Industrial Policy, Productive Transformation, and Pro-poor Growth in the Democratic Republic of Congo

by

OTCHIA Christian Samen

DISSERTATION

Submitted in Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

in International Development

GRADUATE SCHOOL OF INTERNATIONAL DEVELOPMENT

NAGOYA UNIVERSITY

Approved by the Dissertation Committee:

Kiyoshi FUJIKAWA (Chairperson)

Shigeru OTSUBO

Naoko SHINKAI

Approved by the GSID Committee: March 5, 2015

DEDICATION

To the glory of the Almighty GOD

To the progress of Science and Knowledge

To the love of the Kongo

ACKNOWLEDGEMENTS

I cannot find words to express sufficiently my gratitude to my academic advisor Prof. Kiyoshi Fujikawa for his trust, encouragement, and friendliness. Without his guidance, this dissertation would not have been completed.

I consider it as an honor to have worked with Prof. Shigeru T. Otsubo, a fine policy maker. The discussions I had with him were invaluable. I am also indebted to Prof. Naoko Shinkai for the valuable comments and advice used to further improve this dissertation.

I would like to thank Prof. Grégoire Kankwanda Ebulelang and Prof. Daniel Mukoko Samba for providing me the data to run my analysis.

It gives me great pleasure to acknowledge the financial support of MONBUSHO. The administrative and secretarial staff members of the Graduate School of International Development, Nagoya University have provided me the support and equipment I needed to produce my thesis. I am very grateful to them for this generosity.

I have also been blessed in my work with a friendly and cheerful group of colleagues at the UNCTAD Virtual Institute, whose contribution to this research is essential. Thanks go especially to Vlasta Macku and Cristian Ugarte for numerous useful comments and suggestion. I am also deeply indebted to Marion Jansen, who has carefully and intelligently mentored me towards writing policy-oriented papers.

Lastly, I thank my family for their prayers and inspiration. I express my never ending love and respect to my brothers Patrick, Big Winner, and Francis for their encouragement and for pushing me forward. I also take this moment to thank my fiancée and my future mother-in-law for their love and care. Special thanks go to my parents for believing in me and for supporting me throughout my studies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

LIST OF ABBREVIATIONS

ACET	African Center for Economic Transformation
AIDS	Almost Ideal Demand System
AfDB	African Development Bank
BEAU	Bureau d'Etudes d'Aménagement et d'Urbanisme
CDF	Congo Democratic Franc
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
CIF	Cost Insurance and Freight
COMESA	Common Market for Eastern and Southern Africa
CPC	Central Product Classification
CPI	Composite Price Index
DFID	Department for International Development
DRC	Democratic Republic of Congo
ECM	Error Correction Model
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FGT	Foster-Greer-Thorbecke
GAMS	General Algebraic Modelling Software
GIC	Growth Incidence Curve
GTAP	Global Trade Analysis Project
IDE-JETRO	Institute of Developing Economies Japan External Trade Organization
IEA	Integrated Economic Accounts

IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
INS	National Institute of Statistics
ISIC	International Standard Industrial Classification
LA-AIDS	Linear Approximate Almost Ideal Demand System
LDCs	Least Developed Countries
LES	Linear Expenditure System
MDG	Millennium Development Goals
MPM	Multiplier Product Matrix
MSI	Matrix Synergetic Interaction
OECD	Organisation for Economic Co-operation and Development .
PPP	Purchasing Power Parity
SADC	Southern African Development Community
SAM	Social Accounting Matrix for Congo
SNA	System of National Accounts
SNV	Service National de Vulgarisation
SSA	Sub-Saharan Africa
SUT	Supply and Use Tables
TFP	Total Factor Productivity
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNIDO	United Nations Industrial Development Organization
UNU-WIDER	United Nations University - World Institute for Development Economics Research
US$	US Dollar

VECM	Vector Error Correction Model
WHO	World Health Organization
WTO	World Trade Organization

Chapter 1. Introduction

1.1. Introduction

Industrial policy is once again at the top of the policy agenda. To a significant extent, economists demonstrate a broad consensus that coordinated measures to promote and facilitate industrial upgrading and diversification are determinant to accelerate structural transformation, sustain growth, and create better jobs.[1] Despite the fact that the history of industrial policy, particularly in Africa and Latin America, is filled with failure and cautionary tales, the new consensus is empirically supported by the wide variation of the pattern and process of structural transformation among countries; that is, growth enhancing in countries which successfully implemented industrial policies and growth reducing in countries that neglected investment in agricultural, infrastructure, and skills. For instance, Salazar-Xirinachs et al. (2014) argued that East Asian countries used targeted measures to help them absorb know-how, technology, and knowledge from the rest of the world, to assimilate them at a tremendous pace and to diversify into new and more sophisticated products. The reason for this intense use of industrial policy is that product diversification and sophistication are found to be key policies to translate high growth to good quality of employment and poverty reduction (Hausmann et al. 2007; Hausmann and Klinger 2006; Felipe et al. 2012; Mishra et al. 2011).

According to Hausmann and Klinger (2006), countries that export goods associated with higher productivity levels grow more rapidly, even after controlling for initial income per head, human capital levels, and time-invariant country characteristics. Along the same line, countries that export the greatest number of categories of products and those which have more products at different prices within those categories tend to have higher levels of gross domestic product (GDP) (ESCAP 2011). Therefore, diversification toward higher value

[1] OECD countries renewed with industrial policies as a direct response to 2008 economic and financial crisis (OECD 2013).

products is crucial for developing countries to boost and sustain economic growth. To diversify, countries need to upgrade technology in their production and upskill their existing labor (ACET 2014).

It is, however, worth noting that industrial policies have been country specific, depending on the exiting capabilities and institutional capacities (Ferraz et al. 2014; Hausmann and Hidalgo 2011; Chang 2010; Crespi et al. 2014). Gabriele (2010), for example, pointed out that the role of the state in China, far from withering out, is massive, dominant, and crucial to China's industrial development. This role has been recently reflected by the position of China as the world's largest manufacturer. In China, the role of the state in economic development has taken the form of both creating the enabling environment and direct intervention, in terms of promoting structural change and thereby growth in productivity and employment (Lo and Wu 2014). Felipe et al. (2013) further claimed that the key factor underlying China's fast development during the last 50 years is its ability to master and accumulate new and more complex capabilities, which was induced in 1979.

Recently, Africa is increasingly renewing interest in well-coordinated and well-designed industrial policies, given the successful role that development states of East Asia demonstrated in designing and implementing policies.[2] However, the process of structural transformation remains particularly challenging for African countries. Africa's efforts to upgrade and diversify take place in an interdependent world economy where earlier industrializers have already accumulated both enabling capabilities and productive capacities that give their producers significant cost and productivity advantages and equip them to push out the technological frontier through research and innovation.

Due to the role of government in pursuing industrial policies in East Asia, it has been argued that industrial policy might not work in Africa because of deficiencies in governance.

[2] There is a growing body of literature on the relevance of the East Asian model to Sub-Sahara Africa. See, for example, ACET (2014).

In contrast, Greenwald and Stiglitz (2013) argued that effective industrial policies can be implemented in countries with significant deficiencies in governance. An important reason for this is that industrial policies have succeeded in some instances in which they were designed to correct market failures or even to correct other governments.

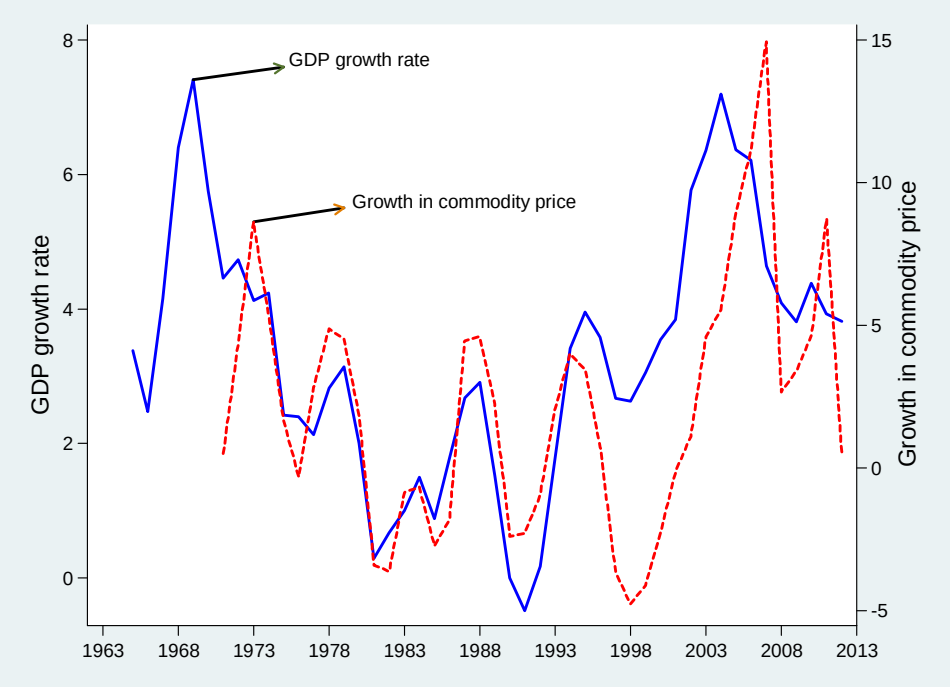
The extent to which well-coordinated industrial policies can be used to accelerate productive transformation in Africa, however, remains to be seen. Certainly, economists suggest that African countries should not mimic paths, models, and specific policies of Asian economies, given that the initial conditions differ and Asian economies followed highly unusual and distinctive paths of growth. Thus, the central question with regard to Africa's development remains how African countries can identify strategies to engineer structural transformation capable of sustaining and converting the recent high growth rate into better jobs and improvement of the standard of living. However, very few studies have investigated the impact of industrial upgrade and productive transformation in Africa, and especially in the Democratic Republic of Congo (DRC).

1.2. Policy context

After a period of relatively unstable and low economic performance, Sub-Saharan Africa (SSA), since 2000, entered a stage of high and sustained economic growth. The real GDP in SSA grew by 87 percent in 13 years (2000-2013). This growth performance is divided into two periods: the boom period (2000-2008) and the after-crisis period (2010-present). From 2000 through 2008, the real GDP of SSA rose by 5.5 percent a year, which is more than twice its pace in the 1980s and 1990s. In fact, SSA grew by an average of 2.2 percent in the 1980s and, in the 1990s, the growth rate was about 1.4 percent. The 2007-08 financial crisis had only temporary effects on African growth, which picked up again in 2010. Since then, such growth averages 4.2 percent annually.

Much of the GDP growth in SSA was driven by the boom in commodity prices and the demand for raw materials as these economies depend on the export of primary commodities.[3] Figure 1-1 illustrates the strong historical correlation between growth in the real GDP and commodity prices in SSA. However, as Deaton (1999) argued, rising prices help economic development in SSA because these economies do better when the prices of commodities are rising than when they are falling. A similar relation holds when one considers recent data. However, the resurgence of growth in SSA is more than a resource boom. According to AfDB et al. (2013), natural resources accounted for roughly 35 percent of Africa's GDP growth since 2000. Trade, construction, and most importantly domestic economic reforms implemented in early 2000 also contributed to African growth.

Figure 1-1: Economic and commodity price growth in SSA, 3-year moving averages



Source: Author's computation based on the World Development Indicators (WDI), The World Bank (2014).

[3] Diao and McMillan (2014) and McMillan and Headey (2014) provide a recent stylized fact regarding growth in Africa.

The difference in domestic reforms and ownership over development programmes explains the heterogeneous performance of SSA groups. Table 1-1 looks at the recent trend of GDP growth in Africa by classifying countries according to resource endowment and access to the sea.[4] As can be seen, resource-rich countries have higher per capita income but growth in resource-rich countries is generally lower than in resource-scarce countries.[5] Resource-rich countries grew at 3.72 percent between 2008 and 2012 while resource-scarce countries grew by 4.54 percent. One can observe also that these patterns do not change when I break down the country classifications into coastal and landlocked. Landlocked resource-rich countries grew at a lower rate than landlocked resource-scarce countries since 2008, while, at the same time, the growth rate in coastal resource-rich countries was weaker than in coastal resource-scarce countries. Table 1-1 further indicates that resource-rich countries have experienced more boom and bust over the period of analysis than resource-scarce countries have. In conclusion, these figures indicate that many African countries seem to remain in a natural resource trap in which resource-rich countries exhibit weaker long-run growth and an increasing rate of poverty than resource-scarce countries.[6]

Table 1-1: GDP growth in Africa, 1960-2012

	Mean GDP per capita					Growth rate of GDP				
	1960-1981	1982-1991	1992-2001	2002-2007	2008-2012	1960-1981	1982-1991	1992-2001	2002-2007	2008-2012
Landlocked Resource-Rich	622.53	1243.06	1675.25	2089.36	2496.63	4.32	6.12	3.20	6.37	3.35
Landlocked Resource-Scarce	422.27	441.90	490.14	528.39	591.78	4.26	2.96	2.83	3.84	4.98
Coastal Resource-Rich	1881.17	1784.72	1749.10	2634.96	2932.09	4.93	1.60	3.58	6.52	3.79
Coastal Resource-Scarce	952.54	1242.88	1449.33	1627.22	1910.68	4.05	2.52	4.07	3.70	4.29
Resource-Rich	1573.50	1687.42	1736.99	2548.81	2863.34	4.78	2.44	3.51	6.49	3.72
Resource-Scarce	720.40	889.51	1055.14	1187.69	1383.12	4.13	2.70	3.60	3.75	4.54

Source: Author's calculations based on WDI, The World Bank (2014).

[4] The classification of countries follows AfDB (2007).

[5] Another striking result is the larger GDP per capita gap between landlocked resource-rich and costal resource-rich and its evolution over time.

[6] See Collier (2007) and Hogan and Sturzenegger (2010) for discussion on the natural resource trap.

1.3. Statement of the problem

The transformation discussed in the previous section is also evident for DRC, as the country achieved unprecedented levels of economic growth since 2000. For the first time in its post-independence economic history, DRC was capable of growing by an average rate of 6 percent and maintained a positive GDP growth for more than 5 years.[7] The mining sector accounted for 32 percent of the Congolese GDP growth between 2001 and 2005. The contribution of mining to GDP growth fell to 12 percent during 2006-2010 due to the commodity price shock that occurred in 2007-08 (Herderschee et al. 2012). In 2009, exports of goods and nonfactor services declined by 30 percent. Imports declined by 40 percent as financing dried up. In early February 2009, gross foreign exchange reserves were almost completely exhausted. From a policy standpoint, this internal structural change indicates that DRC remains very fragile to the international environment and country-specific problems.

Sadly, this recent growth has been jobless, as it did not bring enough structural change capable of creating employment and reducing poverty (AfDB et al. 2013; UNECA 2013). According to the recent report by UNCTAD (2013a), countries with faster GDP growth achieved this with relatively less employment creation. In addition, employment elasticity declined to about half of the Least Developing Countries (LDCs) in the period 2000-2008, and that elasticity tended to fall more frequently in precisely those LDCs that were growing faster. The data reported points out that DRC had low employment elasticity to growth for 2004-2008 – estimated at 0.53 – compared to its neighboring countries such as Burundi (1.18), Chad (1.02), and Central Republic (0.69). In addition, the employment elasticity to growth in DRC is lower for the period 2004-2008 than for 2000-2004.[8] On the other hand, the labor force in the non-agricultural sector is estimated to have had grown by 34-66 percent between 2000 and 2010, and the ratio of youth employment-to-population decreased by 3 percent.

[7] This period is 2002-2012.

[8] In 2000-2004, the employment elasticity to growth was estimated at 0.71.

Consequently, Congolese economic growth reduced poverty slightly in urban areas but increased poverty significantly in rural areas. Urban poverty decreased by 6.9 points between 2005 and 2007, moving from 61.8 percent to 54.9 percent. At the same time, rural poverty increased from 75.8 percent to 82.4 percent. Instead of moving to a higher productivity sector, labor was reallocated to the agriculture sector, where productivity is low and has been decreasing since 1990. According to Herderschee et al. (2012), the agricultural sector has attracted 5 million workers in 5 years, growing from 10 million people in 2010 to 15 million in 2015. As can be seen, low employment and persistent poverty are associated with capital-intensive-led growth and lack of strategies to adequately convert rapid economic growth rates into better jobs, which can in return be associated with difficulties to improve living standards and reduce poverty.

1.4. Objectives of the study

This study, therefore, set out to investigate the potential of industrial policies to boost productivity growth and enhance the process of productive transformation necessary for pro-poor growth. The specific objectives of this study are as follows:

1. To explore the links between productive transformation, employment creation, and pro-poor growth.
2. To design a development strategy based on the economic structure and market prospects.
3. To examine policy options to promote growth and change in industrial structure necessary for development.
4. To identify special institutions that should be created to engineer the economic transformation.
5. To assess the degree of market integration and the role of sequencing reforms.

Industrial policies have been widely used in the literature and political debate, but to date, there is no consensus about its definition.[9] I use a broad definition of industrial policies as a set of government measures implemented in order to foster structural change in favor of a particular development path. Put differently, I define industrial policy as a (large) set of innovation and skill formation, trade, sectoral, and competition policies employed by governments to induce structural change and industrialization. According to this definition, industrial policy can encourage manufacturing, agriculture, or high productive service.[10]

It is necessary here to clarify exactly what is meant by productive transformation. Following the definition provided by Nübler (2014), productive transformation is used to refer to the process of structural change that leads to high-quality job creation through accumulation of capacity and capability, technology adoption, and skill upgrade. The process of productive transformation results in increased wages and reduced poverty. With regard to pro-poor growth, I use two definitions of the term "pro-poor" based on the absolute and relative concepts. I define growth as relative pro-poor if the proportional change in the incomes of the poor is no less than the growth rate in mean income. In absolute terms, growth will be pro-poor when the incomes of the poor grow by an absolute amount that is no less than zero.

1.5. Study hypotheses and research questions

Mining is the only industry which has attracted foreign investment in the economic development history of DRC. The most significant reason is that DRC has static comparative advantage and endowment in natural resources. However, in the actual context of globalization – that is, the food security, rising food price, prospective market in SSA and

[9] The lack of clarity in the concept of industrial policy is part of the controversy on industrial policy. See Di Maio (2014) and Di Maio (2009) for a concise and comprehensive discussion of the concept of industrial policy.

