malnutrition". In: *Global food security* 28, p. 100466.

Reilly, J., N. Hohmann (1993). "Climate Change and Agriculture: The Role of International Trade". In: *The American Economic Review* 83.2, pp. 306–312.

Riedel, J., A. Slany (2019). "The potential of African trade integration – Panel data evidence for the COMESA-EAC-SADC Tripartite". In: *The Journal of International Trade & Economic Development* 28.7, pp. 843–872. DOI: 10.1080/09638199.2019.1575457.

Rippel, Barbara (2011). "Why trade facilitation is important for Africa". In: *Africa Trade Policy Notes* 27.

Robichaud, V. (2001). *Calculating Equivalent and Compensating Variations in CGE Models*. Unpublished Article.

Robinson, S., D. Willenbockel, K. Strzepek (2012). "A Dynamic General Equilibrium Analysis of Adaptation to Climate Change in Ethiopia". In: *Review of Development Economics* 16.3, pp. 489–502. URL: https://doi.org/10.1111/j.1467-9361.2012.00676.x.

Robinson, S., K. Strzepek, R. Cervigni (2013). *The Cost of Adapting to Climate Change in Ethiopia: Sector-Wise and Macro-Economic Estimates*. ESSP Working Paper.

Robson, E. N., K. P. Wijayaratna, V. V. Dixit (2018). "A review of computable general equilibrium models for transport and their applications in appraisal". In: *Transportation Research Part A: Policy and Practice* 116, pp. 31–53. URL: https://doi.org/10.1016/j.tra.2018.06.003.

Rodrik, D. (1998). *Trade Policy and Economic Performance in Sub-Saharan Africa*. NBER Working paper 6562.

– (2018). *New Technologies, Global Value Chains, and the Developing Economies*. Pathways for Prosperity Commission Background Paper Series 1. Oxford, United Kingdom. URL: http://www.pathwayscommission.bsg.ox.ac.uk/.

Rodríguez, F., D. Rodrik (2000). "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence". In: *NBER Macroeconomics Annual* 15. URL: https://doi.org/10.1086/654419.

Rubínová, S., Sebti, Mehdi (2021). *The WTO Global Trade Costs Index and its determinants Standard-Nutzungsbedingungen*. URL: https://doi.org/10.30875/29ba5a43-en.

Sakyi, D., S. K. Afesorgbor (2019). "The Effects of Trade Facilitation on Trade Performance in Africa". In: *Journal of African Trade* 6.1–2. URL: https://doi.org/10.2991/jat.k.191129.001.

Sanny, J., J. Patel (2021a). *Beyond borders? Africans prefer self-reliant development but remain skeptical of free trade and open borders*. Afrobarometer Dispatch No. 433.

Sanny, Josephine Appiah-Nyamekye, Jaynisha Patel (2021b). *Beyond Borders? Africans Prefer Self-Reliant Development but Remain Skeptical of Free Trade and Open Borders*. Dispatch No. 433. Afrobarometer. URL: https://www.afrobarometer.org/wp-content/uploads/2022/02/ad433-africans_prefer_self-reliant_development_skeptical_of_free_trade_and_open_borders-afrobarometer_dispatch-23march21.pdf.

Santos, A. U. (2012). *Trade, Income Distribution and Poverty in Developing Countries: A Survey*. UNCTAD Discussion Paper (207).

Santos, Silva, J. M., S. Tenreyro (2006). "The log of gravity". In: *The Review of Economics and Statistics* 88.4, pp. 641–658. URL: http://direct.mit.edu/rest/article-pdf/88/4/641/1982805/rest.88.4.641.pdf.

Saygili, M., R. Peters, C. Knebel (2018). *African Continental Free Trade Area: challenges and opportunities of tariff reductions*. UNCTAD Research paper.

Seery, E., J. Okanda, M. Lawson (2019). *A Tale of Two Continents: Fighting inequality in Africa*. Oxfam briefing paper. URL: https://doi.org/10.21201/201.4719.

Shapiro, J. S. (2021). "The environmental bias of trade policy". In: *Quarterly Journal of Economics* 136.2, pp. 831–886. URL: https://doi.org/10.1093/qje/qjaa042.

Shepherd, B. (2017). "Infrastructure, trade facilitation, and network connectivity in Sub-Saharan Africa". In: *Journal of African Trade* 3.1–2. URL: https://doi.org/10.1016/j.joat.2017.05.001.

– (2022). "Modelling global value chains: From trade costs to policy impacts". In: *World Economy* 45.8. URL: https://doi.org/10.1111/twec.13268.

Shepherd, Ben (2013). *Who Profits from Trade Facilitation Initiatives?* Tech. rep. 9490. C.E.P.R.

Shukla, R., S. Gleixner, A. W. Yalew, B. Schauberger, D. Sietz, C. Gornott (2021). "Dynamic vulnerability of smallholder agricultural systems in the face of climate change for Ethiopia". In: *Environmental Research Letters* 16.4. URL: https://doi.org/10.1088/1748-9326/abdb5c.

Sifiso, N., N. Bonani, N. Simphiwe, P. Heidi, L. Moses (2017). "Economy-wide effects of drought on South African Agriculture: A computable general equilibrium (CGE) analysis". In: *Journal of Development and Agricultural Economics* 9.3, pp. 46–56. URL: https://doi.org/10.5897/jdae2016.0769.

Simola, A., O. Boysen, E. Ferrari, V. Boulanger (2021). *Potential effects of the African Continental Free Trade Area (AfCFTA) on African agri-food sectors and food security*. JRC Science Policy Brief. URL: https://doi.org/10.2760/531308.

Sithole (2021). *The Role of Trade Facilitation in Addressing Non-Tariff Barriers in the African Continental Free Trade Area*. AfronomicsLaw.

Solomon, R., B. Simane, B. F. Zaitchik (2021). "The Impact of Climate Change on Agriculture Production in Ethiopia: Application of a Dynamic Computable General Equilibrium Model". In: *American Journal of Climate Change* 10.01, pp. 32–50. URL: https://doi.org/10.4236/ajcc.2021.101003.

Sorescu, M. S. (2023). *Multi-year Expert Meeting on Transport, Trade Logistics and Trade Facilitation 10th Session Coordination and digitalization as a means to accelerated and climate-smart trade facilitation The evolving contribution of trade facilitation policies to enhancing trade*. OECD. URL: http://www.oecd.org/tad.

Sorescu, S., C. Bollig (2022). *Trade Facilitation Reforms Worldwide State of Play in 2022*. Organization for Economic Cooperation and Development Trade Policy Paper (263).

Stuart, J. (2022). *Value Chains Can Drive, and be Driven by, the AfCFTA*. Tralac blog. URL: https://trademap.org/.

Svedberg, P. (1991). "The Export Performance of Sub-Saharan Africa". In: *Economic Development and Cultural Change* 39.3, pp. 549–566. URL: https://www.jstor.org/stable/1154386.

Takpara, M. M., C. F. Djiogap, B. Sawadogo (2023). "Trade Policy and African Participation in Global Value Chains: Does Trade Facilitation Matter?" In: *Journal of Economic Integration* 38.1, pp. 59–92. URL: https://doi.org/10.11130/jei.2023.38.1.59.

Tandrayen-Ragoobur, V., P. Ongono, J. Gong (2023). "Infrastructure and intra-regional trade in Africa". In: *World Economy* 46.2. URL: https://doi.org/10.1111/twec.13358.

Tarr, D., S. J. Matusz (2005). *The Adjustment Costs of Trade Liberalization*. Washington, D.C., World Bank Group.

Teichmann, I. (2016). *CGE-Based Methods to Measure the Impact of Trade Liberalization on Poverty*. Deutsches Institut für Wirtschaftsforschung Roundup, Politik im Fokus, Berlin.

Togan, S. (2016). *Transportation Costs, Trade, and Global Value Chains*. Oxford Academic, pp. 1–36. URL: https://doi.org/10.1093/acprof:oso/9780198753407.003.0001.

Tralac (2022). *Intra-Africa trade by REC 2020 update*. Tralac publications.