[10] A recent report by Crespi et al. (2014) uses the term productive development policies, instead of industrial policy, to emphasize that the policies go beyond industry and manufacturing, to include agriculture and service.

South-East Asia, among others – it is certain that the agro-food industry is the only sector in DRC which presents sizable markets for foreign and domestic investors to stay, produce, and conduct marketing. In addition, wider productive transformation can only be successful if a productivity based transformation of Congolese agriculture takes place. This research thus assumes that well-designed and implemented industrial policies, which build capabilities and capacities to transform agriculture and food manufacturing into high-value industries has higher potential to translate the current rapid rates of GDP growth into a more inclusive and sustained growth. The study therefore seeks answers to the following questions:

1. What are the structural features of DRC economy?
2. Why should DRC – a country with a strong comparative advantage in minerals – diversify away from mining?
3. What are the strengths of the linkages between different industries in DRC?
4. How can industrial structure guide the choice of development strategy?
5. What are the best or worse models for pro-poor agricultural modernization?
6. How do household characteristics affect pro-poor agricultural transformation?
7. To what extent does economic diversification into higher value of agro-food products promote industrial development?
8. What is the potential economy-wide and distributional impact of economic policies and institutional reforms that achieve efficiency gains in agro-food marketing and transportation?
9. What are the extent, pattern, and degree of food market integration in DRC?
10. How do reforms which lower trade and transportation costs benefit the poor?
11. What is the synergetic effect between diversification into higher value agro-food products and reforms that increases the market access of DRC agro-food products?

1.6. Methodological remarks

Getting industrial policy right requires a coherent package of macroeconomic, trade, investment, sectoral, labor, and financial policies capable of addressing the structural issues faced by developing countries (Salazar-Xirinachs et al. 2014). This research employs an integrated approach that combines quantitative methods and data drawn from either national surveys or databases maintained by national and public institutions. Quantitative methods are composed of computational methods and statistical analysis, including an input-output based model, computable general equilibrium models, a microsimulation model, linear regressions, regression with categorical predictor variables, and time series regression.

The quantitative data mainly come from two sources: the 2005 supply and uses tables and the *Enquête 123* provided by the Congolese National Institute of Statistics (INS). The *Enquête 123* is a mixed households-informal producer's survey on employment, informal sector, and consumption. This survey is carried out in three phases. The first phase collects information regarding employment and households' economic condition activities. The data collected through the first phase is used to identity household unincorporated enterprises (household whose production unit is not incorporated as a legal entity separate from the owner), which will serve as statistical units for the next stage. The goal of the second phase is to provide information on business conditions, economic performance, and production linkages of the household unincorporated enterprises. Finally, the third phase uses the typical household budget survey to collect information on household consumption.

In addition, I used several datasets for descriptive analysis, including FAOSTAT dataset, UN Comtrade, WDI, and Enterprise survey.

Table 1-2: Research design

Specific objectives	Research questions	Methodology	Data
Explore the links between productive transformation, employment creation, and pro-poor growth	1. What are the structural features of DRC economy?	Descriptive analysis	Various datasets
	2. Why should DRC - a country with a strong comparative advantage in minerals - diversify away from mining?	CGE-Microsimulation, pro-poor growth	DRC SAM (2005)
Design a development strategy based on the economic structure and market prospects	3. What are the strengths of the linkages between different industries in DRC?	Field of influence	DRC SAM (2005)
	4. How can industrial structure guide the choice of development strategy?	Field of influence	DRC SAM (2005)
Examine policy options to promote growth and change in industrial structure necessary for development .	5. What are the best or worse models for pro-poor agricultural modernization?	CGE-Microsimulation, pro-poor growth decomposition	DRC SAM (2005), Household Survey (2005)
	6. How do household characteristics affect pro-poor agricultural transformation?	Linear regression	Household Survey (2005)
Identify special institutions that should be created to engineer the economic transformation.	7. To what extend diversification into higher value of agro-food products promotes industrial development?	CGE-Micromulation augmented with diversification; pro-poor grwoth	DRC SAM (2005), Household Survey (2005)
	8. What are the potential economy-wide and distributional impact of economic policies and institutional reforms that achieve efficiency gains in agro-food marketing and transportation?		
Assess the degree of market integration and the role of sequencing reforms	9. What are the extent, pattern, and degree of food market integration in DRC?	Price transmission and cointegration	Various datasets
	10. How reforms that lower trade and transportation costs benefit the poor?	CGE-Microsimulation; pro-poor growth	DRC SAM (2005), Household Survey (2005)
	11. What are the synergetic effect between diversification into higher value agro-food products and reforms that increase market access of DRC agro-food products?	CGE-Microsimulation	DRC SAM (2005)

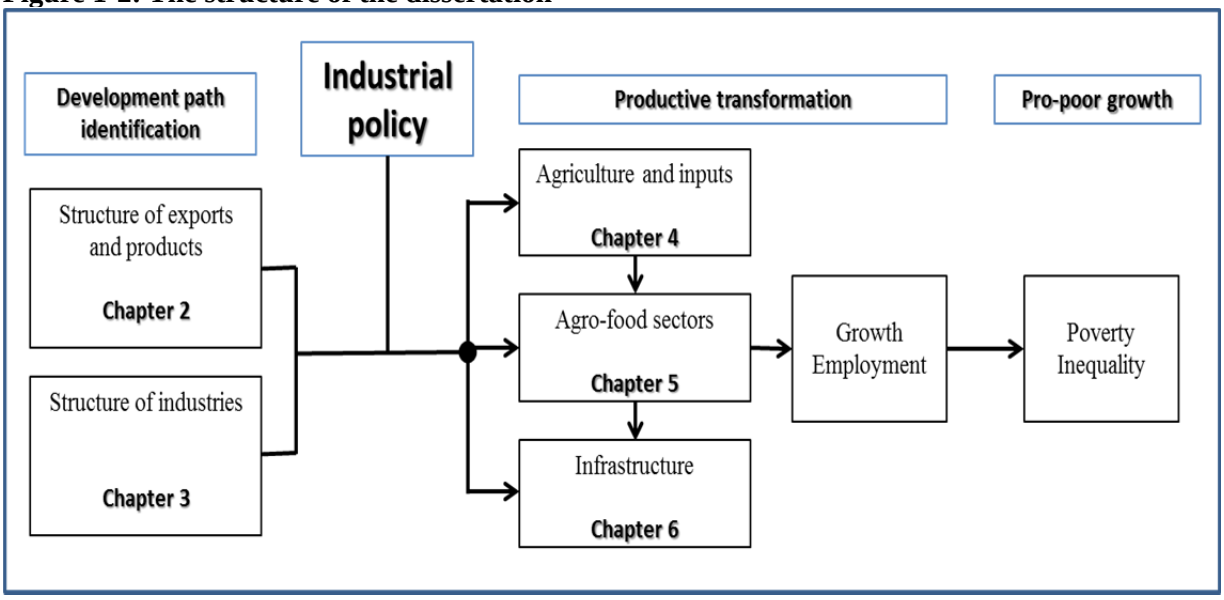
Source: Author's conception.

1.7. Structure of the dissertation

The aim of this dissertation is to provide evidence for the role of well-coordinated industrial policy in DRC. Second, the study provides information on structural change that may result and the extent to which the poor benefits from these policies. In order to make this study easy to follow among prospective readers, I elucidate the structure of the dissertation here and in Figure 1-2.

I organize the dissertation into two parts. The first part includes two chapters that conduct a growth identification analysis to identify development paths for DRC to achieve a productive transformation that creates employment and improves the living standard. The second part includes three chapters and positions the dissertation in relation to key policy lessons from emerging and fast-growing East-Asian economies, as reflected in the recent literature on structural transformation and economic development.

Figure 1-2: The structure of the dissertation



Source: Author's creation.

The overall structure of the dissertation takes the form of seven chapters, including this introductory chapter. Chapter 2 employs the recent literature on diversification to assess the extent to which the DRC economy is diversified and investigates why DRC, which has a strong comparative advantage in natural resource, should diversify away from mining. It also constructs a SAM and develops a CGE model to be used as the basic empirical tool throughout the dissertation. In Chapter 3, I apply the theory of the field of influence to investigate how the current industrial structure of DRC can guide the choice of a development strategy.

Chapter 4 reports the macroeconomic, sectoral, and distributional effects of policies aiming to modernize agriculture. I divide this chapter into six sections. Section 1 serves as an introduction and reviews the literature on the importance of technological change in agriculture and highlighted the role that the nature of technical change has on poverty. Section 2 presents an overview of the agricultural sector in DRC, focusing on production and productivity trends, trade, and consumption patterns as well as the use of fertilizers. Sections 3 and 4 present simultaneously the theoretical background and modeling framework based on which I conduct policy experiments in Section 5. The sixth section summarizes the study's findings, policy recommendations, and implications.

Chapter 5 follows a similar structure as Chapter 4. After Section 1 presents the study content, Section 2 discusses the key stylized facts on the agro-food industry in DRC, based on value addition, productivity, and comparative advantage. Section 3 proposes the policy framework, while Section 4 deals with the methodology of the analysis. Section 5 discusses the results of experiments, and I conclude in Section 6. With regard to Chapter 6, following the introductory section, Section 2 looks at the degree of market integration while Section 3 presents policies to improve market integration. The last section concludes.

The final chapter draws upon the entire thesis, connecting the research questions and empirical findings in order to give an overview of the results. Chapter 7, furthermore, discusses the limitation of the study and includes a discussion on the implication of the findings for better design and implementation of industrial policy in DRC. This chapter ends the dissertation with possible extension for future research.

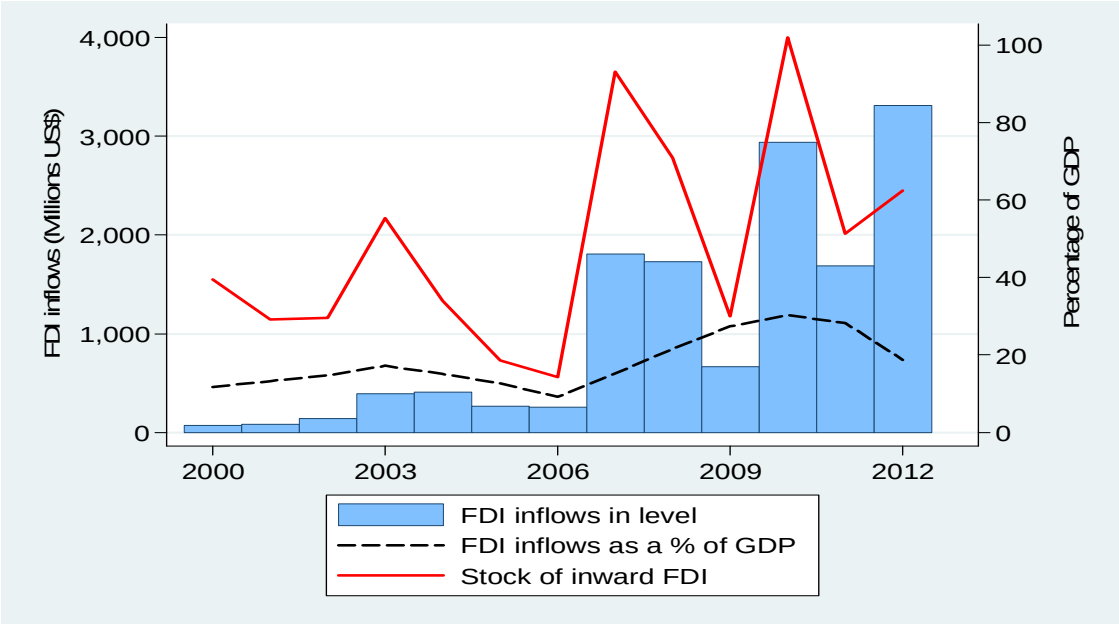
Chapter 2. Mining-based growth and productive transformation in DRC: What can an African lion learn from an Asian tiger?

2.1. Introduction

Two things make East Asian-style economic development important and relevant for Africa, especially for DRC. First, economy growth in Asia, especially in China, has increased the demand for natural resources and led to the expansion of mining capacity of DRC through Foreign Direct Investment (FDI). In 2008, China sealed a historical deal worth US$8.5 billion with DRC to exchange 10.6 million tons of copper and 600,000 tons of cobalt against 3,215 km of railroads, around 7,000 km of roads, 177 hospitals and health centers, two hydroelectric dams, two universities, 5,000 accommodation units, and mining-related infrastructures. This contract generated a lot of controversy in political and donor spheres, given that DRC has accumulated about US$12 billion of debt as of 2008. Another possible reason is the fear of repeating the pattern of economic disaster that DRC experienced between 1975 and 2000 due to the mismanagement of natural resource revenues and rent-seeking activities.

As a matter of fact, FDI inflows to resource-rich African countries has picked up in the last decade, with DRC experiencing a sharp rise since 2007. In 2012, DRC was among the five top listed countries in Africa for having received more than US$3 billion of inward FDI, just behind Nigeria, Mozambique, and South-Africa (UNCTAD 2013b). Inflows to DRC picked up in 2007 by more than 500 percent, amounting to an estimated US$1.8 billion, which was 18 percent of the GDP (Figure 2-1). FDI declined notably in 2009 – even if it was still higher than before 2007 – as a result of the financial crisis, but DRC saw a spectacular rebound of FDI in 2010. As a consequence, DRC stock of inwards FDI increased 3 times compared to its 2000 level.

Figure 2-1: FDI inflows in DRC



Source: Author's computation based on UNCTADSTATS, UNCTAD (2014).

In the literature on economic development, the relative importance of natural resources has been a subject of considerable debate. One of the most important reasons for this is that the development experience of natural resource-rich countries has been mixed (Sachs and Warner 1995b; Sachs and Warner 2001; Isham et al. 2005; Frankel 2010). However, it is a consensus that natural resources are assets for development that require intelligent public policies to complement natural riches with human ingenuity (Lederman and Maloney 2007).

Second, the experience from East Asia has validated the role of diversification into higher value-added products for sustaining economic growth.[11] Therefore, economic diversification has received plenty of attention in the policy discussion and empirical research in the last decades, especially with regard to African economies. The argument in support of this is that concentration of exports to few commodities exports has increased the volatility of export revenue, reducing the productivity and employment in these countries (Ghosh and Ostry 1994; Bleaney and Greenaway 2001). This implies that African countries

[11] Traditional models of economic development, such as structural models (Syrquin 1989; Chenery 1979) and endogenous growth models (Matsuyama 1992), show that diversification from primary products to manufactured exports is a condition for sustained growth.

need to diversify their export structure away from primary products to manufacturing or high productive service in order to build resilience to external shocks (Amin Guitierrez de Pineres and Ferrantino 2000) and sustain growth (McMillan and Harttgen 2014). A second argument in favor of economic diversification lies in the fact that diversification is needed to sustain growth and reduce poverty significantly. This argument is supported by the fact that export diversification toward manufacturing is linked to increased employment, exports, and GDP growth (Agosin 2007; Herzer and Nowak-Lehmann 2006; Lederman and Maloney 2007). Moreover, recent theories on structural change suggest that producing high value-added products is a condition for sustained growth (Hausmann and Rodrik 2003; Hausmann and Klinger 2006; Hausmann et al. 2006). This is because development has been associated with the movement of resource from lower productivity sectors to higher productivity sectors (McMillan et al. 2014; McMillan and Rodrik 2011).

For instance, East Asian countries have diversified their exports into labor-intensive, export-oriented manufacturing due to its large availability of cheap labor, before starting to climb the quality ladder. In recent years, these countries have focused on high-skill content goods such as electronics, automotive products, heavy equipment, and consumer durable goods. China, as the leader of manufacturing exports, has been moving away from labor-intensive goods, specializing on automobiles, industrial equipment, and heavy machinery. In this regard, recent findings have shown that there is a U-shaped relationship between export basket and economic development (Naudé and Rossouw 2011; Imbs and Wacziarg 2003; Hesse 2008). The implication of their finding is that exports diversification yield positive effects only at the early stages of development, until the turning points of about US$9,000 per capita, after which point countries must specialize.

Despite the increasing natural resource-related capital inflows in Africa and the substantial evidence of the role of manufacturing exports in achieving rapid convergence, however, very few studies have investigated the impact of natural resource boom on income

distribution in Africa, and there is still a general lack of research on the potential impact of manufacturing-led growth in natural resource-rich African countries. Therefore, this study makes a major contribution to research on the importance of diversification away from mining by demonstrating, using DRC as a study case, that growth fueled by mining generates the structural effects of Dutch Disease that constrain sustainable growth.

To achieve this, I review first the history of economic growth and investigate the level of export diversification of the DRC economy (Section 2.2). Then, I develop a CGE-microsimulation model to investigate the effects of mining-based growth and manufacturing-driven structural change (Section 2.3). The CGE model (the first step of the analysis) is linked to a microsimulation analysis at the household level (second step) in a top-down fashion. The CGE model generates changes in the prices of factors and goods after a policy change. These changes are then transmitted to the microsimulation model, which takes into account household heterogeneity in terms of factor endowments and consumption patterns. After that, I construct the SAM by which the CGE model is calibrated (Section 2.4). Then, I investigate first the economy-wide and distributional effects of mining-based growth and assess the transmission mechanism of the Dutch Disease in DRC. I also determine the extent to which DRC can efficiently diversify toward labor-intensive, exports-oriented manufacturing, which mimics Asia-style economic diversification (Section 2.5).

2.2. Export diversification in DRC

2.2.1. Growth story

RDC is a country endowed with exceptional natural resources and trade potential. Located in the center of Africa, DRC possesses 34 percent of the world's cobalt reserves, 10 percent of the world's copper reserves, and 64 percent of the world's coltan reserves as well as diamonds, gold, cassiterite (tin ore), timber, coffee, and oil. It enjoys diverse soils and weather patterns

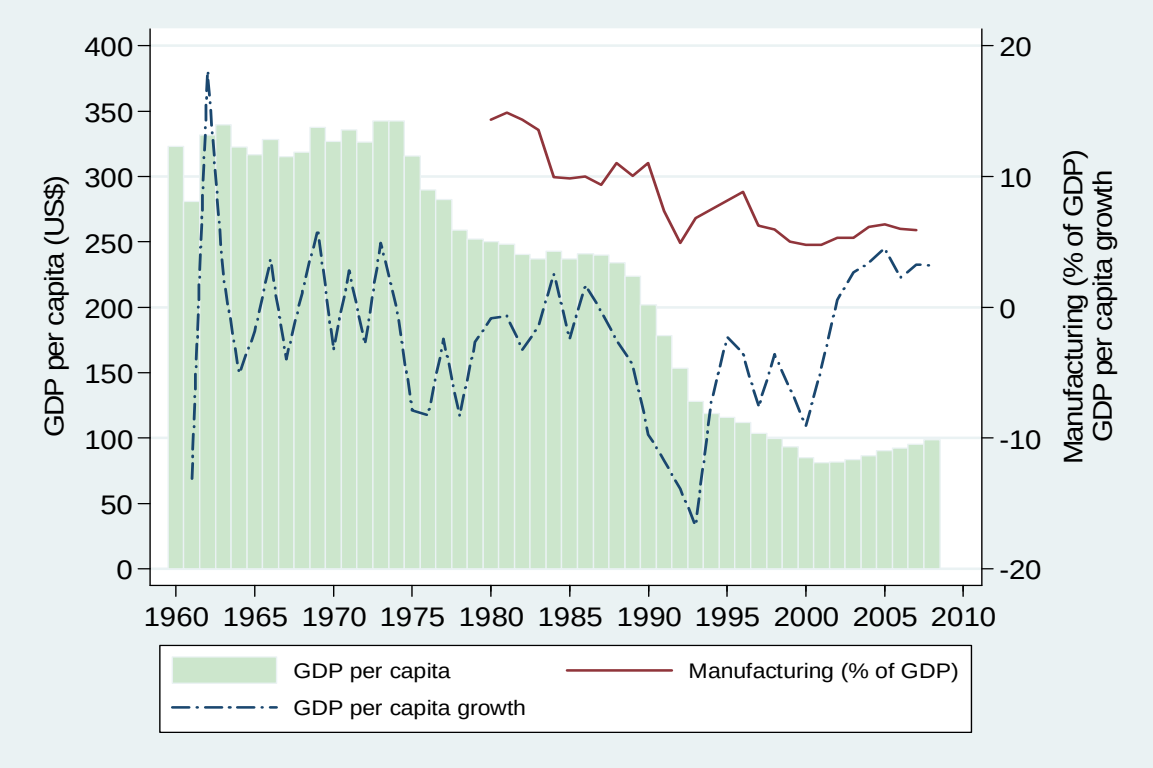
and high quality of pasture land. Nearly 75 percent of the country is covered by the Congo basin, which provides 12.5 percent of the world's rainforest and represents the second largest block of rainforest in the world. DRC's rainforests provide 8 percent of the world's carbon and offer exceptional biodiversity, with more than 600 tree and 10,000 animal species. The Congo River that flows through the forest is the second largest river in the world. Furthermore, DRC has a huge population and country land. It is the second largest and the fourth most populous country in Africa, and borders nine countries.

Despite its abundance of natural resources, DRC ranks as the poorest country in the world, with a GDP per capita at purchasing power parity (PPP) estimated at US$415. The poverty rate is very high, reaching 70 percent of the population. The income and wage inequality Gini coefficients are estimated at 0.46 and 0.65, respectively. In terms of employment, 3.7 percent of total labor force is jobless, and individuals aged 25 to 49 represent 71 percent of unemployment. Despite these unemployment levels, it is worth mentioning that only 13.5 percent of the active population has a stable job, whereas 72.7 percent are underemployed low-cost workers.

DRC economy is chiefly based on the extraction of resources with very limited value addition and domestic linkages. Much of the DRC's growth mainly depends on the prices of copper, cobalt, gold, diamonds, and petroleum. Between 2001 and 2005, the mining sector accounted for 32 percent of GDP growth and for 12 percent between 2006 and 2010. Past development experience has also shown that the extractive mining sector has limits in spurring growth and improving welfare. Specifically, the economic growth records show that the country experienced an economic disaster some years after its independence from Belgium in 1960. The GDP per capita collapsed from US$350 to US$82 between 1973 and 2001 (Figure 2-2). Consequently, deindustrialization occurred in DRC where the manufacturing share fell from 15 percent in 1980 to 5 percent in 2001. This economic

collapse and deindustrialization were a result of the poor domestic industrial policy implemented in early 1970 and inappropriate policy response to external shocks.[12]

Figure 2-2: DRC growth story



Source: Author's computations based on WDI, The World Bank (2014).

As a summary of the major policies starting in 1966, DRC policymakers nationalized all mineral resources and created state-owned enterprises with monopoly rights over mining concessions. In 1970, political leaders designed the "Objectif 80", a 10-year plan of industrialization through excessive external loans. This strategy aimed at doubling copper production, constructing steel mills and deep water ports, and building dams to electrify the entire country. As can be seen, this strategy was too ambitious and inappropriate, as the United States was leading the steel mill industry. In addition to the design, the Objectif 80 was poorly implemented. Next was the Zaïrianization (1973-74), a policy of expropriation of

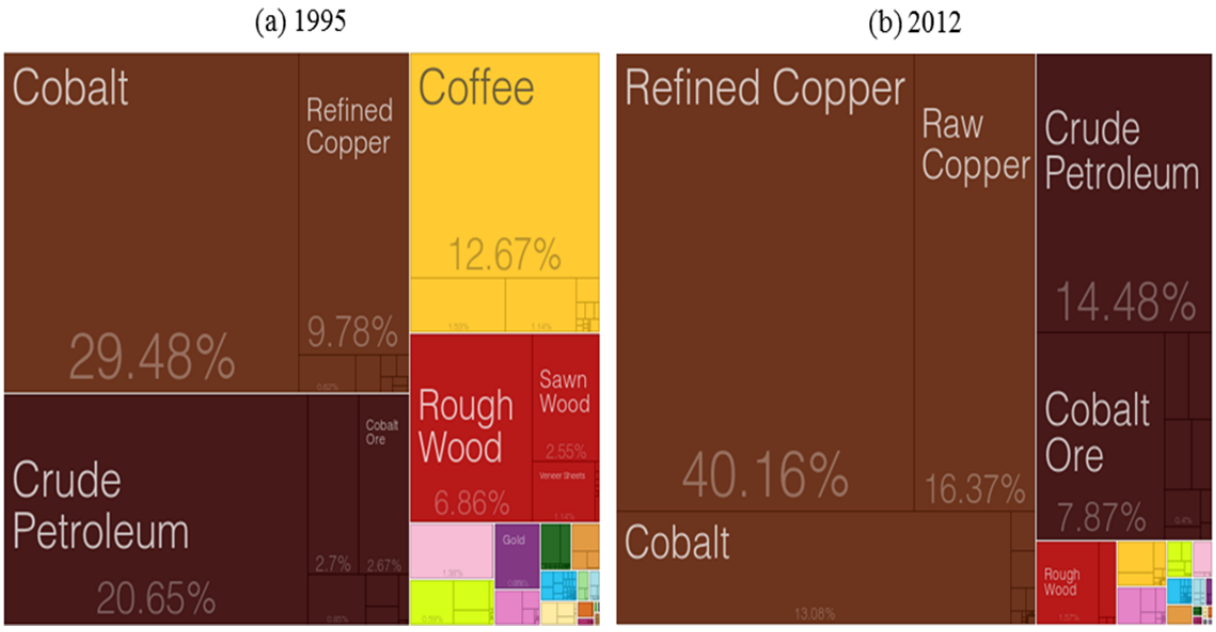
[12] External shocks refers to the oil shock (1973) and the collapse of the price of copper by 40% in 1975 and by 45% in 1981.

production units belonging to foreigners by the state, which then handed them over to the nationals. This policy led to the collapse of large-scale commercial agriculture, favored subsistence agriculture, and distorted economic incentives against agriculture. Finally, the economic disaster was reinforced by external factors such as the 1973 oil shock and the spectacular fall of copper price. Indeed, copper price fell by 40 percent in 1975 and by 45 percent in 1981.

2.2.2. RDC export growth

Figure 2-3 presents the data of DRC major export products in 1995 and 2012. DRC is a primary commodity exporting country due to its natural endowment and static comparative advantage. Major export products include copper, crude petroleum, and cobalt, which represented about 92 percent of total exports in 2012. Other export products include wood, rubber, and palm oil, among others. It is important to mention that DRC exports are very volatile, because they have been driven by international demand and price.

Figure 2-3: DRC export composition



Source: Hausmann et al. (2014) ; author's computation.

Table 2-1 provides information on the export growth rate for the DRC and its neighboring countries in various time periods from 1961-2010. Looking at the coefficient of variation, one can see that the DRC has the most volatile economic growth in the sub-region. The coefficient of variation of DRC exports is about 589 percent, while that of South Africa reached only 105 percent. It can also be seen from Table 2-1 that the sub-region experienced a mixed export performance over time. Although these economies share in common the dependency on commodities exports, their export baskets are quite different. Thus, three patterns can be identified from this diverse experience. Countries like Congo Republic and Gabon experienced a consecutive decrease of their export growth rate, attaining a negative value for some periods. Second, countries like Uganda have shown a positive trend of export growth since 1981-1990. The last group represents countries where structural breaks in exports occurred. In DRC, for example, the structural break in exports occurred between 1981 and 1990 and was due to the collapse of the price of copper as well as the collapse of the mine of Kamoto. The price of copper, which fell by 40 percent in 1975 and 45 percent in 1981, damaged Zambian exports earlier than DRC, because Zambia relied on copper at 80 percent of total exports while for DRC, copper accounted for 46 percent of total exports.

However, unlike DRC, Zambian exports recovered during 1991-2000 after implementing several economic reforms that especially aimed to increase the share of nontraditional exports in total exports. Zambian exports grew by 5 percent in 1991-2000 and 15.1 percent in 2001-2010. This is correlated to the change in the share of nontraditional to total exports, which increased from 8 percent in 1990 to 38 percent in 2003. A structural break occurred in Rwanda exports after 1980. In fact, coffee was the main export product for Rwanda, but the country gradually started to diversify its export mix toward mineral products in the mid-1990s. In this regard, Zambia and Rwanda have realized impressive export growth records in 2001-2010, which are also favored by high commodity prices. Between 2001 and 2010, four countries experienced two-digit export growth. Burundi's export growth was the

highest in the sub-region, attaining 21.56 percent, while DRC's exports grew by 2.48 percent. Note that the DRC export growth for the same period was lower than the Sub-Saharan average. In addition, it has performed badly in the period 1961-2010.

Table 2-1: Exports of goods and services, DRC and selected countries, 1961-2010 (annual growth rate)

	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	Mean	Sdt.dev	Coef.var. (%)
Angola	na	na	na	na	7.41			
Burundi	na	na	na	na	21.56			
Central African Republic	na	na	na	na	-3.91			
Congo Republic	19.88	6.40	6.36	4.15	2.75	7.91	13.33	168.59
DRC	2.63	3.74	8.48	0.84	2.48	3.64	21.46	589.96
Gabon	13.47	9.30	4.88	1.18	-1.11	5.54	12.98	234.18
Rwanda	6.56	13.18	2.81	0.78	13.75	7.42	26.81	361.56
Uganda	na	na	1.96	11.22	21.36	12.23	19.60	160.30
Zambia	2.74	-0.01	-3.39	5.11	15.06	3.87	13.16	339.79
Sub-Saharan Africa	na	na	2.95	4.24	3.38	3.55	3.72	104.91
Mean	9.06	6.52	3.44	3.93	8.27			
Std.dev	7.48	5.06	3.77	3.69	8.40			
Coef.var. (%)	82.61	77.58	109.85	93.84	101.55			

Source: Author's calculations based on WDI, The World Bank (2014).

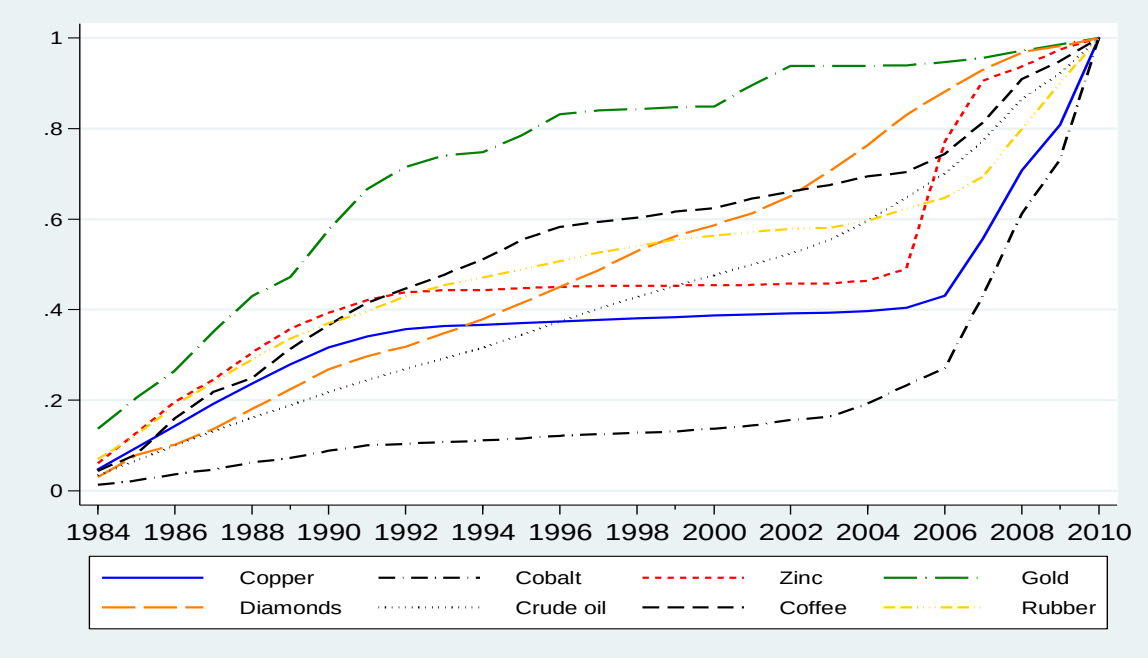
2.2.3. Cumulative export experience function and the industry-specific traditionality index

Economic diversification refers also to a process of creating new products as the economy grows. Countries which produce diverse types of products have a tendency for faster growth. The process of diversification consists of innovation of new products or differentiating products. In this study, I employ a cumulative export experience function to illustrate the traditionality of the DRC's main exports. This analysis provides a visual representation of the movement from traditional to nontraditional exports for the main DRC products. The cumulative export experience function is given by:

$$c_{it} = \frac{\sum_{t_0}^{t} E_{it}}{\sum_{t_0}^{t_1} E_{it}} \qquad (2\text{-}1)$$

where t_0 and t_1 represent the initial and terminal periods of the sample, and E_{it} represents exports by DRC industry *i* in year *t*, expressed in constant US$. The variable c_{it} takes a value at or near 0 at the beginning of the sample period and rises to 1 in the final year. The cumulative export experience function identifies three types of exports, namely traditional, nontraditional, and "constant" exports. Traditional exports are products whose exports took place in large proportion earlier in the period. Their export experience functions are shifted to the left. Nontraditional exports are products whose exports are concentrated in the last period of the sample. This implies that their export experience functions are shifted to the right. Finally, "constant" exports are products whose export experience functions are linear. Their exports are constant over the period of the sample.

Figure 2-4: Cumulative export experience function for DRC's main industries, 1984-2010



Source: Author's calculations based on Banque Centrale du Congo (Various years).

Figure 2-4 portrays the cumulative export experience function for DRC's main industries between 1984 and 2010. Gold is a more traditional export than zinc, rubber, coffee, and copper. Diamond has a linear shape, showing that the real export of diamonds was roughly

constant between 1984 and 2010. Cobalt, copper, rubber, and crude oil are considered nontraditional exports. Among them, cobalt has experimented the biggest export increase in recent years. Despite the fact that the export experience function of copper is shifted to the right early in the period and to the left in the latter part, it should be noted that copper is classified as nontraditional, since it is shifted more to the left. Copper was traditional but has dramatically accelerated its exports.

In order to rank DRC's principal exports in terms of their temporal sequencing, I construct a traditionality index (T_i) as the mean of the cumulative export experience index for each industry as:

$$T_i = \frac{\sum_{t_0}^{t_1} c_{it}}{(t_1 - t_0 + 1)} \tag{2-2}$$

The traditionality index categorizes industries as accelerating export performance or non-accelerating export performance. In this way, an industry is categorized as accelerating export performance when the traditionality index has a higher value. Moreover, the traditionality index and its variance can be used to test the null hypothesis that two industries have identical cumulative export function against the claim that one of the industries has been more "traditional" in several years (Amin Guitierrez de Pineres and Ferrantino 1997).

As Table 2-2 shows, the null hypothesis that all exports followed the same temporal sequencing can be rejected. Consistent with Figure 2-4, gold is the most traditional export, while cobalt yields the most accelerating export performance. Using the average of the traditionality index, 0.46, as a threshold value to separate traditional and nontraditional exports, it appears that crude oil, copper, and cobalt are nontraditional exports in DRC. Crude oil is less traditional than copper, which in turn is less traditional than cobalt. Thus, the DRC accelerated the export performance of some nontraditional exports. Although no mistake should be made between traditional export referred to as primary goods and nontraditional as

manufacturing goods, one should note that Congolese nontraditional exports belong to primary goods, and some of them have been exported before but in smaller proportions.

Table 2-2: Temporal sequencing of DRC real export, 1984-2010

Rank	Principal exports	Traditionality index	Variance of traditionality index	Cumulative exports 2010, US$ (millions)
1	Cobalt	0.2020	0.0280	14194
2	Copper	0.3884	0.0243	16270
3	Crude oil	0.4288	0.0553	8446
4	Rubber	0.4643	0.0356	161
5	Zinc	0.4834	0.0455	817
6	Diamonds	0.5080	0.0779	17325
7	Coffee	0.5426	0.0534	925
8	Gold	0.7338	0.0616	429

Source: Author's calculations based on Banque Centrale du Congo (Various years).