Truong, T. (2010). *Review of Analytical Tools for Assessing Trade and Climate Change Linkages*. Asia-Pacific Research and Training Network on Trade, Working Paper Series. (81).

Tröster, B., E. Janechová (2021). *The long journey towards Pan-African integration: The African Continental Free Trade Area and its challenges*. ÖFSE Briefing Paper, No. 31, Austrian Foundation for Development Research (ÖFSE), Vienna. URL: https://doi.org/10.60637/2021-bp31.

UNCTAD, United Nation Conference on Trade and Development (2021a). *Economic Development in Africa Report 2021: Reaping the Potential Benefits of the African Continental Free Trade Area for Inclusive Growth*.

– (2021b). *Reaping the potential benefits of the African Continental Free Trade Area for inclusive growth - Introduction*.

– (2022). *Key Statistics and Trends in Trade Policy 2022: Green goods trade and trade policies*. UNCTAD/DITC/TAB/2023/2.

– (2023a). *Mapping Trade-related Measures in the Nationally Determined Contributions: Technical note*. UNCTAD/DITC/MISC/2023/15.

– (2023b). *Trade and Development Report Update: Global Trends and Prospects*. United Nations Conference on Trade and Development, UNCTAD/GDS/INF/2023/1.

– (2024). *Key Statistics and Trends in International Trade 2023*. United Nations.

UNDP, United Nation Development Program (2023). *Working Paper Series Can Ethiopia Become a Manufacturing Powerhouse?* UNDP Working Paper Series.

UNDP and OPHI, United Nations Development Program Oxford Poverti and Human Development Initiative (2024). *Multidimensional Poverty Index 2024: Poverty Amid Conflict*. United Nation Development Program and Oxford Multidimensional Poverty Index report. URL: http://hdr.undp.org/.

United Nations Economic Commission for Africa (2018). *AfCFTA: An Opportunity to Boost Africa's Economic Transformation*. © UN. ECA. Addis Ababa: United Nations Economic Commission for Africa. URL: https://hdl.handle.net/10855/45632.

USDA, United States Department of, Agriculture (2024). *Ethiopian Agricultural Exports Thrive Despite the Red Sea Shipping Disruption*. Voluntary Report ET2024-0013. Approved by Justina Torry. Addis Ababa, Ethiopia: United States Department of Agriculture (USDA), Foreign Agricultural Service. URL: https://www.fas.usda.gov/data/ethiopian-agricultural-exports-thrive-despite-red-sea-shipping-disruption.

Valensisi, Giovanni, Robert, T. Lisinge (2013). *Trade Facilitation from an African Perspective*. Addis Ababa: United Nations, Economic Commission for Africa.

Van Der, Ven, C., L. Signé (2021). *Greening the AfCFTA: It is not too late*. Africa Growth Initiative at Brookings Policy Brief. URL: https://ieep.eu/uploads/articles/attachments/c527f72f-1c99-4383-ba65-.

Villoria, N. B., S. Arita, S. Sydow (2024). "The Roles of Agricultural Trade and Trade Policy in Climate Change Adaptation and Mitigation". In: *Environmental Research: Food Systems* 1.2, p. 022002.

Waldhoff, S. T., I. S. Wing, J. Edmonds, G. Leng, X. Zhang (2020). "Future climate impacts on global agricultural yields over the 21st century". In: *Environmental Research Letters* 15.11. URL: https://doi.org/10.1088/1748-9326/abadcb.

Warr, P. (2014). "Agricultural liberalization, poverty and inequality: Indonesia and Thailand". In: *Journal of Asian Economics* 35, pp. 92–106. URL: https://doi.org/10.1016/j.asieco.2014.10.003.

Wassie, M. A., L. Kornher, J. Von, Braun (2022). *African Continental Free Trade Agreement: A Review of Analyses of Likely Impacts and Challenges of Implementation*. ZEF Working Paper (217). URL: https://doi.org/10.13140/RG.2.2.24481.28007.

Wassie, M. A., L. Kornher, C. Zaki (2024). *Revisiting the Impact of Trade Facilitation Measures in Africa: Structural Gravity Estimation and Ad Valorem Tariff Equivalents*. The Journal of International Trade and Economic Development (Forthcoming). URL: http://ageconsearch.umn.edu/.

WHITESHIELD (2022). *Trade impact 2.0: Facilitating Trade Through Public-Private Partnerships: Trade Impact Assessment White Paper on Impact Monitoring*. Strategy & Public Policy Advisory, London, England.

Wilson, J. S., C. L. Mann, T. Otsuki (2004). *Assessing the Potential Benefit of Trade Facilitation: A Global Perspective*. World Bank, available at: http://econ.worldbank.org/.

Winters, L. A., N. McCulloch, A. McKay (2004). "Trade Liberalization and Poverty: The Evidence So Far". In: *Journal of Economic Literature* 1, pp. 72–115.

Winters, L. A., A. Martuscelli (2014). "Trade liberalization and poverty: What have we learned in a decade?" In: *Annual Review of Resource Economics* 6.1, pp. 493–512. URL: https://doi.org/10.1146/annurev-resource-110713-105054.

World Bank (2008). *Ethiopia: A Country Study on the Economic Impacts of Climate Change*. The World Bank report (46946-ET).

– (2010). *Economics of Adaptation to Climate Change: Ethiopia*. The World Bank Group, Washington, DC.

– (2020a). *Doing Business 2020: Comparing Business Regulation in 190 Economies*. The World Bank, Washington, DC. URL: https://doi.org/10.1596/978-1-4648-1440-2.

– (2020b). *The African Continental Free Trade Area: Economic and Distributional Effects*. The World Bank, Washington, DC.

World Bank (2021). *The Trade and Climate Change Nexus: The Urgency and Opportunities for Developing Countries*. The World Bank, Washington DC.
– (2023). *Regional Integration Removes Barriers to Development in Africa*. World Bank.
– (2024a). *Country Climate and Development report*. The World Bank Group Eastern and Southern Africa, Ethiopia country report, Washington, DC. URL: http://www.worldbank.org/.
– (2024b). *Country Climate and Development Report. EASTERN AND SOUTHERN AFRICA: ETHIOPIA*. The World Bank Group, Washington, DC. URL: http://www.worldbank.org/.
– (2024c). *Digital Transformation Drives Development in AFE and AFW Africa*. https://www.worldbank.org/en/results/2024/01/18/digital-transformation-drives-development-in-afe-afw-africa. World Bank.
– (2024d). *Eastern and Southern Africa: Country Climate and Development Report for Ethiopia*. http://www.worldbank.org/. World Bank, Washington, DC.
WTO, World Trade Organization (2018). *World Trade Report 2018: The future of world trade: How digital technologies are transforming global commerce*. WTO report. URL: http://www.wto.org/.
– (2021). *World Trade Report 2021: Economic resilience and trade*. WTO report. URL: http://www.wto.org/.
– (2022). *World Trade Report 2022: Climate change and international trade*. WTO report. URL: http://www.wto.org/.
– (2023). *Trade Policy Tools for Climate Action*. WTO report.
– (2024). *Evolution of trade under the WTO: handy statistics*. WTO, documents, data and resources. URL: https://www.wto.org/english/res_e/statis_e/trade_evolution_e/evolution_trade_wto_e.htm\#fnt1.
Yalew, A., G. Hirte, H. Lotze-Campen, S. Tscharaktschiew (2017). *Economic effects of climate change in developing countries: Economy-wide and regional analysis for Ethiopia*. CEPIE Working Paper, No. 10/17. URL: https://nbn-resolving.de/urn:nbn:de:bsz:14-qucosa-227554.
Yang, L., Q. Dong, Z. Tong, Q. Wang, J. Wu (2022). "Logistics input intensity, trade facilitation and comparative advantage". In: *Journal of International Trade and Economic Development* 31.5. URL: https://doi.org/10.1080/09638199.2021.2011380.
Yang, Y., S. Gupta (2005). *Regional Trade Arrangements in Africa: Past Performance and the Way Forward*. IMF working paper (WP/05/36).
Yotov, Y. V. (2022). "On the role of domestic trade flows for estimating the gravity model of trade". In: *Contemporary Economic Policy* 40.3. URL: https://doi.org/10.1111/coep.12567.
You, J., C. Ringler (2010). *Hydro-economic modeling of climate change impacts in Ethiopia*. IFPRI Discussion Paper (960). URL: http://www.ifpri.org/publications/results/taxonomy%3A468.