2.2.4. Export concentration

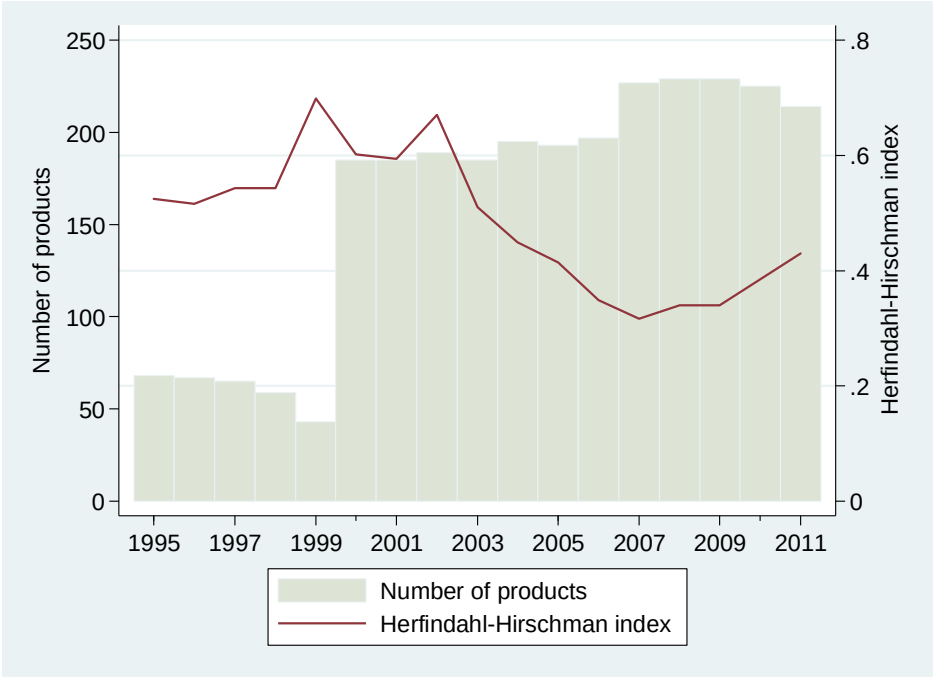
Figure 2-5 gives the level of export diversification in DRC and selected countries using the Herfindahl-Hirschman index. The Herfindahl-Hirschman index, normalized to range between zero and one, shows whether a country relies on few exports or on a more diversified export mix. It is given by

$$HHI_j = \frac{\sqrt{\sum_{i=1}^{n}\left(\frac{E_i}{X}\right)^2} - \sqrt{1/n}}{1 - \sqrt{1/n}} \tag{2-3}$$

where E_i is the exports value of products i, X the total export, and n is the number of products at the 3-digit SITC level. A value of 0 indicates maximum diversification, and 1 means that all exports are concentrated in one product. Figure 2-5 shows that DRC went through a process of increasing exports concentration until 1999. The process of export concentration was spectacularly reversed in 2000-2005, as a result of trade liberalization and economic reforms. However, it resumed in 2007 due to the commodity price increase. The

concentration index improved from 0.31 in 2007 to 0.43 in 2011 as a result of increasing capital inflows from China. Nevertheless, the level of DRC export concentration in 2011 remains at 0.09 point lower than that of 1995, indicating that DRC exports have been quite diversified in recent years.

Figure 2-5: DRC Export concentration index, 1995-2011



Source: Author's computation based on UNCTADSTATS, UNCTAD (2014).

In terms of the relative export concentration, based on the share of top exports in the total bundle, Table 2-3 indicates that DRC's exports are increasingly more concentrated in an handful of products, while other benchmarking countries show a decreasing concentration of exports in a narrow range of products. In the 2000s, 90 percent of DRC exports were concentrated in only five products, while the ten largest exported products accounted for 96 percent in the DRC export portfolio.

Table 2-3: DRC relative export concentration (share of total exports)

	Five largest products exported				Ten largest products exported				Twenty largest products exported			
	1970s	1980s	1990s	2000s	1970s	1980s	1990s	2000s	1970s	1980s	1990s	2000s
DRC	0.87	0.85	0.89	0.90	0.94	0.93	0.95	0.96	0.98	0.98	0.98	0.99
Kenya	0.71	0.72	0.59	0.53	0.80	0.82	0.70	0.63	0.88	0.91	0.80	0.74
Malaysia	0.67	0.56	0.34	0.37	0.83	0.72	0.47	0.50	0.88	0.80	0.62	0.64
Mauritius	0.69	0.74	0.67	0.61	0.79	0.83	0.80	0.78	0.89	0.92	0.89	0.87
South Africa	0.42	0.42	0.40	0.36	0.60	0.54	0.49	0.48	0.73	0.66	0.59	0.57

Source: Author's computation based on UNCTADSTATS, UNCTAD (2014).

2.2.5. Structural dynamics of DRC exports

In this section, I analyze the structural change in DRC exports using two types of indexes. These indexes measure the short-run and medium-run structural change in DRC's exports composition. On one hand, I use TRAD5 index as a measure of the medium-run structural change. This index is computed as the variance of the traditionality index calculated across industries using five-year intervals. Figure 2-6 displays TRAD5 value for 1986-2008; the value of 1986, for instance, is calculated using the period of 1984-1988 as a reference period. Higher values of TRAD5 indicate an episode of structural change, meaning that industries experienced relatively divergent patterns of export growth during the period in question. Conversely, a low variance implies that the composition of exports was relatively stable over the 5-year period. On the other hand, I use CSX index as a measure of short-run structural change to capture the change in export composition taking place in a single year. This index is computed as

$$\text{CSX} = \sum_{i=1}^{12} min\left(s_i, s_{i,t-1}\right) \tag{2-4}$$

where $s_i = e_{it} / \sum_{i\in(1,12)} e_{it}$ is the share of industry i's exports in national exports in year t. The CSX index takes values ranging from 0 to 1. A value of 0 implies that the country exports

a portfolio of goods, none of which were exported in the previous year, whereas a value of 1 indicates that there is no change in export composition.

Figure 2-6: Structural Change in DRC Exports, 1984-2010

Source: Author's calculations based on Banque Centrale du Congo (Various years).

Figure 2-6 indicates that the years from 1991 to 1994 are associated with abrupt structural change, primarily due to the low price of key exports and internal forces. A second period of structural change occurs in 2002-2008. This is due to the economic reform implemented since the country has been politically stable as well as the increasing demand of mining. Similarly, the CSX index on the right side of Figure 2-6 depicts that, although the composition of DRC export has been relatively stable, the period of 2005-2006 exhibits significant change in the DRC export portfolio.

2.2.6. Diversification of markets of DRC export

Table 2-4 presents the top 15 export destinations for DRC between 1995 and 2010. First, the table shows the increasing importance of emerging economies as new destinations for DRC exports. Exports to Brazil and Saudi Arabia have been accelerated in 2006-2010, while DRC

exports to China have increased consequently since 2001. For example, Brazil and Saudi Arabia accounted for only 0.05 percent of DRC exports in 2001-2005, while in 2006-2010, these countries represented 5.02 percent of DRC exports. Meanwhile, DRC traditional partners such as the United States have dramatically lost their market share. DRC exports to the United States accounted for 42.34 percent in 1995-2000 and 10.11 percent in 2006-2010.

Table 2-4: RDC's Export Destinations, 1995-2010

Partner Country	1995-2000		2001-2005		2006-2010	
	% of total exports	Rank	% of total exports	Rank	% of total exports	Rank
Brazil	0.25	13	0.05	13	2.26	4
Canada	2.58	8	0.04	14	0.02	15
China	0.30	12	11.97	3	45.72	1
France	4.04	5	21.17	2	2.07	5
Germany	5.63	4	2.07	7	0.69	9
India	3.46	7	0.62	10	2.05	6
Italy	8.90	3	2.99	5	1.24	7
Japan	9.09	2	2.41	6	0.26	11
Portugal	3.97	6	3.03	4	0.98	8
Russia	0.09	14	0.14	12	0.13	13
Saudi Arabia	0.01	15	0.00	15	2.76	3
Spain	2.11	9	1.23	9	0.17	12
Switzerland	0.46	11	0.17	11	0.02	14
United Kingdom	2.01	10	1.80	8	0.52	10
United States	42.34	1	32.85	1	10.11	2
	85.22		**80.54**		**69.02**	

Source: Author's calculations based on data from UNCTADSTATS, UNCTAD (2014).

Second, China has overtaken the United States and the European Union to become the main destination of DRC exports. In the beginning of the period of analysis, China ranked 12th as an export destination, followed by Brazil, Russia, and Saudi Arabia; meanwhile, the US and Japan were the top 2 DRC trading partners. In 2001-2005, China was ranked as the 3rd destination of DRC exports, right after the United States and France. The period between 2006 and 2010 shows a different picture. In this period, Japan is ranked 11th, preceding Spain, Russia, Switzerland, and Russia. On the other hand, Saudi Arabia and Brazil alongside China emerge in the top 5 destinations for DRC exports.

2.3. Modeling framework

The empirical analysis combines a CGE model and a microsimulation model to study the impact of macroeconomic policies at the household level. Both models are integrated by the top-down approach, which consists of simulating policy change in a CGE model, and then transmitting those changes into a microsimulation model that models household behavior. Section 2.3.1 describes the CGE models in detail, while Section 2.3.2 presents the microsimulation model used for the analysis.

2.3.1. CGE model

To assess the economy-wide and distributional and poverty effects of mining based growth in the DRC, I developed a CGE-microsimulation framework. I used a top-down approach to combine the CGE model (top module of the framework) and the microsimulation model (bottom module). The top module models all the interactions registered in the DRC's SAM and delivers changes in factor and goods prices. Using those changes in prices, the bottom module takes into account household heterogeneity in terms of factor endowments and consumption patterns to simulate the welfare distribution across households. The general specification of the Congolese CGE model follows the basic structure of the single-country model as described by Dervis et al. (1982). However, I closely follow Arndt et al. (2000) and Löfgren et al. (2002) for the specification of the structural and empirical features of the Congolese economy. Among the main features, the model considers trade and transportation costs for marketed commodities separately, and allows for home-produced consumption. The following provides a brief description of the main characteristics of the CGE model, including its general structure, the specification of transaction costs and home consumption, and the core features of the microsimulation model.[13]

[13] The equations of the CGE model can be found in the Annex.

There are 19 sectors in the Congolese CGE model, each of which produces a distinct commodity. Figure 2-7 presents the structure of production and allocation. It is assumed that all producers operate under constant returns to scale and a perfectly competitive market. Sectoral production is modelled as a Leontief function of intermediate inputs and value added. This assumption introduces some rigidity in the model as it implies zero substitutability between value added and intermediate inputs. Intermediate input is represented by a Leontief function of disaggregated intermediate inputs. To generate value added, producers combine labor and capital. This combination is specified by a constant elasticity of substitution (CES) aggregate function. Capital, which includes all types of assets (such as land and machinery) used in production activities, is assumed to be sector-specific.[14] The labor market is decomposed into high-skilled, semi-skilled, and low-skilled categories.[15] In addition, each of these labor categories is segmented into urban and rural areas.

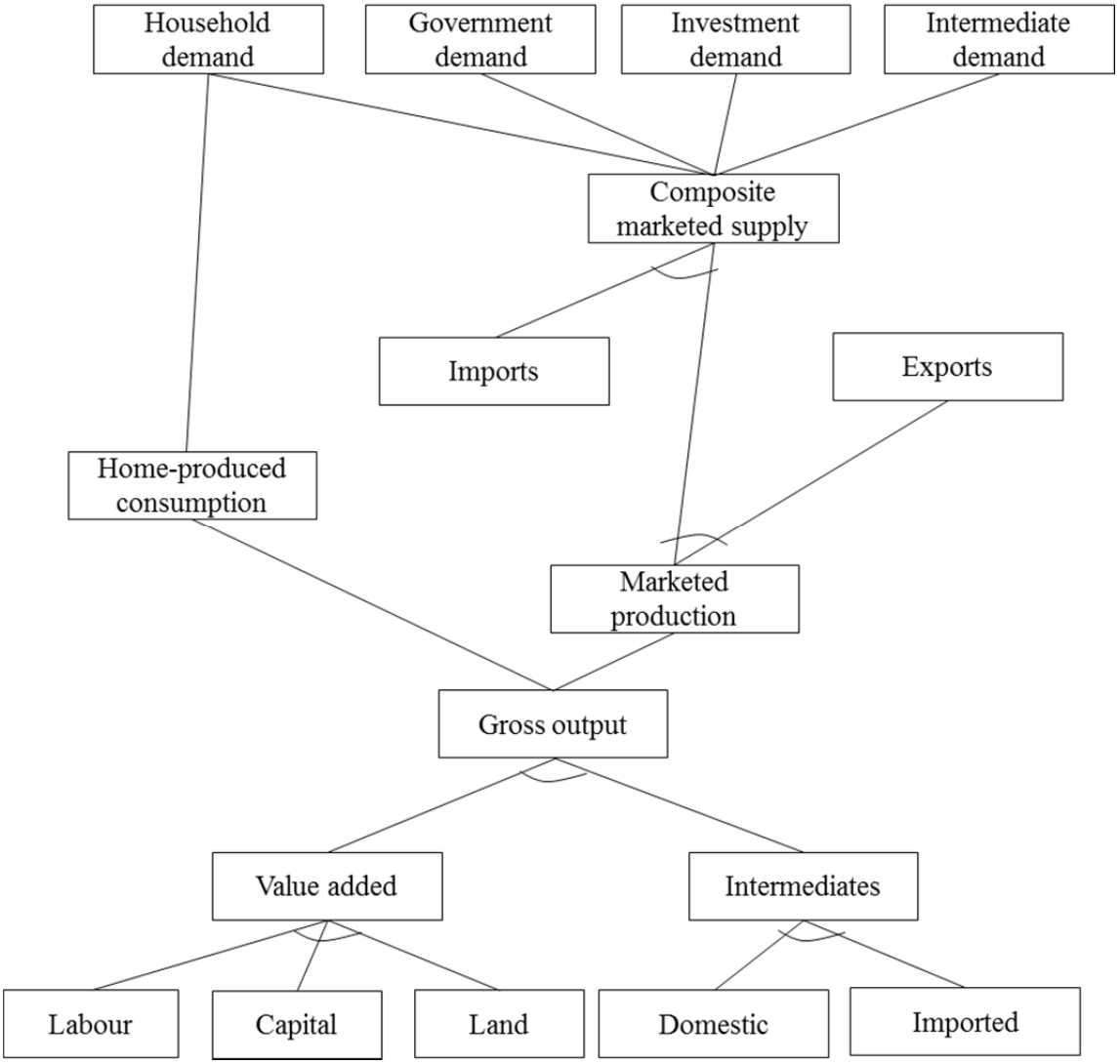
Equation 2-5 defines the composite value added. In this equation, QF denotes the factor (labour, capital, and land) demand quantity, while δ_{fa}^{p} is the CES value-added function share parameter, fpr_{fa} the productivity of factor, and ρ the substitution parameter. α_a^p is the efficiency parameter, which is also used in this study to simulate total factor productivity (TFP) growth:

$$QV_a = \alpha_a^p \sum_f \left(\delta_{fa}^{p} \cdot fpr_{fa} \cdot QF_{fa}^{-\rho_a^p}\right)^{-1/\rho_a^p} \tag{2-5}$$

[14] Capital is immobile because, in the short term, it is difficult to transform machinery for use in another sector.

[15] Low-skilled labor includes workers who have at most finished primary school. Semi-skilled labor includes workers with secondary schooling, including those with technical training. High-skilled workers are those with college, university, and post-university education.

Figure 2-7: Structure of production and allocation



Source: Author's conception.

Each sector produces outputs with fixed-yield coefficients and allocates them to market sale or home consumption. The production and allocation process is shown in equation 2-6, where $QXAC_{ac}$ denotes the marketed production, QHA_{ach} denotes home-produced consumption, QA_a denotes output, and θ_{ac} denotes yields of output per unit of activity:

$$QXAC_{ac} + \sum_{h} QHA_{ach} = \theta_{ac} \cdot QA_{a} \tag{2-6}$$

With regard to marketed production, producers are assumed to optimally deliver output to the domestic and export markets, given the relative prices and the imperfect transformability between exports and domestic sales expressed by a constant elasticity of transformation (CET) function. The producer price of exported goods (called the export price) is the world price adjusted by the exchange rate, export taxes, and transaction costs. Similar to the export side, we adopt the Armington assumption of imperfect substitutability between imported and locally produced goods on the consumer side. The consumer price of imports (called the import price) is the world price adjusted by the exchange rate and tariffs, plus the transaction costs per unit of import. Finally, as the DRC accounts for a very small share of world trade, the small-country assumption is adopted for both import and export markets. This implies that the DRC faces perfectly elastic world supply and demand at fixed world import and export prices.

In the model, domestic transaction costs are calculated as the difference between the domestic demand price (the price paid by consumers) and the domestic supply price (the price received by producers) for goods that are produced and sold domestically. These transaction costs are very high in the DRC, as they reflect poor infrastructure and high costs of capital.[16] In the CGE model, transaction costs also apply to imported and exported goods, as shown in Figure 2-8. It is assumed that each unit of a given agricultural and manufactured good requires a fixed amount per unit of trade and transportation services in order to reach the market. The demand for trade and transportation services QT_c is given by

$$QT_c = \sum_{c'} \left(cd_{c,c'} \cdot QD_{c'} + cm_{c,c'} \cdot QM_{c'} + ce_{c,c'} \cdot QE_{c'} \right) \tag{2-7}$$

[16] The high cost of capital generally results in high costs of holding inventories and high risks associated with trading activities.

where cd_{cc}, cm_c and ce_{cc} are, respectively, domestic production, import, and export transaction cost coefficients of commodity *c*.

A feature that distinguishes this model from other CGE models is that it is extended to separately account for the use of trade services and transportation services within transaction costs.[17] This implies that two production activities provide transaction services associated with goods produced and sold domestically, imported, and exported.

The model also makes it possible to account for home consumption of own-production. This property allows modelling the consumption by households of some of their own production instead of selling it at a low price or purchasing similar goods at a high price.[18] Final household demand follows a linear expenditure system (LES) derived from the maximization of the Stone-Geary utility function subject to a budget constraint. Optimization leads to demand functions for marketed commodities and for home-produced commodities. Demand for marketed commodities is represented by an LES function of total household consumption expenditure, a commodity's composite market price,[19] and other commodity prices. Demand for home-produced commodities is free of transaction costs and uses producer prices.[20]

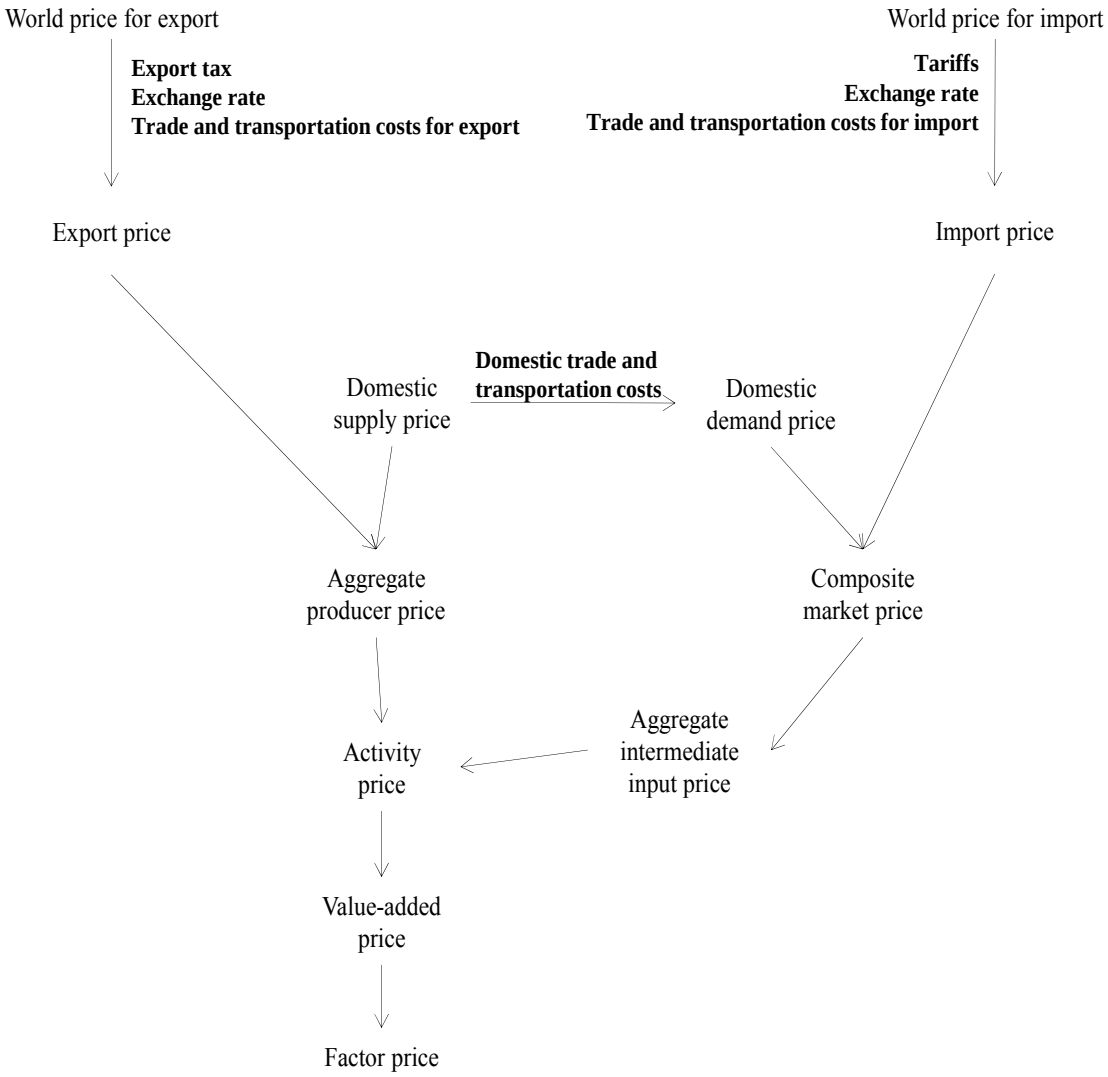
[17] From a policy standpoint, policies affecting trade margins may differ from those affecting transportation margins.

[18] Home-produced consumption is represented in the SAM (see Section 2.4) by payments from households to activities. From the household's income side, activities pay to production factors and production factors to households. For a detailed description of how home-produced consumption is treated in the model see Lofgren *et al.* (2002).

[19] The composite price is the domestic market price paid by consumers. The composite price differs from the domestic demand price in that the former includes locally produced and imported goods, while the latter only includes locally produced goods.

[20] Producer prices differ from domestic supply prices in that the former consider both locally sold and exported goods, while the latter only consider locally sold goods.

Figure 2-8: The price system



Source: Author's creation.

2.3.2. Microsimulation model

Turning the attention to the microsimulation model, the simulation includes all of the 12,098 households from the 2005 household and informal producer survey. The model assumes that a policy change affects household welfare through the change in domestic market prices, producer prices, and factor income. This assumption in turn implies that the welfare effects depend on household consumption patterns and factor endowments. Changes in factor income

(dw_l/w_l), marketed commodities prices (dp_g/p_g), and producer prices (dp_{hg}/p_{hg}) from the CGE model are fed into the microsimulation model to determine welfare gains or losses of each of the 12,098 households. The first-order welfare change function dW_h/y_h is given as[21]

$$\boldsymbol{dW_h/y_h = \sum_l \emptyset_h^l (dw_l/w_l) - \sum_g \theta_h^g (dp_g/p_g) - \sum_{hg} \theta_h^{hg} (dp_{hg}/p_{hg})} \quad (2\text{-}8)$$

where $\emptyset_h^l$ is the share of labor category l in labor income of household h,[22] θ_h^g is the share of marketed good g in the total consumption expenditure of household h, θ_h^{hg} is the share of home-produced good g in the total consumption expenditure of household h, and y_h is household income.

2.4. Data

This subsection organizes DRC national accounts and household survey data into a SAM; that is, a comprehensive analytical framework representing all economic transactions that took place in DRC in 2005. Typically, a SAM is an economy-wide data framework representing the economy of a nation. By convention, it is organized in a square matrix in which each account is represented by a row and a column. Each cell shows expenditure by the column account and a source of income to the row account. SAMs are based on the double-entry accounting principle that, for each account, total income (row total) and total expenditure (column total) must balance.

DRC has a short history in constructing SAMs. The few existing ones date back to the late eighties and early nineties. A first version of a DRC SAM was constructed for the

[21] This equation is a variant of Chen and Ravallion (2004). I neglect the second-order effects as the price and wage changes are small.

[22] Factor income of households includes income from labor, land, and capital. Production income of households does not go to households directly, but through production factors.

base year of 1980 by the United Nations Economic Commission for Africa (UNECA 1984). Later, Kamiantako (1993) developed a 14-sector SAM for 1987 in order to assess the impact of stabilization and structural policies in Zaire[23]. The 1987 SAM was constructed based on the system of national accounts of 1968, and it incorporated six types of labor (Low-class unpaid labor, low-class paid labor, unskilled labor, low-skilled labor, semi-skilled labor, high-skilled labor) as well as two kinds of capital according to their source (formal and informal). Other agents were households, firm, government, the rest of the world, and the capital account. This SAM disaggregated households according to socio-professional groups, distinguishing nine household categories.

This study elaborates a more recent SAM for the reference year 2005, compiled according to the recommendations of the 1993 System of National Accounts (United Nations 1993). The main sources of information are the supply and use tables and integrated economic accounts produced by the Congolese National Institute of Statistics (INS 2008). Data from household surveys, the *Enquête 1-2-3*, were used to disaggregate labor. This SAM contains a detailed production side (19 activities), tax (subsidies) account, and labor types. In addition, the following characteristics of the 2005 SAM are worth noting: unlike the previous SAMs, the 2005 SAM makes a distinction between "activity" and "commodity" accounts. The activity accounts describe sectors that produce commodities which are valued at producer or farm-gate price. The commodity accounts represent market places in which commodities from activity accounts are sold. Those sales are valuated at market prices. This distinction allows one single activity to produce multiple commodities or multiple activities to produce one single commodity. The SAM also explicitly accounts for transactions costs (also referred to as marketing margins). Furthermore, the SAM distinguishes between home consumption and consumption of marketed commodities. Home consumption represents household production,

[23] DRC was named Zaire between 1971 and 1997.

which doesn't enter the market and, therefore, is not subjected to marketing margins and sales taxes.

I followed three steps in order to build the SAM. First, I constructed a highly aggregated SAM (macro SAM) using the integrated economic accounts. In a second step, I disaggregated the Macro SAM into an unbalanced Micro SAM using both supply and use tables and 1-2-3 survey data. Since the two data sources are not reconciled, I applied a cross-entropy balancing approach to estimate a new balanced Micro SAM. The Macro SAM is a highly aggregated SAM which reflects the structure of the Congolese economy in 2005. It follows the standard SAM structure as discussed in Pyatt and Round (1985).

Additional data, including household demand elasticities, trade elasticities, and production elasticities, are required to fully run the CGE model. Household demand elasticities include income elasticity and the Frisch parameter and were estimated based on the *Enquête 1-2-3* survey data.[24] Trade elasticities include elasticities for the Armington and transformation functions. Armington elasticities represent the elasticity of substitution in demand between imported commodities and domestic goods, whereas transformation elasticities include substitution elasticities among primary inputs in the value-added production function. For the case of the DRC, no trade elasticity was found due to the lack of time series data. Therefore, trade elasticities used in this study are from the Global Trade and Analysis Project (GTAP) based on Dimaranan (2006). Finally, production elasticities, which are drawn from the empirical CGE literature for African economies, vary between 0.3 and 1.2 (Fagernas 2004; Diao 2012).[25]

[24] I use the Linear Approximate Almost Ideal Demand System (Deaton and Muellbauer 1980; Alston et al. 1994) to estimate income elasticities. This system is used instead of the LES demand system, because it can treat zero and no consumption in the household data.

[25] Production elasticities, which include factor substitution elasticities, take a lower value (0.3~0.8) for agriculture, forestry, and mining.

2.4.1. Structure of the macro SAM

The basic structure of the DRC macro SAM is shown in Table 2-5. It is a square matrix comprising 8 accounts. Typically, these sectors are activities, commodities, factor, households, enterprises, government, investment, and the rest of the world. The activities account indicates domestic production activities. Goods and non-factor services produced in economy are either sold in the commodities market or home-consumed. These outputs are valued at producer prices. Moreover, each activity produces only one commodity. Domestic production requires intermediate inputs as well as the service of primary factors. Domestic producers also pay indirect taxes (deducted by government subsidies). On the other hand, the commodities account describes activity outputs which are supplied (in the columns) to the commodities market as marketed commodities and imports by domestic producer and the rest of the world respectively. Commodities are valued at purchaser prices by adding taxes, tariffs and marketing margins to domestic outputs and imports, respectively valued at producer price and CIF prices. They are demanded (in the rows) for intermediate inputs, final private consumption, final government consumption, and investment purposes. Furthermore, the output is sold in the foreign market in the form of exports.

The factors account refers to three factors of production, namely land, labor, and capital. The service of factors of production to the activities account is paid in the form of operating surplus for the capital and land, and compensation of employees for the labor. This income is thereby distributed in column 3 to households, enterprises and government. The source of household total income consists of wage, rents, distributed profits and other transfers from enterprises, government and the rest of the world. Household income is also generated through inter-household transfers. Consequently, households allocate their income to home consumption, consumption of marketed outputs, income taxes and transfers (rest of the world as well as other households) and household savings. Enterprises earn income (in the rows) through gross operating surplus and transfers from the rest of the world. Enterprise's

expenditure (in the columns) includes distributed profits, corporates taxes, and other transfers to households and the rest of the world. By definition, enterprises do not save but they use their undistributed profits after tax for investment.

Table 2-5: Structure of the DRC SAM

		Activities	Commodities	Factors	Households	Enterprises	Government	Savings -Investment	ROW	Total
		1	2	3	4	5	6	7	8	9
Activities	1		Marketed outputs		Home-consumed outputs					Total domestic production
Commodities	2	Intermediate inputs	Market margins		Private consumption		Government consumption	Investment	Exports	Total marketed supply
Factors	3	Value added								Total factor income
Households	4			Factor income to households	Inter household transfers	Distributed profits, other transfers	Transfers to households		Foreign transfers	Total household income
Enterprises	5			Factor income to enterprises					Foreign transfers	Total enterprise income
Government	6	Indirect taxes	Sales taxes, import tariffs	Factor taxes	Income taxes	Corporate taxes			Foreign transfers	Total government income
Savings -Investment	7				Household savings	Corporate savings	Government savings		Foreign savings	Total savings
ROW	8		Imports			Surplus to RoW	Government transfers to RoW			Foreign exchange outflays
Total	9	Total cost of production	Total absorption	Total value added	Total household expenditure	Total enterprise expenditure	Total government expenditure	Total investment	Foreign exchange earnings	

Source: Adapted from Löfgren et al. (2002).

The rest of the world account records all transactions between domestic institutions, factors or commodity accounts and the rest of the world. Its income includes payment for imports, capital inflows and foreign transfer from government, while expenditure is made up of payments for export and foreign transfers to households, enterprises and government.

2.4.2. Numerical version of the macro SAM

DRC macro SAM is numerically constructed following the macro SAM structure presented above. As noted in SNA 93, a SAM is "the presentation of SNA accounts in a matrix which elaborates the linkages between the supply and uses tables and institutional sector accounts"

(United Nations 1993). To compile the SAM, I followed the procedure described in Santos (2006). The supply and use tables and institutional sector accounts were found consistent in that they produced a balanced macro SAM. The DRC macro SAM for the base year 2005 is presented in Table 2-6.

Table 2-6: DRC macro SAM (CDF, Million)

		Activities	Commodities	Factors	Households	Enterprises	Government	Savings - Investment	ROW	Total
		1	2	3	4	5	6	7	8	9
Activities	1		7,064,807		1,040,599					8,105,406
Commodities	2	2,838,480			3,600,805		240,245	681,418	1,242,930	8,603,878
Factors	3	5,221,752								5,221,752
Households	4			4,063,865	51,458	619,937	157,823		36,392	4,929,475
Enterprises	5			1,094,631					41,228	1,135,859
Government	6	45,174	203,182	63,256	30,058	183,015			219,578	744,263
Savings - Investment	7				182,108	203,058	278,280		17,972	681,418
ROW	8		1,335,889		24,447	129,849	67,915			1,558,100
Total	9	8,105,406	8,603,878	5,221,752	4,929,475	1,135,859	744,263	681,418	1,558,100	31,283,701

Source: Author's calculations.

2.4.3. From Macro SAM to micro SAM

This subsection aims at constructing a disaggregated (micro) SAM. The SAM disaggregation process consists of breaking down separately each of the main accounts contained in the macro SAM and the nonzero data entries. In addition, the nonzero data entries in the macro SAM serve as controlling totals when main accounts are disaggregated. To disaggregate the macro SAM, I used the supply and uses tables and the *Enquête 1-2-3* on employment, informal sector and household living conditions as follows.

- The activity and commodity accounts were broken down into 19 sub-accounts, since direct mapping for productive activities was possible from the supply and uses tables. In fact, the supply and uses tables contain 20 productive sectors and commodities, where 2 are related to agriculture activities, 7 to manufacturing activities and 11 to services. However, I decided to merge indirectly measured financial intermediation services (SIFIM) to financial intermediation to avoid negative value in the SAM.
- The government recurrent account was disaggregated into five different types of taxes and tariffs. These include sales taxes, import tariffs, export tariffs, tax on product, and direct taxes (income taxes and corporate taxes).
- Using the employment module of the *Enquête 1-2-3*, labor was disaggregated into six categories according to workers' education (low-skilled, semi-skilled, and high-skilled) and location (urban, rural).[26]
- Labor figures from the *Enquête 1-2-3* were slightly different from national accounts. Therefore, the prior micro SAM ended up being unbalanced. The rebalancing of the micro SAM was made using the cross entropy method (Robinson and El-Said 2000).

2.4.4. Problem encountered

In the supply and uses tables, I found the total labor cost within the production system was underestimated as it did not include the income paid to the non-wage labor. DRC household survey defines non-wage labor as those who run own business, are working as apprentice, or are unpaid workers. They represent 84.5 percent of the total labor costs, among them 70.3 percent belong to the informal sector. Thus, non-wage labor compensation was predicted using Heckman selection model (Heckman 1979) and used to adjust official figures.

[26] "Low-skilled" labor includes workers who never attended school, not yet finished primary school, and finished primary school; "semi-skilled" labor includes workers with secondary schooling, including those with technical training. "High-skilled" finally includes workers with college, university and post-university education.

2.4.5. Structural characteristics of DRC economy

This subsection will discuss three structural features of the DRC economy. These features are related to production and export structure, transaction costs, and sectoral production costs. Table 2-7 provides basic data on sectors included in the DRC SAM. The table shows that DRC depends on agriculture, which accounts for 20.7 percent of the total value added. This sector is followed by transportation, trade, mining, and processed foods, with shares of total value added of 13.9, 13.5, 12.8, and 11.2 percent, respectively. These top five largest contributors to value added also contribute with a high share of total production. Agriculture contributes to total production by 15.6 percent, processed foods by 15.5 percent, transportation by 13.1 percent, trade by 10.7 percent, and mining by 10.7 percent. It is worth mentioning that home-consumed production represents 12.8 percent of the total production. In addition, it accounts for 54.2 percent of forestry output, 38.4 percent for other services output, 31 percent of agriculture, and 29 percent for processed foods output.

DRC mainly imports chemicals, other manufacturing, and processed foods. These three categories account for 64.9 percent of total imports. In the context of imports, Table 2-7 also provides information on import competition ratio, defined as the ratio of imports to the domestic production. This indicator shows that other manufacturing faces the highest import competition, with 67.5 percent of total demand supplied by foreign producers. Other sectors facing important import competition are chemicals (44.5%), non-metals (43.3%), processed foods (17.2%), and textiles (14.9%). With regard to exports, Table 2-7 indicates that mining represents 69.1 percent of total exports, whereas in agriculture the corresponding share is only 1 percent. As indicated by the export intensity ratio, which depicts the export share of domestic production, mining is the most export-intense sector, since all of its production is exported. Other manufacturing appears to be the second most export-intense sector, because it exports 82.2 percent of its output. It is followed by wood (56.5%) and personal and other community services (31.9%).