Zaki, C. (2014). "An empirical assessment of the trade facilitation initiative: Econometric evidence and global economic effects". In: *World Trade Review* 13.1, pp. 103–130. URL: https://doi.org/10.1017/S1474745613000256.

– (2015). "How does trade facilitation affect international trade". In: *European Journal of Development Research* 27.1. URL: https://doi.org/10.1057/ejdr.2014.36.

Ziesmer, J., D. Jin, S. D. Thube, C. Henning (2023). "A Dynamic Baseline Calibration Procedure for CGE models". In: *Computational Economics* 61.4, pp. 1331–1368. URL: https://doi.org/10.1007/s10614-022-10248-4.

Appendix A

Appendix to chapter 3

1. Description and summary of variables

TABLE A.1: List of variables

Variable	Definition	Time	Source	Adjustments
Trade volume	Trade in amount and value	2006-2020	CEPII-BACI	no
Time to export/import	No. of days to export/import	2006-2020	WB doing business	No. of days (2006-2015)/hours 2016-2020
ETI	Average and difference between exporter/importer	2012-2016	WEF	average/difference of the exporters/importers
LPI	Weighted Average of the indices/differences	2007-2018	WB	Weighted average & difference of exporter/importer
Distance	The geographical distance between the exporter & importer	2006-2020	CEPII	no
GDP	Gross domestic product of exporter & importer	2006-2020	WDI	no
Gravity	Gravity variables	2006-2020	CEPII	no

TABLE A.2: Descriptive Statistics

Variables	Observations	Mean	Standard Deviation	Min/Max
Trade flow (in thousands)	5,824,862	9435.3	184104.5	0/6.39e+07
Tariff (MFN simple average)	5,747,073	9	18.38	0/3000
Time to export (days)	1,745	23.82	15.9	3/102
Time to import (days)	1,745	26.82	19.76	5.13/113
LPI index (1-5 scale)	1,880	2.85	0.59	1.21/4.23
ETI index (1-7 scale)	402	4.28	0.71	2.63/6.14
GDP origin	198,054	2.97E+08	7.00E+08	104668.7/5.95e+09
GDP destination	200,695	3.57E+08	7.75E+08	197558.7/5.95e+09
Distance capital	201,540	7479.238	4330.036	8/19854
Contiguity	201,540	0.018175	0.133585	0/1
Common colony	201,540	0.090076	0.286292	0/1

Source: Author's computation

TABLE A.3: Africa-Global: Impact of Tariffs and Time on Trade Flows

[1]

	Import			**Export**		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(1+tariff)	-1.37***	-1.27***	-1.37***	-1.73***	-1.16***	-1.73***
	(0.08)	(0.04)	(0.06)	(0.05)	(0.07)	(0.05)
Ln(time) ave	-0.132***			-0.147***		
	(0.02)			(0.10)		
Ln(time) Abs diff		-0.187***			-0.140***	
		(0.01)			(0.02)	
Ln(time) diff			-0.187***			-0.039***
			(0.01)			(0.01)
Constant	11.79***	11.82***	11.79***	13.39***	13.69***	13.39***
	(0.08)	(0.09)	(0.08)	(0.09)	(0.30)	(0.09)
Importer-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer-product-exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	928,110	928,110	928,110	587,697	587,697	587,697

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2. Estimation results for LPI and ETI

TABLE A.4: Intra-Africa Trade: Impact of Tariffs and Time on Trade Flows

	Dependent: Import			**Dependent: Export**		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(1+tariff)	-1.23***	-1.02***	-1.23***	-1.18***	-1.10***	-1.18***
	(0.06)	(0.07)	(0.03)	(0.07)	(0.07)	(0.05)
Ln(time) ave	-0.191**			-0.130***		
	(0.017)			(0.021)		
Ln(time) Abs diff		-0.171***			-0.071**	
		(0.04)			(0.03)	
Ln(time) diff			-0.171***			-0.170***
			(0.04)			(0.05)
Constant	12.17***	12.32***	12.17***	11.63***	11.02***	11.63***
	(0.18)	(0.56)	(0.18)	(0.15)	(0.55)	(0.15)
Importer-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer-product-exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	173338	173338	173338	166471	166471	166471

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE A.5: Result of the impact of LPI on Africa trade flow

	Africa-global Import		**Africa-global export**		**Intra-Africa import**		**Intra-Africa export**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln (1+Tariff)	-1.23***	-1.12***	-0.92***	-1.23**	-1.18***	-2.11***	-1.62***	-1.33***
	(0.03)	(0.09)	(0.03)	(0.62)	(0.11)	(0.75)	(0.11)	(0.61)
Ln (LPI) Avg.	2.83***		2.33***		3.47***		3.84***	
	(0.16)		(0.36)		(0.41)		(0.36)	
Ln (LPI) Diff.		2.63***		2.18***		3.41***		3.72***
		(0.16)		(0.36)		(0.83)		(0.36)
Constant	7.87***	9.69***	11.66***	14.30**	8.91***	11.11***	9.23***	11.68**
	(0.18)	(0.11)	(0.31)	(0.15)	(0.46)	(0.32)	(0.31)	(0.15)
Importer-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer-product-exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	622504	622504	599554	599554	133853	133853	118925	118925

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All estimations are run using the PPML high dimensional fixed effect estimator.

TABLE A.6: Result of the impact of ETI on Africa trade

	Africa-global Import		Africa-global export		Intra-Africa Import		Intra-Africa export	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln (1+tariff)	- 1.30*** (0.52)	- 1.15*** (0.25)	- 1.34** (0.62)	- 0.94*** (0.12)	- 1.14*** (0.05)	- 0.85*** (0.03)	- 2.20** (1.05)	- 1.41*** (0.03)
Ln (ETI) Avg.	1.90*** (0.62)		1.42** (0.69)		1.44*** (0.41)		2.07*** (0.41)	
Ln (ETI) Diff.		1.83*** (0.22)		1.68*** (0.24)		0.91 (0.36)		1.81*** (0.06)
Constant	18.11*** (2.67)	15.31*** (3.73)	12.36*** (0.64)	11.61*** (1.16)	11.43*** (1.42)	10.73*** (0.10)	11.43*** (1.42)	10.73*** (0.10)
Imp-product-year FE	YES	YES	YES	YES	YES	YES	YES	YES
Exp-product-year FE	YES	YES	YES	YES	YES	YES	YES	YES
Imp-product-exp FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	184137	184137	112373	112373	72457	72457	58442	58442

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ All estimations are run using the PPML high dimensional fixed effect estimator.