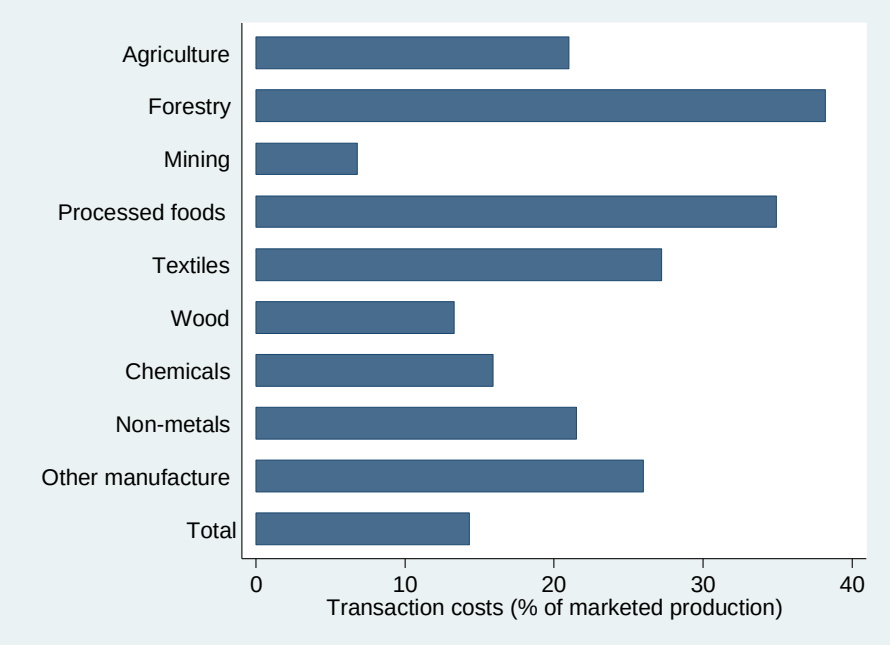
Table 2-7: Structure of the economy of the DRC, 2005

Sectors	Production (%)	HP (% of Q)	Value-added (%)	Imports (%)	Exports (%)	IPR	EI	Tariffs	TRMG (sh of total supply)	TPMG (sh of total supply)
Agriculture	25.24	19.22	20.74	2.56	1.01	0.02	0.61	0.05	0.14	0.07
Forestry	1.90	50.72	2.03	0.00	0.63	0.00	0.05		0.20	0.19
Mining	11.30	0.14	12.78	7.89	69.14	0.10	0.94	0.02	0.01	0.06
Processed foods	11.35	39.83	11.23	19.60	0.87	0.22	0.01	0.09	0.24	0.11
Textiles	1.57	0.44	1.56	2.33	0.10	0.20	0.01	0.52	0.20	0.07
Wood	0.39	0.22	0.34	0.14	1.59	0.06	0.63	0.19	0.09	0.04
Chemicals	3.59	1.08	3.26	22.78	2.88	0.51	0.12	0.10	0.09	0.07
Non-metals	0.56	0.07	0.44	2.54	0.60	0.43	0.16	0.09	0.12	0.09
Other manufacture	1.11	0.95	1.10	22.48	9.57	0.77	0.80	0.21	0.13	0.13
Utilities	1.13		1.07	0.00	1.13	0.00	0.15			
Construction	5.28		3.87	0.83	0.01	0.03	0.00			
Trade	10.95		13.49	0.00	0.00	0.00	0.00			
Hotels and catering	2.77		0.54	1.90	0.12	0.10	0.01			
Transportation	12.36		13.87	8.10	1.53	0.10	0.02			
Education and health	1.20		3.04	0.00	0.00	0.00	0.00			
Financial intermediation	1.23		0.74	0.95	0.12	0.11	0.01			
Other services	4.29		6.49	4.77	2.62	0.15	0.09			
Personal and other community services	3.73		3.29	3.12	8.10	0.12	0.33			
Private households with employed persons	0.03		0.12	0.00	0.00	0.00	0.00			
All	100		100	100	100	2.92	4.48			

Source: Author's calculation based on DRC SAM.
Note: HP stands for home consumption share of production; IPR stands for import penetration ratios; EI stands for export intensity; TRMG stands for trade margins; TPMG stands for transportation margins.

The existence of transaction costs is another structural feature that impacts the production process and competitiveness of DRC products. Transaction costs, defined as margins between farm gate prices and consumer prices, reflect poor infrastructure and high costs of capital. The high cost of capital generally results in high costs of holding inventories and high risks associated with trading activities. Figure 2-9 shows the transaction costs for agriculture and manufacture, expressed as the percentage of the total value of the supply of marketed output. It appears that transaction costs are particularly important in forestry (38.2%), processed foods (34.9%), textiles (27.2 %), other manufacturing (26%), non-metals (21.5%), and agriculture (21%). These important transaction costs are the cause of the high share of home-consumed production, especially in forestry, agriculture, and processed foods.

Figure 2-9: Transaction costs



Source: Author's computations based on 2005 DRC SAM.

Table 2-8 presents the structure of the sectoral production costs (net of subsidies) in DRC. This table shows that natural resource-related sectors have the lowest share of costs for intermediate inputs; it represents 13.8 percent of total production costs in agriculture, 28.2 percent in forestry, and 25 percent in mining. The limited intermediate input use in agriculture and forestry reflects the rudimentary nature of technology used in these sectors. Since 99.5 percent of mining production is exported, limited intermediate input use in this sector exhibits that minerals are basically exported in their extraction stage, without any value addition or processing. The top five sectors with the highest share of intermediate input costs of production in the sectoral net production are hotels and catering (87.3%), financial intermediation (59.7%), chemicals (55.1%), processed foods (54%), and textiles (53.8%). Among them, chemicals and processed foods do not appear to be very flexible to pass cost pressure onto their factors because of their high share of imports. Inversely, agriculture, mining, and wood will be very responsive to cost pressure. In fact, these sectors account for the higher factor of production cost and a small import share.

Table 2-8: Sectoral production costs

	Intermediate inputs	Factors of Production	Production taxes	Total
Agriculture	13.8	86.2	0.0	100
Forestry	28.2	71.8	0.0	100
Mining	25.0	71.6	3.4	100
Processed foods	54.0	45.9	0.1	100
Textiles	53.8	46.2	0.0	100
Wood	40.0	59.5	0.5	100
Chemicals	55.1	41.5	3.4	100
Non-metals	48.2	51.5	0.3	100
Other manufacture	51.5	47.2	1.3	100
Utilities	35.0	63.6	1.4	100
Construction	52.4	47.6	0.0	100
Trade	20.0	79.9	0.2	100
Hotels and catering	87.3	12.7	0.0	100
Transportation	30.6	69.2	0.2	100
Education and health	19.7	80.3	0.0	100
Financial intermediation	59.7	46.3	-6.0	100
Other services	24.6	75.4	0.0	100
Personal and other community services	45.4	54.6	0.0	100
Private households with employed persons		100.0	0.0	100
Total	35.0	64.4	0.6	100

Source: Author's computations based on 2005 DRC SAM.

2.5. Policy experiments

2.5.1. Simulation scenario

Rapid economic growth in emerging developing countries has boosted DRC's mining export over the last years. It is known that resource boom afflicts countries with Dutch Disease in which the growth of natural resources and capital inflow lead to real exchange appreciation and make other tradable and non-tradable sectors less competitive. The first scenario (Scenario 1) aims to assess the economy-wide and distributional effects of the natural resource boom in DRC. In other words, I determine how much the mining growth affects wages, earnings, and output in other sectors and to what extent the poor benefit through employment and consumption.[27] In the model, I implement this scenario by increasing the TFP of mining sector by 2 percent.

[27] For a discussion on industrialization by processing of primary commodities, see Cramer (1999), Gibbon

The second scenario (Scenario 2) consists of evaluating the potential effects of an alternative growth strategy based on manufacturing. Again, the scenario mimics the industrialization path of recent emerging economies, which built capabilities and capacities to transform manufacturing industries.[28] This scenario assumes that productivity in the DRC manufacturing sector (food processing, textiles, wood, chemicals, non-metals, and other manufacturing) increases by 2 percent.

In these scenarios, I assume that the direct tax rates are fixed and government savings adjust endogenously to ensure that government accounts balance. For the saving-investment account, the balanced closure specifies aggregate investment and government consumption as fixed shares of total domestic absorption. The foreign exchange closure assumes a flexible exchange rate maintains a fixed level of foreign savings, which is consistent with the floating exchange rate system adopted in the DRC.

Different factor markets reach equilibrium in different ways. In the short-run simulation, labor is unemployed and mobile across sectors, given high unemployment rate among all labor categories. Wages are fixed for all labor categories, and employment level adjusts to reach equilibrium in labor market. Capital and land are fully employed and sector specific so that their returns adjust to reach equilibrium in the sector-specific market for capital and land. In the long-run simulation, labor is fully employed and mobile across sectors, but not across regions.[29] Capital is fully employed and mobile across sectors.

2.5.2. Macroeconomic results

Table 2-9 reports the impacts of the two scenarios on selected macro indicators and their long-run impacts. The increase in productivity in the mining and manufacturing sectors produced the expected positive impact on the economy. GPD and exports increase. The

(2001), and Owens and Wood (1997).

[28] For a discussion on the relevance of East Asia development experience to Africa, see Harrold et al. (1996)

[29] This is because the model is run in the short-term perspective and I do not model the decision to migrate.

increase of exports leads to an appreciation of the exchange rate, and consequently, imports increase to restore the equilibrium in the foreign market. However, the qualitative effects of these scenarios are quite different. Looking at the short-run impact of mining-led growth, Table 2-9 indicates that the major improvements are found in exports and imports, which increase respectively by 1.51 and 1.41 percent. This is because mining is an export-intensive sector and contributes to about 70 percent of DRC total exports.

Table 2-9: Macro impacts

	Short-run		Long-run	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
GDP	0.65	0.93	0.59	0.75
Absorption	0.64	0.91	0.58	0.73
Private consumption	0.58	0.99	0.51	0.81
Investment	1.01	0.48	1.23	0.45
Government consumption	0.85	0.53	0.22	0.12
Exports	1.51	0.90	1.72	0.71
Imports	1.41	0.84	1.60	0.66
Exchange rate	-0.35	-0.15	-2.79	-0.08
Price index	-1.90	-0.19	-0.61	-0.35
Factor returns				
Urban low-skilled	0.32	1.46	-0.48	1.39
Urban semi-skilled	0.36	1.20	-0.24	1.21
Urban high-skilled	-0.68	0.81	-1.73	1.22
Rural low-skilled	0.80	0.74	0.74	0.73
Rural semi-skilled	1.14	0.54	1.44	0.07
Rural high-skilled	0.13	1.04	-0.58	1.18
Capital	0.47	0.67	0.31	0.69
Land	0.38	0.93	0.28	0.83

Source: Author's calculations.

Mining productivity improvement generates strong growth in investment and government consumption, which increase by 1.01 and 0.85 percent, respectively, as compared to the 0.58 percent increase of private consumption. High increase in public investment and government consumption is mainly due to the increase in mining royalties and taxes. It is further

interesting to note that the effect of mining growth on investment gets larger in the long run than in the short run, implying that mining royalties, under effective management, can become a significant source of investment in DRC. On the other hand, manufacturing-led growth boosts private consumption and exports. Under this scenario, private consumption increases by 0.99 percent, whereas investment increases by 0.48 percent.

Productivity growth in the mining sector generates mixed results on factor income, especially in the returns to labor. The finding suggests that growth led by the mining sector is not translated into strong household income. Data in Table 2-9 show that income of urban high-skilled labor decreases by 0.68 percent while that of urban semi-skilled and low-skilled workers increase by 0.36 and 0.32 percent, respectively. The wage of urban high-skilled workers decreases mainly because of the contraction of other manufacturing and utilities sectors where their labor is used extensively (See Table 2-10). In rural areas, the income of semi-skilled workers raises the most, by around 1.14 percent; it is followed by low-skilled labor (0.80%). In the long run, however, mining productivity growth has negative effects on urban wages as well as rural high-skilled wages. The most significant fall in wages occurs for high-skilled workers in both rural and urban areas. The wages of urban high-skilled and rural high-skilled workers decreases by 1.73 and 0.58 percent, respectively, while those of urban semi- and low-skilled workers decrease by 0.24 and 0.48 percent. The reason for this is the deindustrialization that occurs due to significant appreciation of the long-run exchange rate, which increased by 2.79 percent.

With regard to the changes in factor earnings due to manufacturing growth (Scenario 2), the simulation results indicate that factor income generally increases in urban and rural areas, but there is a variation in the distribution between regions and across labor categories. For example, the income of urban low-skilled and semi-skilled workers rises more than that of urban high-skilled workers, whereas in rural areas, high-skilled workers gain the most.

2.5.3. Sectoral results

Mining boom generates mixed sectoral impacts in the short-run and the long-run, meaning that positive effects are not evenly shared across sectors. The finding suggests that mining growth negatively affects export-oriented sectors and those with a high import penetration ratio. Note also that the long-run impacts are stronger than in the short run because of the loss of competitiveness and deindustrialization. This is amplified, as capital is attracted to capital-intensive sectors such as mining. Thus, looking within sectors, one can see that export-oriented sectors suffer huge production losses compared to sectors facing high import competition. For instance, wood and other manufacturing decrease in the long run by 20.10 and 18.90 percent, respectively, whereas chemicals and non-metals decrease by 0.44 and 1.84 percent.

Table 2-10: Impacts on domestic production and intermediate inputs

Sectors	Domestic Production		Intermediate inputs		Domestic Production		Intermediate inputs	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Agriculture	0.10	0.11	0.55	0.55	-0.08	0.27	0.50	0.67
Forestry	-0.15	0.29	-0.12	0.30	-1.32	0.68	-1.25	0.72
Mining	5.27	-0.08	4.51	-0.07	10.67	-3.46	9.33	-3.19
Processed foods	0.20	1.95	0.35	0.19	0.13	1.55	0.26	0.48
Textiles	0.36	1.86	0.61	0.28	0.11	1.61	0.42	0.67
Wood	-4.45	8.46	-4.93	7.53	-20.10	25.21	-20.00	23.66
Chemicals	0.07	2.23	0.18	0.88	-0.44	1.94	-0.05	0.99
Non-metals	-0.39	3.00	-0.33	1.74	-1.84	3.54	-1.49	2.45
Other manufacture	-2.72	6.28	-3.18	5.79	-18.90	23.71	-18.72	22.58
Utilities	-1.10	0.59	-0.91	0.75	-2.75	0.52	-2.39	0.89
Construction	1.01	0.49	1.46	0.65	1.19	0.45	1.60	0.72
Trade	0.39	0.88	1.14	2.10	0.22	1.02	0.66	1.22
Hotels and catering	0.76	1.04	0.80	1.11	0.50	1.28	0.54	1.38
Transportation	0.02	0.48	0.20	1.03	-0.96	1.13	-0.52	1.41
Education and health	0.54	0.52	1.12	0.72	0.26	0.18	0.94	0.51
Financial intermediation	0.38	1.25	0.54	1.19	-1.08	2.43	-1.09	2.57
Other services	0.01	0.11	0.14	0.23	-1.09	0.13	-0.74	0.32

Source: Author's calculations.

Furthermore, the second interesting finding is that mining growth generates a marginal impact on other domestic industries with low trade as well as non-tradable sectors. This finding reflects the lack of linkage between mining and the domestic economy. For example, the processed food and textile sectors grow by 0.20 and 0.36 percent while non-tradable sectors

such as transportation and trade grow by 0.02 and 0.39 percent, respectively. These results are comparable with those of Diao and McMillan (2014), who found that capital inflows, which also lead to the appreciation of the exchange rate, improve output of micro, small, and medium enterprises that produce only for domestic markets and lead to stagnant growth of large enterprises in the formal economy.

Nonetheless, the findings from the CGE model suggest that the mining sector will remain the driver of economic growth in DRC for many years and attract most of the investment. As can be seen in Table 2-10, under scenario 1, the production of mining increases two times when all factors are mobile, as opposed to when they are immobile. The only non-mining sector that benefits the most is construction, whose production increases by 19 percent. This is because construction is the largest supplier of intermediate inputs to mining. According to Table 2-10, the aggregate intermediate input of construction increases by 1.60 percent in the long run, as compared to 1.46 percent in the short run. On the other hand, mining growth leads to a decrease in agriculture and transportation, among others, in the long run due to the change in capital rent in these sectors. This finding shows that agriculture marginally contracts by 0.08 percent and transportation by 0.96 percent in the long run, whereas in the short run, these sectors grow by 0.10 and 0.02 percent, respectively. For a policy perspective, this result suggests that agriculture and transportation cannot be sustained in the long run without particular attention from the government.

In terms of broad-based manufacturing-led growth (Scenario 2), the results show that all economic sectors expand, except for mining. The findings also indicate potential growth in services such as financial intermediation, hotels and catering, trade, and construction. The short-run effects of this simulation indicate that hotels and catering expand by 1.04 percent, while financial intermediation and trade grow by 1.25 and 0.88 percent. Another important finding is that agriculture and transportation are more responsive to manufacturing growth in the long run as factors (especially labor) reallocate in response to changes in wages and rents.

Table 2-10 shows that agriculture expands by 0.27 percent in the long run, as compared to 0.11 percent in the short run, while transportation expands by 1.13 percent in the long run against 0.48 percent in the short run.

Turning to the impact of mining growth on exports and imports, the finding confirms the Dutch Disease effect, which tends to be permanent even in the long run. The results in Table 2-11 show that, due to the appreciation of the exchange rate generated by substantial mining exports, exports in all the other sectors shrink. In the short run, the largest reduction appears to have occurred in agriculture and processed food as mining expansion diminishes the competitiveness of these industries. Another important reason is that these sectors are highly exposed to international competition, as tariff protection is very low, 5 and 9 percent respectively. Thus, imports also increase the most in these sectors, as mining exports expansion generates enough resources for the economy to increase all categories of imports, except for wood products. In fact, production of wood falls more than the decline in imports because of the imperfect substitution between imports and domestic production.