TABLE A.7: Correlation analysis of TF, TC and AVEs

Correlation between TF and TC: Africa-global				
	Ln (ave. time)	Ln (diff. time)	Ln (abs diff. time)	Ln (TC)
Ln (ave. time)	1.00			
Ln (diff. time)	0.6637	1.00		
Ln (abs diff. time)	0.6637	1.00	1.00	
Ln (TC)	0.1224	0.1369	0.1369	1.00
Correlation between TF and trade cost: intra-Africa trade				
	Ln (ave. time)	Ln (diff. time)	Ln (abs diff. time)	Ln (TC)
Ln (ave. time)	1.00			
Ln (diff. time)	0.765	1.00		
Ln (abs diff. time)	0.5833	0.4113	1.00	
Ln (TC)	0.1240	0.09100	0.0565	1.00
Correlation between AVE of time and TC				
	AVE to import	AVE to export	AVE TC	
AVE to import	1.000			
AVE to export	0.9998	1.000		
AVE TC	0.4834	0.4874	1.0000	

TABLE A.8: OLS estimation of Trade Cost on TF

	Dependent: TC (Africa-global)			Dependent: TC (intra-Africa)		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (time trade_diff)	0.044**			0.061***		
	(0.02)			(0.00)		
Ln (time trade_ave)		0.056			0.059**	
		(0.05)			(0.02)	
Ln (time trade_diffabs)			0.034***			0.028**
			(0.00)			(0.013)
Ln (1+ tariff)	0.210***	0.237***	0.238***	0.314***	0.333***	0.324***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	5.445***	5.412***	5.429***	5.242***	5.270***	5.228***
	(0.00)	(0.00)	(0.00)	(0.09)	(0.02)	(0.01)
Importer_year	Yes	Yes	Yes	Yes	Yes	Yes
Exporter_year	Yes	Yes	Yes	Yes	Yes	Yes
Importer_exporter	Yes	Yes	Yes	Yes	Yes	Yes
Observations	719019	719019	719019	126933	126933	126933

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE A.9: PPML estimation: trade impact of time to trade and TC residual

	Africa-Global	Intra-African
Ln(1+tariff)	-1.88***	-1.55***
	(0.04)	(0.07)
Ln(time trade _diff)	-0.101***	-0.153***
	(0.01)	(0.05)
Residual1	-0.012	-0.025
	(0.01)	(0.03)
Constant	11.9464***	12.0546***
	(0.09)	(0.19)
Importer-product-year FE	Yes	Yes
Exporter-product-year FE	Yes	Yes
Importer-product-exporter FE	Yes	Yes
Observations	772500	95875

Standard errors in parentheses. *Note:* Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are run using a PPML high dimensional fixed effect estimator.

TABLE A.10: Counterfactual simulated import/export impacts

4

Countries	Scenario 1 Export (%Δ)	Scenario 1 Import (%Δ)	Scenario 2 Export (%Δ)	Scenario 2 Import (%Δ)	Scenario 3 Export (%Δ)	Scenario 3 Import (%Δ)
Algeria	3.96	10.69	31.54	41.96	16.09	36.92
Angola	3.31	10.00	31.97	42.32	15.37	36.07
Benin	0.41	6.92	33.87	43.93	12.13	32.25
Botswana	4.42	11.18	31.23	41.70	16.61	37.53
Burkina Faso	0.51	7.02	33.81	43.88	12.24	33.38
Burundi	15.56	23.04	23.90	35.48	29.04	42.19
Cabo Verde	6.11	0.04	38.18	47.58	14.84	20.65
Cameroon	7.70	1.72	39.21	48.46	13.07	22.57
Central African Republic	20.99	28.83	20.32	32.44	35.11	49.36
Chad	0.78	5.65	34.66	44.60	10.80	30.68
Comoros	13.32	20.66	25.38	36.73	28.54	49.25
Congo	1.23	7.78	33.34	43.48	13.04	33.33
Djibouti	3.93	10.66	31.56	41.97	16.06	36.89
Equatorial Guinea	6.99	0.96	38.75	48.07	11.87	22.50
Ethiopia	1.70	4.67	35.27	45.11	19.77	29.47
Gabon	1.35	5.04	35.03	44.92	10.16	29.93
Gambia	2.54	9.18	32.48	42.75	14.50	35.05
Ghana	2.11	4.22	35.54	45.35	9.31	28.92
Guinea	3.46	2.79	36.43	46.10	13.80	27.15
Guinea-Bissau	2.83	3.47	36.01	45.74	8.51	27.99
Kenya	1.00	5.41	34.8	44.72	10.55	30.39
Lesotho	0.19	6.68	34.02	44.06	11.88	31.96
Liberia	8.54	2.61	39.77	48.93	15.14	20.46
Libya	9.68	3.83	40.52	49.57	5.86	18.96
Madagascar	3.01	3.27	36.13	45.84	8.31	27.75
Malawi	3.67	2.57	36.56	46.22	9.57	26.87
Mali	2.97	3.31	36.10	45.83	8.35	27.79
Mauritania	2.21	4.12	35.60	45.40	9.20	28.80
Mauritius	7.66	1.69	39.19	48.45	3.11	21.61
Morocco	3.83	2.40	36.67	46.30	7.40	26.67
Namibia	2.72	3.58	35.94	45.68	8.63	28.13
Niger	2.20	4.14	35.59	45.39	9.21	28.81
Nigeria	2.86	3.43	36.03	45.76	8.47	27.94
Rwanda	5.78	0.33	37.95	47.39	5.22	24.10
Senegal	3.76	2.47	36.62	46.27	7.47	26.75
Seychelles	7.79	1.82	39.28	48.51	2.97	21.45
Sierra Leone	2.52	3.80	35.80	45.57	8.86	28.39
South Africa	0	0	34.32	44.31	11.38	31.36
Sudan	2.89	3.40	36.05	45.78	8.44	27.90
Togo	1.79	4.57	35.32	45.16	18.67	29.35
Tunisia	0.49	7.00	33.82	43.89	12.22	32.35
Uganda	0.98	7.52	33.50	43.62	12.76	33.00
Tanzania	3.04	3.24	36.15	45.86	15.27	27.70
Zambia	1.28	5.11	24.99	44.88	10.24	30.02
Zimbabwe	7.90	14.89	28.94	39.75	20.49	42.12

Source: Authors' own elaboration based on simulation results.

TABLE A.11: List of African countries included in the analysis

Algeria
Angola
Benin
Botswana
Burkina Faso
Cameroon
Central African Republic
Chad
Comoros
Congo, Dem. Rep.
Congo, Rep.
Cote d'Ivoire
Djibouti
Egypt, Arab Rep.
Equatorial Guinea
Ethiopia
Gambia
Gabon
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Libya
Madagascar
Malawi
Mali
Mauritania
Mauritius
Morocco
Mozambique
Namibia
Rwanda
Senegal
Seychelles
Sierra Leone
South Africa
Sudan
Tanzania
Togo
Tunisia
Uganda
Zambia
Zimbabwe