Table 2-11: Impact on trade

Sectors	Short-run				Long-run			
	Exports		Imports		Exports		Imports	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Agriculture	-11.99	-3.61	2.85	1.18	-16.64	-0.99	3.76	0.60
Forestry	-11.01	-1.68	1.23	0.77	-20.52	1.82	1.02	1.17
Mining	5.36	-0.09	1.31	0.91	10.86	-3.54	1.51	0.85
Processed foods	-11.73	16.56	1.41	1.01	-15.85	12.49	1.76	0.74
Textiles	-9.51	19.69	1.37	1.12	-14.00	14.30	1.53	0.89
Wood	-6.98	10.78	-0.42	2.96	-26.58	30.80	-7.19	10.31
Chemicals	-6.94	14.43	1.49	0.59	-12.43	12.61	1.89	0.31
Non-metals	-7.81	15.17	1.77	0.48	-16.41	17.13	2.16	0.40
Other manufacture	-2.14	7.03	1.42	0.79	-19.43	25.49	1.60	0.59
Utilities	-9.11	-0.10	0.86	0.79	-15.94	-0.20	0.42	0.81
Construction	-9.07	-1.07	1.55	0.57	-11.74	0.68	1.89	0.44
Trade								
Hotels and catering	-9.54	2.67	1.39	0.95	-13.25	4.63	1.36	1.09
Transportation	-8.40	-5.51	0.85	1.07	-15.91	0.01	0.55	1.24
Education and health								
Financial intermediation	-9.25	-2.43	1.08	1.51	-14.21	0.50	-0.11	2.56
Other services	-9.10	-3.18	1.25	0.90	-16.38	-0.86	1.12	0.56

Source: Author's calculations.

Table 2-11 also summarizes the effect of broad-based manufacturing-led growth on exports and imports. The finding indicates positive effects on sectoral exports growth, particularly in the long run. One of the issues that emerge from these findings is that some sectors such as construction and transportation can suffer from adjustment costs in the short run due to the immobility of capital. Nonetheless, it is interesting to note that, in both short- and long-run simulations, hotels and the catering sector exhibit positive exports growth, with higher magnitude in the long run.

2.5.4. Distributional effects

To assess the distributional effects of the policy scenarios, I run a non-parametric locally weighted regression based on the welfare function shown previously.[30] The method allows for plotting the distribution of average welfare changes along the entire income distribution. In this context, one can conclude that a policy change improves welfare when the distribution curve of average welfare lies above the null horizontal line. In addition, if the slope of the distribution curve is downward, then the policy change is deemed to be pro-poor, as welfare gains are higher for those who are poorer. For each policy experiment, the distributional effects are estimated at the urban, rural, and national levels.

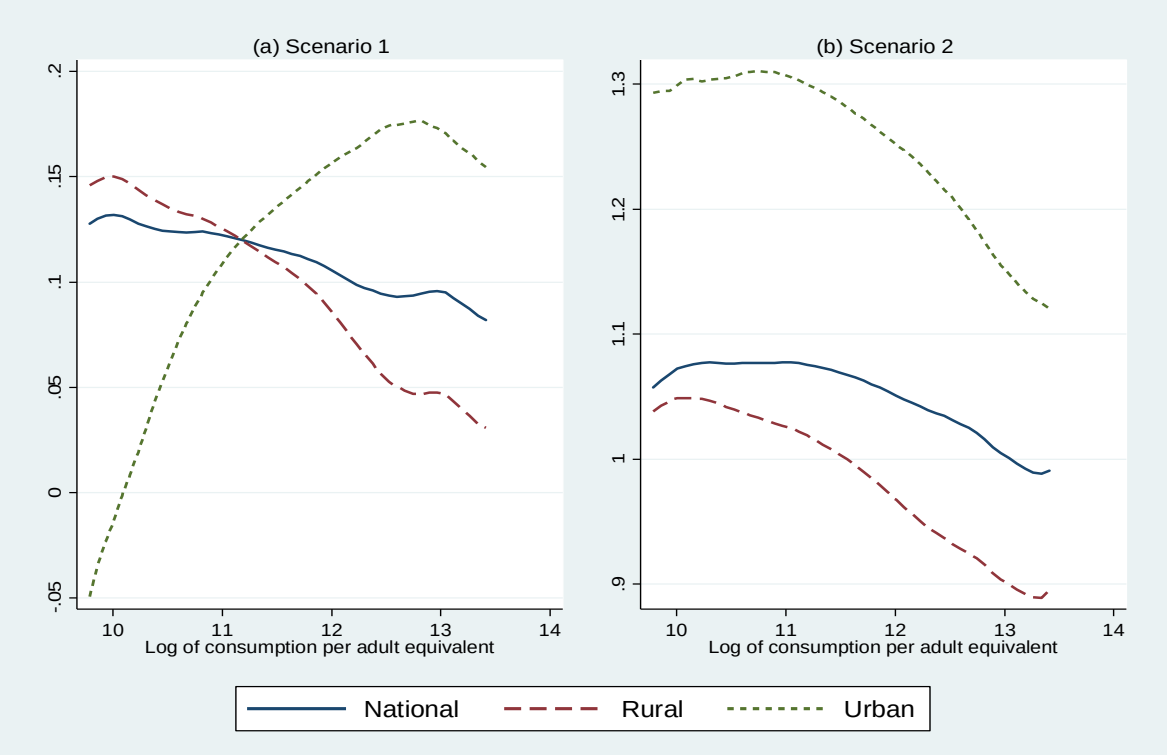
Figure 2-10 plots the short-run total welfare implications of mining growth (Scenario 1) and broad-based manufacturing growth (Scenario 2) across the entire income distribution.[31] The figure reveals that both policy experiments produce welfare gains for all households on the national level. Mining growth by itself produces a small welfare effect, which does not significantly differ in terms of income distribution. In urban areas, it leads to welfare losses for the very poor, whereas the highest welfare gains appear to have been accrued to households at the lower tail of the welfare distribution, as Panel (a) of Figure 2-10 shows.

[30] I use the kernel-weighted local polynomial smoothing (lpoly) available in Stata. For further details, see e.g. Porto (2006)

[31] This analysis is based on the short-run simulation.

This figure also shows that urban households' gains are lower than those for rural households in the lower part of the income distribution. In rural areas, however, mining growth tends to benefit the poorer. A possible explanation is the role of artisanal and informal mining, which goes hand in hand with formal mining. In rural DRC, many poor households, including women and kids, work as "creuseurs" (diggers) and traders in artisanal mining because few alternative employment opportunities exist.[32]

Figure 2-10: Pro-poor growth



Source: Author's calculations.

Panel (b) of Figure 2-10 shows the distributional effects of broad-based manufacturing growth. It shows that urban households capture higher benefits than those of rural households due to the strong effects on productivity improvement in urban incomes. The second interesting finding is that this policy scenario generates pro-poor welfare effects, as households at the lower tail of the income distribution in urban and rural areas benefit more than those at the

[32] For a discussion on artisanal mining in DRC, see Vlassenroot and Raeymaekers (2004).

upper tail. The impact of broad-based manufacturing growth on consumption contributed more to welfare gains of poor households than the impact on factor income. This is explained by the large share of agricultural-related goods in total food consumption of these households, the price change of products, and the change in factor income due to manufacturing growth seen in the previous section.

2.6. Conclusion and discussion

The main goal of the current study was to investigate the economy-wide and distributional effects of mining-based growth and assess the transmission mechanism of the Dutch Disease in DRC. In order to provide an alternative growth strategy that might help to mitigate the negative effects of the Dutch Disease, this paper sought to determine the extent to which DRC can efficiently diversify toward (labor-intensive) manufacturing exports by mimicking the Asia-style economic diversification.

This study provided an important opportunity to advance the understanding of the role of economic structure and inter-industry linkage in the transmission of natural resource boom by using DRC as a study case. DRC exports are increasingly more concentrated in a handful of products, which implies that 90 percent of DRC exports are concentrated in only five products, and the ten largest exported products accounted for 96 percent in the DRC export portfolio. DRC exports have been quite diversified in recent years, but the composition of exports has been relatively stable. This is because DRC accelerated export performance of some nontraditional exports. However, these nontraditional exports are primary goods, and some of them have been exported before but in smaller proportions. Small diversification in DRC mining occurred because China has overtaken the United States and the European Union to become the main destination of DRC exports.

The investigation of mining-based growth has shown a positive impact on GDP and exports, as mining is largely an export-intensive sector. The findings suggest that mining will

remain the key driver of DRC exports for a very long time but possibly not the source of growth. As such, I find that exports led by mining are higher in the long run, whereas GDP growth is lower than in the short run. There are several possible reasons for this result; the most plausible is the existence of the Dutch Disease and the structural change that it generates. The findings show the presence on the Dutch Disease effects in the macro and sectoral effects. For example, the results of the simulation show that, because of the mining boom, the real exchange rate appreciated so much so that it dampened exports and production of other tradable sectors. It is worth mentioning that the effects tend to be persistent in the long run if the DRC government maintains the same spending patterns. From a policy standpoint, this result shows the importance of deliberate industrial policy to change the long-run pattern of structural transformation.

The most striking finding in regard to the Dutch Disease symptoms is that mining-based growth generated small effects on wages and negatively affected the wages of high-skilled urban workers. There are two reasons for this. First, the mining sector is a very capital- and export-intensive sector with little employment elasticity and no linkages with the domestic economy. Second and most importantly, the structural effects of Dutch Disease tend to reduce investment incentive in high-skilled exports-related sectors, which further leads to disinvestment in human capabilities. There are similarities between the effects of the natural resource boom on employment and wage found in this study and the stylized facts described by Gylfason et al. (1999) and Hirschman (1958).

One interesting finding was that mining-based growth had anti-poor effects in urban areas and almost neutral effects in rural areas. Surprisingly, mining-based growth generated higher welfare gains for poor rural households compared to their counterparts in urban areas, where welfare losses occurred. The pro-rural effects may results from the spillover effects due to artisanal mining in rural areas as well as traditional and subsistence activities that produce for local or domestic markets.

Furthermore, the current findings clearly supported the relevance of mining rents to promote structural change and diversification. The results of mining growth simulation showed significant increase in public investment and government consumption. The results also showed that the persistent structural effects of Dutch Disease are likely to occur if the DRC government keeps the same spending patterns. Despite the fact that this study does not simulate an alternative spending pattern due to mineral rents, it is clear from the scenario of manufacturing-driven growth that DRC must foster structural transformation away from mining. In fact, the mimicking of Asia-style transformation indicates that it generates a productive transformation that produced pro-poor effects. An implication of these findings is that DRC should re-direct investment in labor-intensive manufacturing to provide a high employment base for future growth prospect.

However, new initial conditions for African manufacturing growth are different from the East Asian tigers. In the initial stage of the East Asian industrial development, global trade was characterized by a rapidly growing manufacturing sector, whereas the nature of global trade is nowadays characterized by a high productive service (manufacturing-related service) sectors. In recent years, Factory Asia has become the new player in global manufacturing and service trade, with China at the center due to its dynamic comparative advantage. According to the projection by Anderson and Strutt (2014), China will become the world's top producing country not only of primary products but also of manufacturing. Global manufacturing is characterized by high specialization in small tasks due to the fragmentation of production. This may not be beneficial for African economies who contribute a small portion of low value-added labor intensive activities in the global manufacturing value chain. The East Asian Tigers benefitted from a rapidly expanding manufacturing sector. The African Lions are benefitting from increases in productivity in the service sector, while the agricultural sector remains unproductive.

There is, therefore, a need for DRC to:

(1) Improve macroeconomic policy and exchange rate management. Sound macroeconomic management should mitigate the negative effects of exchange appreciation.

(2) Add local content and manage artisanal/informal mining.

(3) Invest in pro-poor, rural-based development policies.

(4) Identify manufacturing and high productive service industries as its key niche. These sectors should be identified based on their potential to generate broad-based growth and the prospect of possible high-growth markets, especially within the sub-region as the experience of Latin America.

(5) Provide a strategic support to increase the shared capabilities required to engineer growth in these sectors. The policy must aim at increasing the efficiency of existing capabilities, building new capabilities, and increase competitiveness of these industries. This is because I found that DRC exports primary products with low value addition, and the mining boom lead to unproductive transformation, where export-intensive sectors with high imports share collapse.

(6) Reform markets and builds institutions that facilitate trade and reduce transaction costs. The study finds that transaction costs are very high, especially in forestry, processed foods, textiles, and other manufacturing. For example, agriculture accounts for 20.7 percent of the total value added and 15.6 percent of total production. However, 31 percent of agriculture production is home consumed and does not enter the market.

(7) Improve accountability and management of natural resource fund. The research has shown the importance of investment in achieving the policy objectives. DRC should align public and private funding and institutions to facilitate the movement and reallocation of funds.

Chapter 3. How can industrial structure guide the choice of development strategy? A field of influence analysis for the DRC

3.1. Introduction

In chapter 2, I found that mining based growth leads to unproductive transformation due to the persistent structural effects of the Dutch Disease. The findings have also shown that an alternative growth strategy led by a labor intensive Asian-type manufacturing growth generates a productive transformation that produces pro-poor effects. However, the current nature of the global manufacturing landscape makes it difficult for DRC to create competitive advantage in these industries.[33] The Factory Asia is now the driver of this new era of global manufacturing, with China being the top manufacturer.[34] This era is driven by shifts in demand and innovations in materials, processes, information technology, and operations. It contrasts with China's initial condition, which was characterized by the shifts in the cost and the availability of factor inputs (Manyika et al. 2012). China's initial condition created an opportunity for East-Asian economies to industrialize with labor intensive, export-oriented manufacturing.

In recent years, China and the factory Asia started to move up the quality ladder by manufacturing more of the high-skill content goods. Production system has become very fragmented with an increasing role of trade in tasks – that is, trade of intermediate goods – and efficient logistics (manufacturing-related services).[35] As a consequence, economies are becoming more and more integrated through supply chains. According to Manyika et al. (2012), highly R&D and trade intensive industries such as autos, chemicals, and pharmaceutical represent the largest share (34%) in the global manufacturing value added

[33] For a more "pessimist" view about Africa's industrialization, see for example Kaplinsky and Morris (2008).
[34] Baldwin (2008) first used this concept to describe fractionalized and dispersed manufacturing in East Asia.
[35] The report by IDE-JETRO and World Trade Organization (2011) provides clear picture of the trade patterns and global value chains in East Asia.

while labor intensive goods represent only 7 percent. Regional processing of rubber, plastic, metal, and food products represents 28 percent of total manufacturing value added and is labor and trade intensive. In 2012, China manufactured half of industrialized countries products (UNIDO 2013). The projection by Anderson and Strutt (2014) indicates that China will remain the world's top manufacture in 2030 with the share of 28.9 percent of global value added.

Nonetheless, the new initial conditions for industrial development, with "Factory Asia" as the new players in the global manufacturing and service trade, offer exploitable possibilities for Africa to industrialize. For example, Page (2012) argued that rising costs and demand in Asia can serve as an opportunity for Africa to industrialize. Similarly, UNIDO (2013) pointed out that Africa faces openings in low-tech labor-intensive industries such as agroindustry, textiles, and clothing and apparel.

However, there have been few empirical investigations into how Africa can strategically industrialize, based on its structure and future market prospects. The major objective of this chapter is thus to examine how the linkages among economic sectors of DRC can orientate an industrialization strategy. In this regard, I use the field of influence of changes in input-output coefficient initiated in Hewings et al. (1988) and further in Hewings et al. (1989) to interpret structural change and the process of technological diffusion. The field of influence approach extends the traditional key sector analysis by identifying the combination of key sectors that have the largest contribution to economy-wide output. This study differs to the previous application of the field of influence of changes in that it uses the minimum information decomposition of the Leontief inverse as recently suggested by Sonis et al. (2000), to identify the future possible pathway of DRC economic development.

The findings highlight the importance of creating agricultural value chains and establishing a competitive agrofood industry in DRC. The analysis suggests that increasing value addition in and processing capacity of agricultural products will generate the most

important volume change in the economy, and improving the efficiency of financial intermediation will have an important additional scale effect. The findings also pinpoint the role of investment in transportation infrastructure and trade institutions in creating domestic and regional markets for competitive agrofood products.

The remainder of the chapter is organized as follows. Section 3.1 provides a brief description of the minimum decomposition of the Leontief inverse used to analyze the field of influence of changes among sectors of the economy. Section 3.4 reports the findings and section 3.5 concludes.

3.2. Methodology

Following Defourny and Thorbecke (1984), a SAM based input output model can be given as follows:

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{x} = \mathbf{B}\mathbf{x} \tag{3-1}$$

$$\mathbf{A} = [a_{ij}] \tag{3-2}$$

where **A** is an input coefficient matrix, $\mathbf{B}=(\mathbf{I}-\mathbf{A})^{-1}$ is the SAM multiplier matrix or the Leontief inverse matrix, **y** is the income from endogenous accounts and **x**, a vector for exogenous accounts. The endogenous accounts consist of production (activities and commodities), factors and private domestic institutions (households and enterprises), while government, capital account and the rest of world are set as exogenous accounts.

The field of influence of changes approach (Sonis and Hewings 1992; Hewings et al. 1989; Hewings et al. 1988) was introduced to assess the change in the Leontief inverse matrix due to the change in one or more direct input coefficients. This approach assumes that changes in some set of inter-industry flows are likely to have far more contribution to the

functioning of the economy than others, and thus stimulate the process of economic change. For an economic policy perspective, those changes consist of an adoption of emerging new technologies, improvement in efficiency of economic process, increase in competitiveness, or changes in product lines (Hewings and Sonis 2009; Sonis et al. 1995). In this study, I apply the minimum information method (Sonis et al. 2000) to decompose the Leontief inverse matrix into two main components, namely the Multiplier Product Matrix[36] (MPM) and the Matrix Synergetic Interaction[37] (MSI). The MPM shows how each sector is related to the rest of the economy and describes the intensity of these interactions. As such, the MPM indicates the degree to which changes in one sector are likely to affect the entire economy. This also implies that it can handle the traditional key sectors analysis based on Rasmussen-Hirschman backward and forward linkages.

In addition, the MPM provides an artificial visualization of the structure of the economy, where the interactions between sectors are presented in terms of backward and forward linkages. On the order hand, the MSI represents the economic interaction between different sectors. Unlike the MPM, the MSI takes into account the specifics of the pair-wise sectoral interaction, and considers the combination of changes in two sectors that would generate the most significant impact to the economy. The MSI includes the scaling effects of the intrasectoral economic activities and the linkages. The scaling effects reflect the self-influence of sectors whereas the linkages reflect the bilateral balances and imbalances between sectoral inputs and outputs. Thus, the minimum information based decomposition of the Leontief inverse can be written as:

$$\mathbf{B} = \mathbf{M} - \mathbf{N} \tag{3-3}$$

$$\mathbf{B} = \mathbf{M} + \mathbf{D} + \mathbf{S} + \mathbf{S_a} \tag{3-4}$$

[36] The first order matrix of field of influence
[37] The second order matrix of field of influence

where **M** is the multiplier product matrix, **N** is the matrix of impacts of synergetic interactions, **D** is the additional sectoral scale effects, and **S** and $\mathbf{S_a}$ are the symmetric and antisymmetric tendencies in synergetic interactions between sectors.