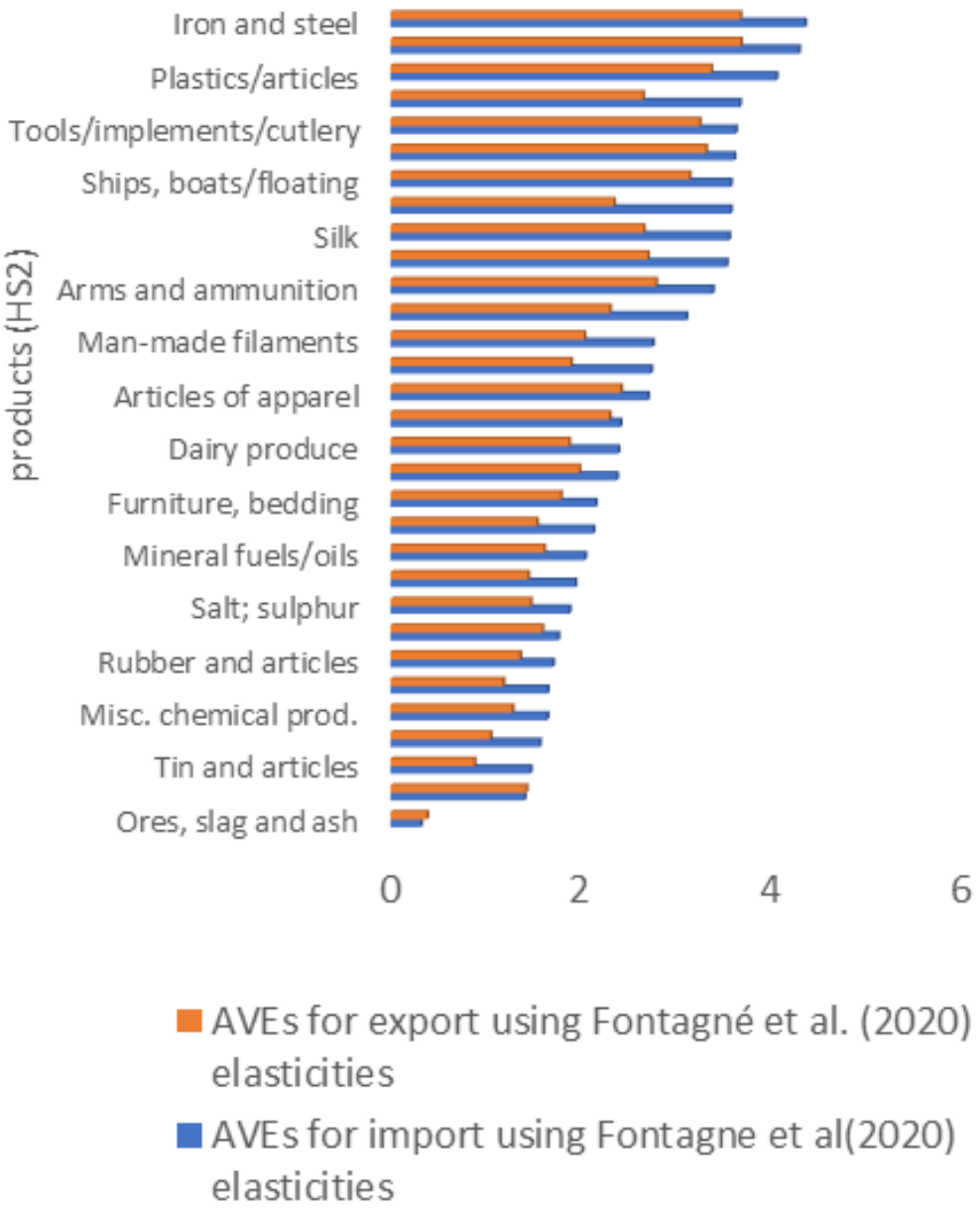

FIGURE A.1: AVEs by product group using Fontagné et al. (2020) trade elasticities of tariff (for least cost products)

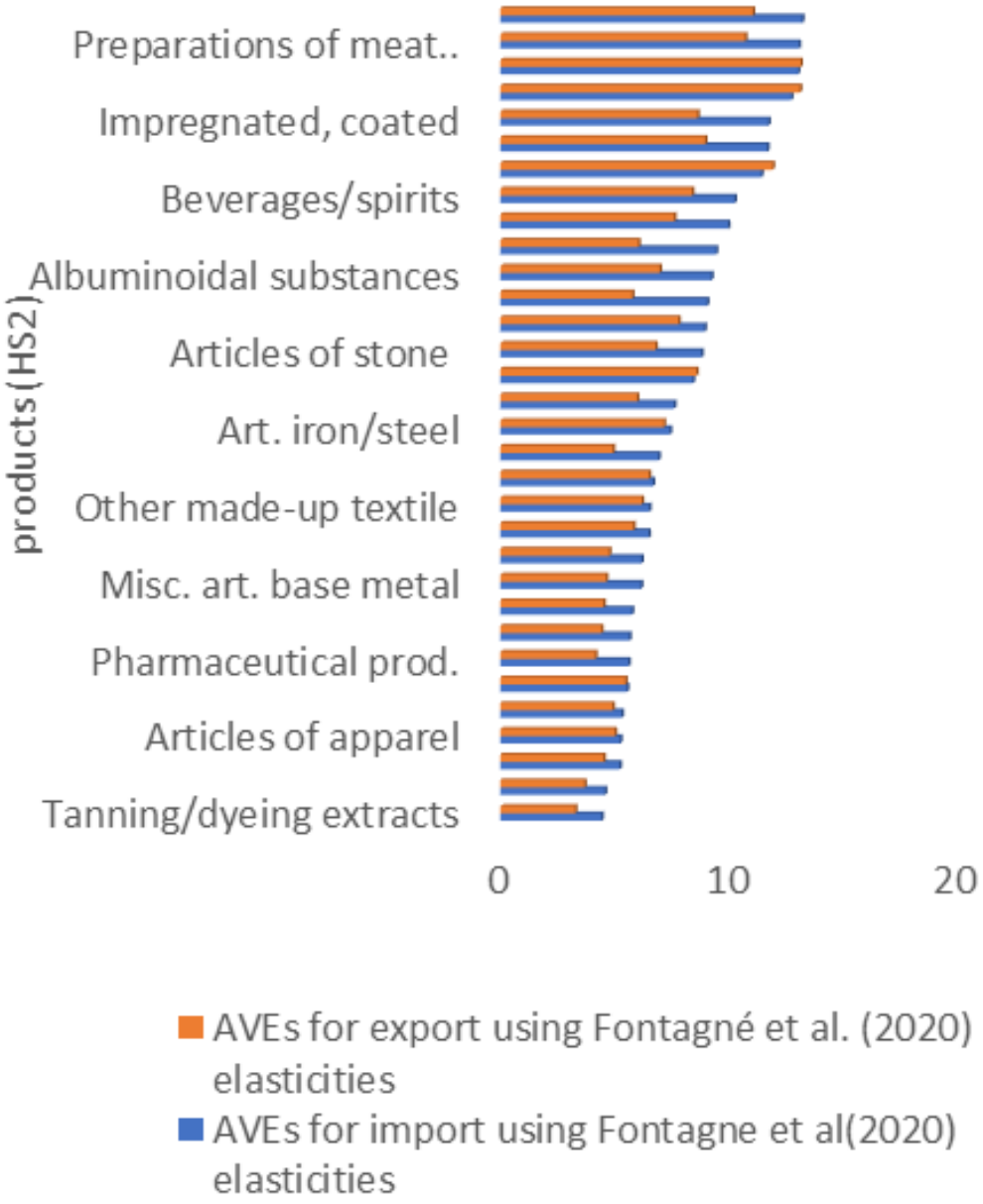

FIGURE A.2: AVEs by product group using Fontagné et al. (2020) trade elasticities of tariff (for medium cost products)

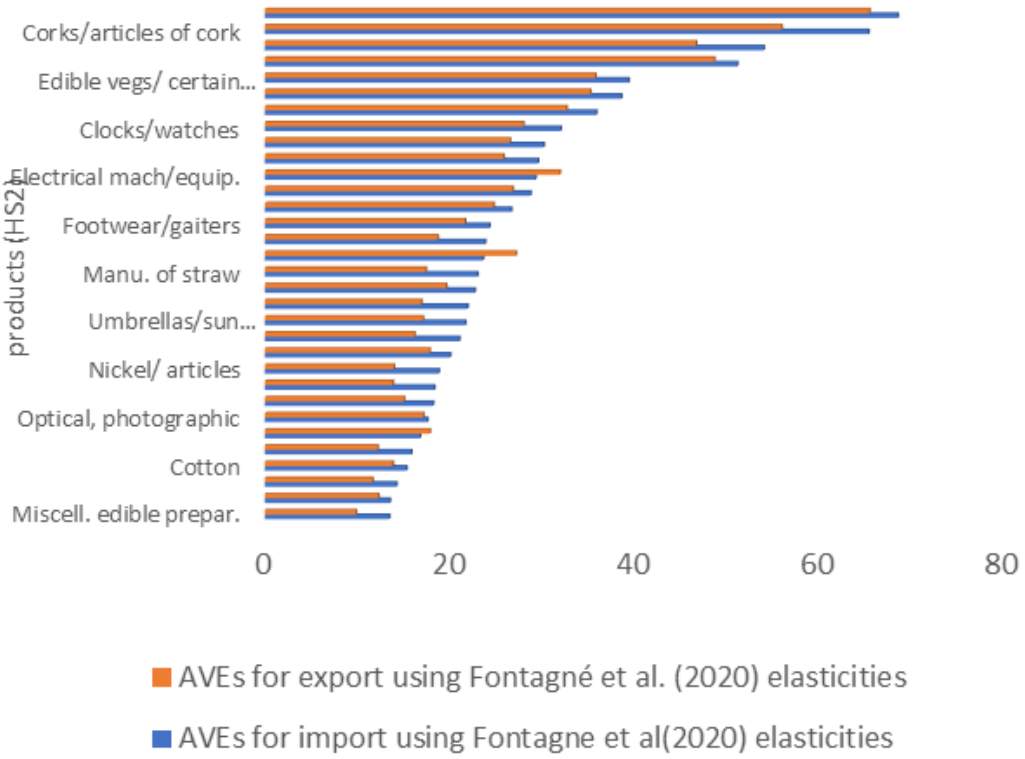

FIGURE A.3: AVEs by product group using Fontagné et al. (2020) trade elasticities of tariff (for high cost products)

Appendix B

Appendix to chapter 4

1. Theoretical framework of the CGE model

In the following technical description of the dynamic CGE model, the description of the flow of the economic activities in economy is presented with the kind of technology applied in each of the activities. For instance, the top household utility function is presented in Cobb-Douglas function whereas, the Armington function is used in the composite domestic and imported goods aggregation. By the same way, the production function at the top is a Leontief function of intermediate goods and value added.

2. Basic functions of the standard CGE model

1. Price Block

The price block of equations consists of the import price in local currency paid by the domestic users, excluding the sales tax, the export price in local currency received by the domestic producers when they export, and the same as the import price equation but excluding the tax and the cost of trade inputs, domestic price of domestically sold, activity price. The system of equations is differentiated by the assumed quality differences among commodities of different origins and destinations (exports, imports, and domestic outputs used domestically). *1. Domestic Sales Price Equation* PDS_c *:*

$$PDS_c = (1 + tqc) \cdot PX_c \tag{B.1}$$

where: PDS_c : Supply price of commodity c produced and sold domestically

tqc : Sales tax rate on commodity c

PX_c : Producer price of commodity c

2. Composite Commodity Price PQ_c *:*

$$PQ_c = \left[\alpha_c \cdot (PM_c)^{-\rho_c} + (1 - \alpha_c) \cdot (PD_c)^{-\rho_c}\right]^{-\frac{1}{\rho_c}} \tag{B.2}$$

PQ_c : Composite commodity price

PM_c : Import price of commodity c

PD_c: Domestic price of commodity c

α_c : Shift parameter for Armington function

ρ_c : Armington function exponent

2. Activity Production Function QA_a

Th four main blocks in the production and trade block are the domestic production and input use; the allocation of domestic output to home consumption, the domestic market, and exports; the aggregation of supply to the domestic market; and the definition of the demand for trade inputs that is generated by the distribution process. Production is based on a perfectly competitive market. Production is carried out by activities that are assumed to maximize profits subject to their technology, taking prices as given. Therefore, the production technology at the top of the nest is either a CES or a Leontief function of the quantities of value-added and aggregate intermediate input use.

$$QA_a = \left[\alpha_{va,a} \cdot (QVA_a)^{\rho_{va,a}} + \sum_{c \in C} \delta_{ac} \cdot (QINT_{c,a})^{\rho_{va,a}} \right]^{\frac{1}{\rho_{va,a}}} \tag{B.3}$$

QA_a : Level of activity a

QVA_a: Quantity of aggregate value-added

$QINT_{c,a}$: Quantity of intermediate input ccc used in activity a

$\alpha_{va,a}$: Shift parameter for CES production function

δ_{ac} : Share parameter for intermediate input c

$\rho_{va,a}$: CES production function exponent

3. Export Supply Function QE_c

$$QE_c = \alpha_t \cdot \left(\frac{PE_c}{PX_c} \right)^{\rho_t} \tag{B.4}$$

QE_c : Quantity of exports of commodity c

PE_c : Export price of commodity c

α_t : Shift parameter for CET function

ρ_t : CET function exponent

PX_c : average output price

4. Institution Block

The institution block of equations consists of the domestic nongovernment and governmental institutions and the external or the rest of the world. Factor income, household consumption expenditures on home commodities and marketed commodities, intra-institutional transfers, investments, government income and expenditure. In general, these institutional blocks are households, enterprises, government, and the rest of the world. 1. **Household Consumption Demand** $QH_{c,h}$:

$$QH_{c,h} = \beta_{h,c} \cdot (Y_h - T_h) + \gamma_{h,c} \tag{B.5}$$

$QH_{c,h}$: Quantity of commodity ccc consumed by household h

$\beta_{h,c}$: Marginal share of consumption spending on commodity c

Y_h : Income of household h

T_h: Taxes paid by household h

$\gamma_{h,c}$: Subsistence consumption of commodity c

2. Government Revenue YG :

$$YG = \sum_{i \in INS} TINS_i \tag{B.6}$$

YG : Total government revenue

$TINS_i$: Direct taxes collected from institution I including transfers

5. System Constraint Block

1. **Market Equilibrium for Commodity** $COMEQUIL_c$:

$$QD_c + QX_c = QQ_c \tag{B.7}$$

$COMEQUIL_c$: Composite commodity market equilibrium for commodity c

QD_c : Quantity demanded of commodity c

QX_c : Quantity of domestic output of commodity c

QQ_c : Total quantity supplied to the domestic market 2. **Savings-Investment Balance** $SAVINVBAL$:

$$\sum_{i \in INS} S_i = \sum_{i \in c} QINV_c \tag{B.8}$$

$SAVINVBAL$: Savings-Investment balance

S_i : Savings by institution i

$QINV_c$: Quantity of investment demand for commodity c

3. Parameter and Variable Descriptions

- $\alpha_a(A)$: Shift parameter for top-level CES function for activity A
- $\alpha_{ac}(C)$: Shift parameter for domestic commodity aggregation function for commodity C
- $\delta_a(A)$: Share parameter for top-level CES function for activity A
- $\rho_{ac}(C)$: Exponent for domestic commodity aggregation function for commodity C
- PQ_c: Composite commodity price
- QVA_a: Quantity of aggregate value-added
- WF_f: Average price of factor f
- PX_c: Producer price of commodity c

4. Simulation scenarios of productivity shocks

TABLE B.1: Annual crop productivity shocks under RCP4.5

RCP4	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Maize	-0.18	-0.05	0.00	-0.02	-0.23	0.23	0.04	0.11	0.18	0.10	0.23	0.16	0.12	0.11	-0.20
Rice	-0.09	-0.04	0.04	0.01	-0.10	0.16	-0.05	0.08	0.13	0.12	0.10	0.05	0.07	0.05	-0.17
Pulse	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Oilseeds	-0.05	-0.02	0.02	0.00	-0.05	0.08	-0.02	0.04	0.06	0.06	0.05	0.02	0.04	0.03	-0.08
Fruits	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Root	0.07	-0.11	-0.24	0.02	0.04	0.01	-0.15	0.09	-0.04	0.04	-0.02	-0.06	-0.02	0.00	-0.07
Other cereals	-0.13	0.03	0.01	-0.11	-0.33	0.22	0.03	0.11	0.25	0.00	0.20	0.18	0.11	0.15	-0.14
Coffee	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Other crop	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Cotton	-0.29	0.14	0.08	0.77	1.79	-0.07	-0.47	0.54	0.14	0.01	0.01	-0.95	-0.72	0.38	-0.30
Sugar	0.02	-0.06	-0.23	-0.09	0.03	0.17	-0.14	-0.02	-0.03	-0.05	-0.10	-0.10	-0.03	-0.23	-0.20

Source: Based on (Waldhoff et al., 2020) projections

TABLE B.2: Annual crop productivity shocks under RCP8.5

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Maize	0.04	-0.20	0.17	0.19	-0.01	0.01	0.14	0.01	0.21	0.22	0.02	-0.02	0.14	0.11	-0.13
Rice	-0.03	-0.21	-0.01	0.06	-0.05	-0.04	0.06	-0.05	0.10	0.11	0.02	-0.06	0.01	0.09	-0.15
Pulse	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19	-2.19
Oilseed	-0.02	-0.11	0.00	0.03	-0.03	-0.02	0.03	-0.03	0.05	0.05	0.01	-0.03	0.01	0.04	-0.08
Fruit	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56
Root	0.07	0.10	0.15	0.01	0.04	-0.07	0.09	0.12	-0.12	-0.01	0.06	0.03	0.14	0.02	-0.02
Other cereals	0.17	-0.05	0.11	0.14	0.13	0.08	0.09	0.13	0.23	0.21	0.02	0.03	0.25	0.15	-0.08
Coffee	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61	-1.61
Other crop	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97	-1.97
Cotton	-0.57	-0.54	-0.14	-0.46	-0.89	-0.39	-0.19	0.59	-0.78	0.05	0.70	0.44	-0.27	-0.52	-0.50
Sugar	0.10	-0.15	-0.06	-0.10	-0.09	-0.14	0.01	-0.09	-0.08	-0.16	-0.03	-0.06	-0.04	-0.03	-0.16

Source: Based on (Waldhoff et al., 2020) projections

6. Simulation results

In this section, some results from the CGE model simulation are reported and accordingly mentioned in the different parts of the dissertation.

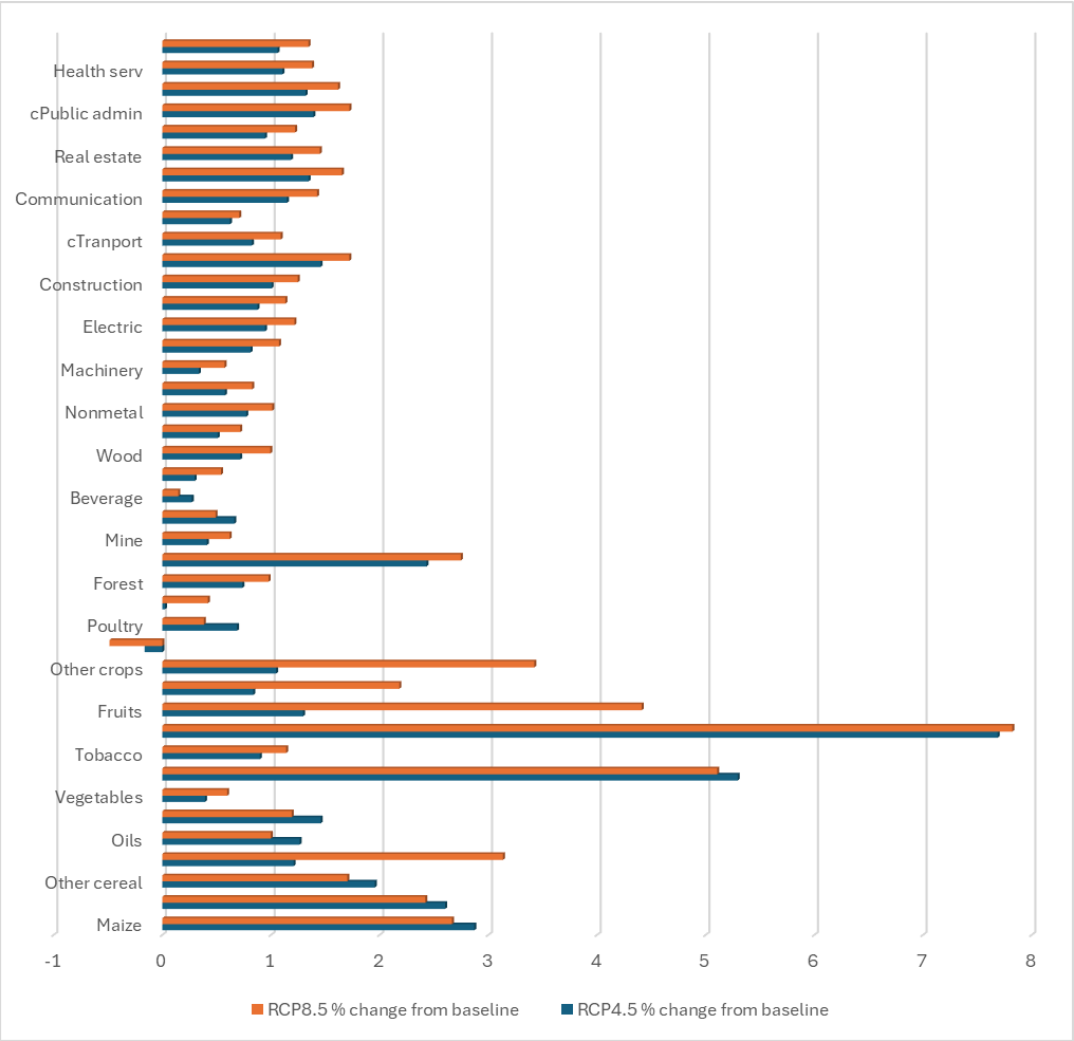

FIGURE B.1: Price effects of climate change

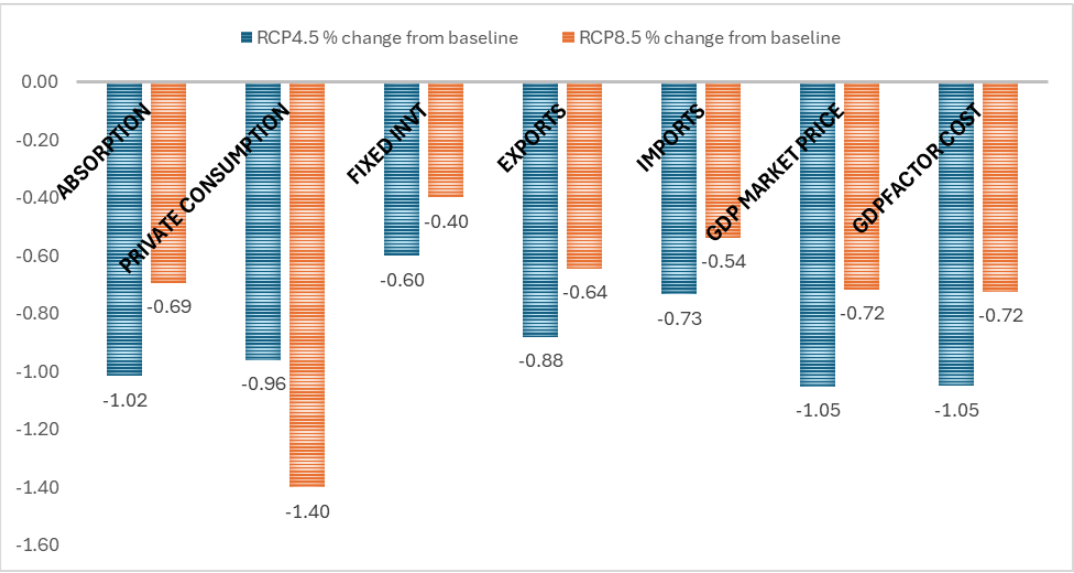

FIGURE B.2: Climate change impacts on Macroeconomic indicators

Appendix C

Appendix to chapter 5

1. Simulation results (not reported in the discussion sections) Although the results in the paper reported separately for climate change with and without AfCFTA implementation, this appendices section is presented in more detail and mixed for comparison. Each result is presented with a clear description of the scenarios for each simulation.

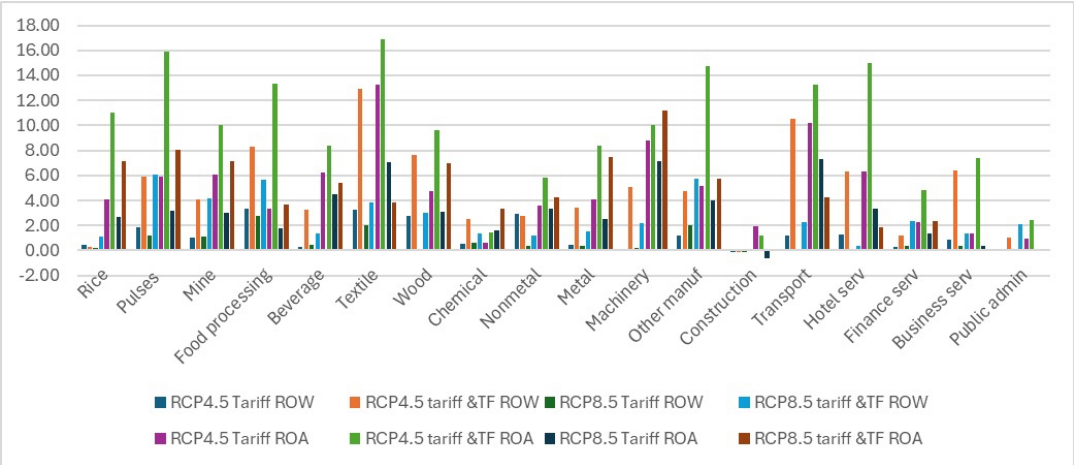

FIGURE C.1: Export impacts of the AfCFTA under climate change

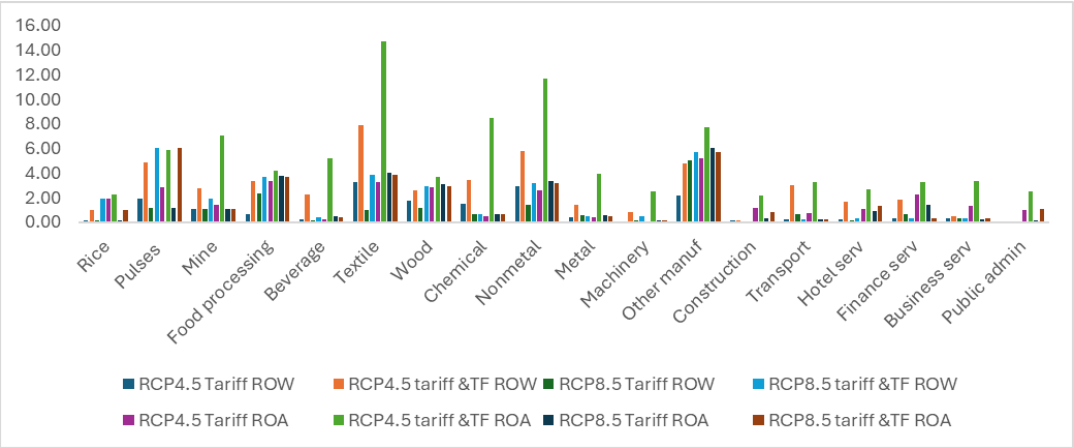

FIGURE C.2: Import impact of the AFCFTA under climate change

Ethiopia National Trade Policy Makers Survey

Mengistu Alamneh Wassie
s72mwass@uni-bonn.de (0923554912)
Doctoral student, University of Bonn, ZEF, Germany
In Collaboration with IFPRI

Good morning / afternoon. My name is MENGISTU ALAMBNEH WASSIE. I am conducting this survey for my doctoral study on "the perceptions and expectations of the AfCFTA". The information provided by you in this interview will contribute to understand the policy environment and changes for the implementation of the AfCFTA in Ethiopia. Thank You for your willingness to participate for this interview.

✓ In this questionnaire, only the trade of goods and not include service trade as trade in service has a different characteristic than trade in goods and deemed need a different approach/questions.

Date of interview: _____ / _____ / _____

Name of Surveyed institution: _____

Name of the office/department: _____

Position in the office: _____

Sector where s/he works: _____

i. Questions on the trade environment

1. **Do you think AfCFTA is good/has benefits for Ethiopia?**

   ☐ Yes

   ☐ No

2. **On a scale of 1 to 5, how would you rate the clarity and accessibility of Ethiopia's trade policies and regulations relative to other neighbouring countries in the agriculture sector (major exports such as coffee, vegetables, cash crops etc.?)**

   1. ☐
   2. ☐
   3. ☐
   4. ☐
   5. ☐

   ✓ Are there any specific trade facilitation policies that you believe have significantly improved trade processes?

3. **In your opinion, how efficient are the customs procedures at Ethiopian ports and border crossings as compared Kenya, South Africa, and Egypt? (Scale: Very Inefficient - Very Efficient)**

Export	**Import**
☐ Very Efficient	☐ Very Efficient
☐ Efficient	☐ Efficient
☐ Average	☐ Average
☐ Inefficient	☐ Inefficient
☐ Very Inefficient	☐ Very Inefficient

4. **In your opinion, how efficient is the digital technologies integration with the trade facilitation in Ethiopia (Scale: Very Inefficient - Very Efficient)**

Export	**Import**
☐ Very Efficient	☐ Very Efficient
☐ Efficient	☐ Efficient
☐ Average	☐ Average
☐ Inefficient	☐ Inefficient
☐ Very Inefficient	☐ Very Inefficient

5. **If yes, how have these technologies impacted the efficiency and transparency of trade operations? What are your opinions?**

6. **Do you think regional economic integration, such as the COMESA and now African Continental Free Trade Area (AfCFTA), have a significant impact on Ethiopia's trade?**

Export	**Import**
☐ Yes	☐ Yes
☐ No	☐ No

   If yes, how it (will) affected in your opinion?

7. **Do you think regional economic integrations, such as the COMESA and now African Continental Free Trade Area (AfCFTA), have a significant impact on Ethiopia's trade facilitation strategies?**

   ☐ Yes

   ☐ No

   If yes, How and in which areas?

8. **Did covid have an impact on the export/import of Ethiopia? If yes and was product specific, could you tell me which products were most affected?**

   ☐ Yes

   ☐ No

   which (export/import) one was highly affected? Could you tell me why those impacts if there was and which one were related to trade procedures (any measure related to pandemic control) and policy changes (tariff, quota or SPS)?

9. **Do you think Ethiopian trade (export) has (fully) recovered from the Covid-19 pandemic shock?**

   ☐ Yes

   ☐ No

   If yes, what changes have been made throughout the recovery?

10. **In your opinion, what are the top three trade facilitation priorities for enhancing Ethiopian trade in the next future/five years?**

Export (main exports such as coffee sesame, textile, ...)	**Import (food items, manufacturing inputs ...)**
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____

11. **Can you identify/order any infrastructure challenges (transport, logistics, communication) that currently hinder the most trade in the agriculture and manufacturing sector?**

Export	**Import**
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____

ii. Questions on the logistics performance of Ethiopia

12. **How would you rate the efficiency of customs and border management clearance in Ethiopia (export/import) over the past decade relative to neighbouring countries? (1 to 7)**

    1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐

13. **In scale of 1 to 7, how would you rate the quality of trade- and transport-related infrastructure in Ethiopia over the past decade relative to neighbouring countries?**

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐

14. **In scale of 1 to 7, how would you rate the ease of arranging competitively priced international shipments in Ethiopia over the past years relative to neighbouring countries?**

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐

15. **In scale of 1 to 7, how would you rate the competence and quality of logistics services in Ethiopia over the past years relative to neighbouring countries?**

Export **Import**

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐1. ☑ ☐2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐

16. **In scale of 1 to 7, how would you rate the ability to track and trace consignments in Ethiopia over the past years relative to neighbouring countries?**

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐

17. **In scale of 1 to 7, how would you rate the frequency with which shipments reach consignees within the scheduled or expected delivery time of Ethiopia relative to neighbouring countries?**

Export **Import**

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐1. ☑ ☐2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐

iii. Open questions

18. **What are the current prioritized trade policies and regulations in the agricultural and food related products in Ethiopia, and how have they evolved in recent years?**

19. **What are the major challenges or bottlenecks faced by businesses engaging in import and export activities in Ethiopia? The bottlenecks that traders complain the most.**

20. **Do you agree that Ethiopia collaborates with neighbouring countries such as COMESA and other African countries to enhance cross-border trade and improve trade routes? Could you give me some examples?**

21. **Are there any initiatives or programs in place to promote the adoption of digital technologies for paperless trade documentation and customs clearance? How effective have these been? Any threats?**

22. **What role did trade facilitation play in attracting foreign direct investment (FDI) to Ethiopia? Are there specific sectors that benefit the most from improved trade facilitation?**

23. **How does Ethiopia ensure compliance with international trade agreements like WTO while safeguarding its national interests? What reforms have been made to facilitate the WTO accession?**

24. **Are there any specific sectors or industries that have seen substantial growth due to improvements in trade facilitation? Can you provide examples?**

25. **What strategies are being pursued to enhance trade capacity-building for Ethiopian businesses, especially small and medium-sized enterprises (SMEs)?**