3.2.1. Multiplier product matrix and key sectors analysis

Let $\mathbf{B_{i.}}$ and $\mathbf{B_{.j}}$ denote the sum of the *i*-th column and the *j*-th row of the Leontief inverse matrix. Let also v denote the sum of all cells of the inverse matrix. These are defined as:

$$\mathbf{B_{i.}} = \sum_{j=1}^{n} b_{ij} \tag{3-5}$$

$$\mathbf{B_{.j}} = \sum_{i=1}^{n} b_{ij} \tag{3-6}$$

$$v = \sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij} \tag{3-7}$$

The input-output Multiplier Product Matrix **M** (Sonis and Hewings 1989) describes the intensity of the first order change in the sum of all cells of the inverse matrix caused by changes in the technical coefficients. It is defined as:

$$\mathbf{M} = \frac{1}{v}\left[\mathbf{B_{i.}}\mathbf{B_{.j}}\right] = \frac{1}{v}\begin{pmatrix}\mathbf{B_{1.}}\\ \mathbf{B_{2.}}\\ \vdots\\ \mathbf{B_{n.}}\end{pmatrix}(\mathbf{B_{.1}} \quad \mathbf{B_{.2}} \quad \cdots \quad \mathbf{B_{.n}}) \tag{3-8}$$

Sonis et al. (2000) demonstrated that the structure of the MPM is connected with the properties of sectoral backward and forward linkages. The authors argued that the column and row multipliers for MPM are the same as those for the Leontief inverse matrix. Consequently, the key sector analysis based on Rasmussen-Hirschman linkages indices can be carried out within the MPM. Key sectors are defined as sectors with both backward and forward linkages

greater than 1. Backward oriented sectors are defined as sectors with backward linkages greater than 1, and forward linkages less than 1, while forward oriented sectors are defined as those with forward linkages greater than 1 and backward linkages less than 1. Finally, weak sectors are defined as sectors without any linkages greater than 1.

The Rasmussen-Hirschman backward ($\mathbf{BL_j}$) and forward ($\mathbf{FL_i}$) linkages can be written as follows:

$$\mathbf{BL_j} = \frac{\frac{1}{19}\sum_{i=1}^{19} b_{ij}}{\frac{1}{19^2}\sum_{i.j=1}^{19} b_{ij}} = \frac{\frac{1}{19}\mathbf{B_{.j}}}{\frac{1}{19^2}v} = \frac{\mathbf{B_{.j}}}{\frac{1}{19}v} \tag{3-9}$$

$$\mathbf{FL_i} = \frac{\frac{1}{19}\sum_{j=1}^{19} b_{ij}}{\frac{1}{19^2}\sum_{i.j=1}^{19} b_{ij}} = \frac{\frac{1}{19}\mathbf{B_{i.}}}{\frac{1}{19^2}v} = \frac{\mathbf{B_{i.}}}{\frac{1}{19}v} \tag{3-10}$$

In addition to key sector analysis, the structure of the MPM can be rearranged to produce an artificial structural view of the economy. In this case, the sum of the *j*-th column and the *i*-th row of the MPM are rearranged according to the rank-size hierarchy of the backward (for columns) and forward (for rows) linkages. Using this hierarchical system, the elements of the MPM represent the intensities of the first order of field of influence of changes. These intensities are used to measure the inverse important parameters for which a change would create the greatest impact in the input-output system.

3.2.2. Matrix of impacts of synergetic interactions

The MSI **N** deals with simultaneous changes in two elements of the matrix of direct inputs. This matrix allows us to investigate the group of two key sectors that would generate the greatest impact in the economy. It is given by:

$$\mathbf{N} = \mathbf{M} - \mathbf{B} \tag{3-11}$$

MSI can be further decomposed into the scaling effects of the intrasectoral economic activities (**D**) and linkages (**R**) as follows:

$$\mathbf{D} = \mathbf{diag}(\mathbf{B} - \mathbf{M}) \tag{3-12}$$

$$\mathbf{R} = \mathbf{B} - \mathbf{M} - \mathbf{D} \tag{3-13}$$

where **D** is the diagonal of matrix **N** and **R** is the residual matrix with a zero main diagonal.

In the final stage of the decomposition of MSI, the matrix **R** is broken down into two components, **S** and $\mathbf{S_a}$. **S** and $\mathbf{S_a}$ are respectively the symmetric and antisymmetric parts of **R**. They represent the bilateral balances and imbalances between sectoral inputs and outputs. They are given by:

$$R = \frac{1}{2}(R + R') + \frac{1}{2}(R - R') = S + S_a \tag{3-14}$$

where $\mathbf{R}'$ is the transposed matrix.

3.4. Empirical applications

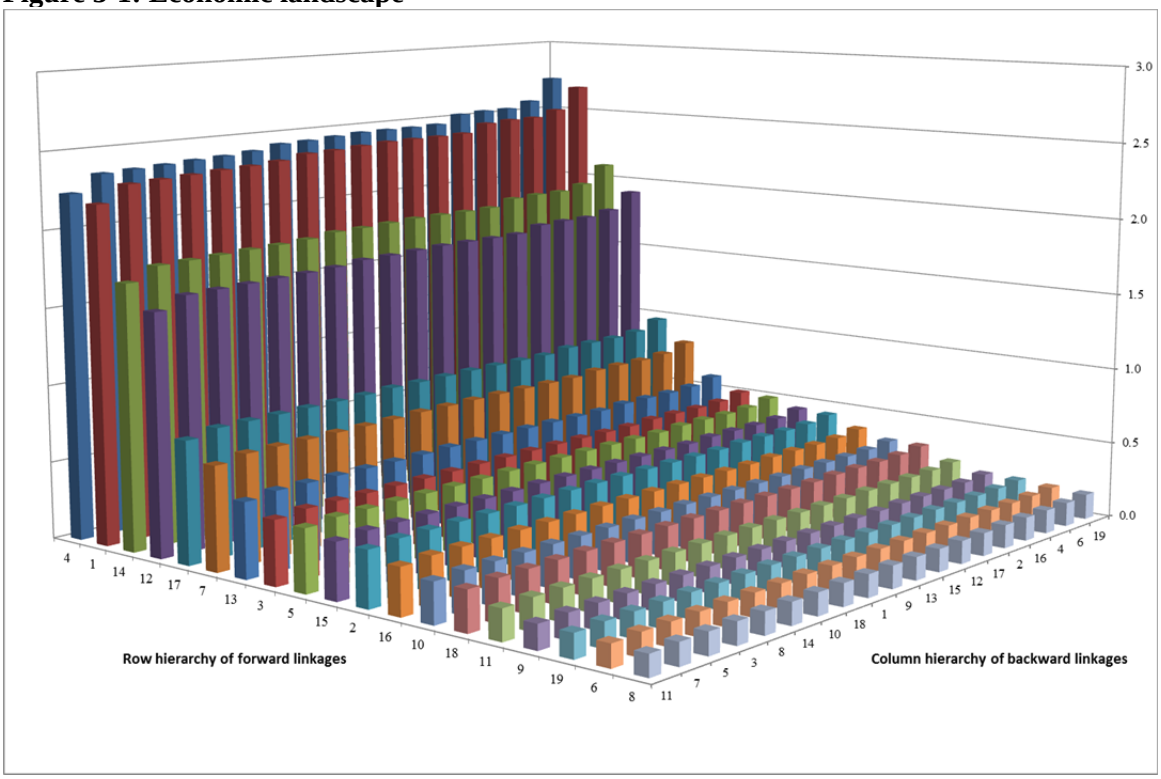
The main aim of this section is to decompose the Leontief inverse of the SAM I constructed in the previous chapter, and design appropriate development policies based on the field of influence of changes. In order to enrich policy design, I devote the first subsection to the analysis of the linkages in DRC's economy.

3.4.1. Economic landscape

Figure 3-1 provides the visual representation of the DRC economic structure in terms of economic landscape, using the information from the multiplier product matrix (Table 3-1). The economic landscape reveals the industries' structural relations through the hierarchy of

backward and forward linkages. This figure shows that at the apex (highest bar) of the hierarchy is the intersection of sector 4 (processed foods) and sector 19 (private households with employed persons), and the second apex, after removing sector 4 (processed foods) and 19 (private households with employed persons) is the intersection of sector 1 (agriculture) and 6 (wood). Figure 3-1 reflects that DRC economy remains at a rudimentary stage.

Figure 3-1: Economic landscape



Source: Author's calculations based on the 2005 DRC SAM.

The absence of mining or any manufacturing sector in the first and second apexes shows that industrial process has not started yet in DRC. Moreover, it is puzzling to notice the remarkable impact of service sectors. In fact, the third and fourth apexes (after removing the first and second) are at the intersection of the sectors 14-4 (Transportation-Processed foods) and 12-16 (Trade-Financial intermediation). This reflects the dual characteristics of the DRC economy where agriculture and service (informal sector) play a more active role in the economy. In addition, sector 1 (agriculture) and sector 4 (processed food) have similar height

of intersection row with the rest of the economy. This indicates they both have the strongest relationships with other sectors. However, the varying landscapes show that there is huge variation in inter-industry linkages, among which most are low.[38]

Table 3-1: The multiplier product matrix

Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	2.38	2.47	2.31	2.48	2.30	2.52	2.30	2.32	2.39	2.35	2.19	2.40	2.40	2.33	2.40	2.48	2.41	2.38	2.67
2	0.39	0.40	0.38	0.41	0.38	0.41	0.38	0.38	0.39	0.38	0.36	0.39	0.39	0.38	0.39	0.41	0.39	0.39	0.44
3	0.45	0.47	0.44	0.47	0.44	0.48	0.43	0.44	0.45	0.44	0.41	0.45	0.45	0.44	0.45	0.47	0.46	0.45	0.51
4	2.43	2.52	2.36	2.53	2.35	2.57	2.34	2.37	2.44	2.39	2.24	2.46	2.45	2.38	2.46	2.53	2.46	2.43	2.73
5	0.44	0.45	0.43	0.46	0.43	0.46	0.42	0.43	0.44	0.43	0.40	0.44	0.44	0.43	0.44	0.46	0.44	0.44	0.49
6	0.15	0.16	0.15	0.16	0.15	0.16	0.15	0.15	0.15	0.15	0.14	0.16	0.15	0.15	0.16	0.16	0.16	0.15	0.17
7	0.73	0.75	0.71	0.76	0.71	0.77	0.70	0.71	0.73	0.72	0.67	0.74	0.74	0.71	0.74	0.76	0.74	0.73	0.82
8	0.15	0.15	0.14	0.15	0.14	0.15	0.14	0.14	0.15	0.14	0.13	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.16
9	0.17	0.17	0.16	0.17	0.16	0.18	0.16	0.16	0.17	0.17	0.15	0.17	0.17	0.16	0.17	0.17	0.17	0.17	0.19
10	0.28	0.29	0.27	0.29	0.27	0.30	0.27	0.27	0.28	0.28	0.26	0.28	0.28	0.28	0.28	0.29	0.28	0.28	0.32
11	0.21	0.22	0.21	0.22	0.21	0.22	0.20	0.21	0.21	0.21	0.19	0.21	0.21	0.21	0.21	0.22	0.21	0.21	0.24
12	1.70	1.76	1.65	1.77	1.65	1.80	1.64	1.66	1.71	1.67	1.56	1.72	1.72	1.66	1.72	1.77	1.72	1.70	1.91
13	0.53	0.54	0.51	0.55	0.51	0.56	0.51	0.51	0.53	0.52	0.48	0.53	0.53	0.52	0.53	0.55	0.53	0.53	0.59
14	1.87	1.93	1.81	1.94	1.81	1.97	1.80	1.82	1.88	1.84	1.72	1.89	1.88	1.83	1.89	1.94	1.89	1.86	2.10
15	0.40	0.41	0.38	0.41	0.38	0.42	0.38	0.39	0.40	0.39	0.36	0.40	0.40	0.39	0.40	0.41	0.40	0.39	0.44
16	0.33	0.34	0.32	0.34	0.32	0.35	0.32	0.32	0.33	0.32	0.30	0.33	0.33	0.32	0.33	0.34	0.33	0.33	0.37
17	0.86	0.89	0.84	0.90	0.83	0.91	0.83	0.84	0.86	0.85	0.79	0.87	0.87	0.84	0.87	0.89	0.87	0.86	0.97
18	0.28	0.29	0.27	0.29	0.27	0.30	0.27	0.27	0.28	0.28	0.26	0.28	0.28	0.27	0.28	0.29	0.28	0.28	0.32
19	0.16	0.17	0.16	0.17	0.16	0.17	0.16	0.16	0.17	0.16	0.15	0.17	0.17	0.16	0.17	0.17	0.17	0.16	0.18

Source: Author's calculations based on the DRC 2005 SAM.

3.4.2. Key sector analysis

Table 3-2 reports the Hirschman-Rasmussen backward and forward linkages indices for DRC in 2005. The forward linkage (in percentage terms) of sector *j* quantifies the change in income in sector *j*, relative to the average change in the economy, caused by a unitary injection in the final demand of all sectors. If the forward linkage for sector *j* is greater than one hundred percent, the change in sector *j*'s income is higher than the average income change in the economy after a unitary injection in all sectors. On the other hand, the backward linkage of sector *j* quantifies the change in economy wide income, relative to the average change in the economy, caused by a unitary injection in the final demand of sector *j*.

[38] The average of individual value in the MPM is 0.74

Table 3-2 shows that fourteen sectors have strong backward linkages. Among them, sector 19 (private households with employed persons), and sector 6 (wood) have the strongest backward linkage. These sectors are followed by sector 4 (processed foods), 16 (financial intermediation), and 2 (forestry). On the other hand, non-metals, mining, textiles, chemicals and construction have the weakest backward linkages. In terms of forward linkages, processed foods, agriculture, transportation and trade are the only four sectors which have strongest forward linkages. There remaining sectors have weak forward linkages.

Table 3-2: Sectoral linkages

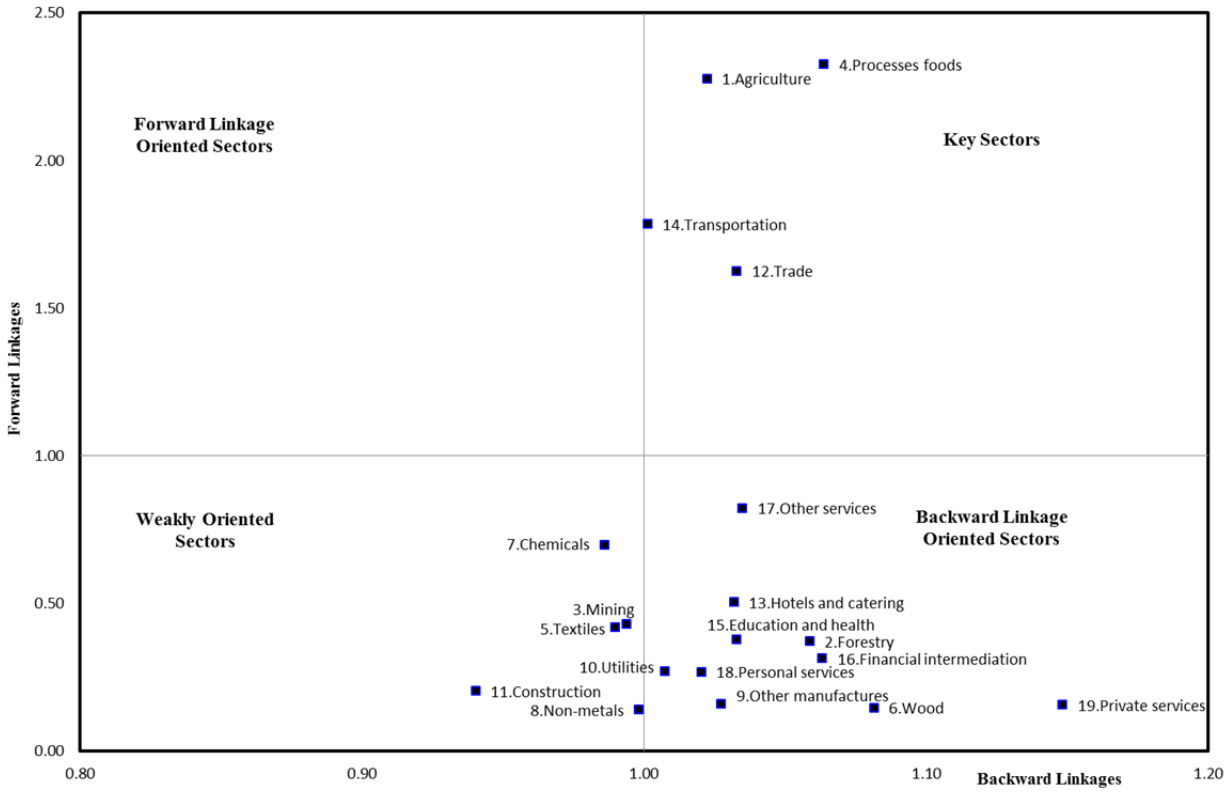
#	Sector	Backward Linkages		Forward Linkages	
		Index	Rank	Index	Rank
1	Agriculture	1.02	11	2.28	2
2	Forestry	1.06	5	0.37	11
3	Mining	0.99	16	0.43	8
4	Processed foods	1.06	3	2.32	1
5	Textiles	0.99	17	0.42	9
6	Wood	1.08	2	0.15	18
7	Chemicals	0.99	18	0.70	6
8	Non-metals	1.00	15	0.14	19
9	Other manufacture	1.03	10	0.16	16
10	Utilities	1.01	13	0.27	13
11	Construction	0.94	19	0.20	15
12	Trade	1.03	7	1.63	4
13	Hotels and catering	1.03	9	0.50	7
14	Transportation	1.00	14	1.79	3
15	Education and health	1.03	8	0.38	10
16	Financial intermediation	1.06	4	0.31	12
17	Other services	1.03	6	0.82	5
18	Personal and other community services	1.02	12	0.27	14
19	Private households with employed persons	1.15	1	0.16	17

Source: Author's calculations.

According to Figure 3-2, which displays the key sectors analysis, sectors 1 (agriculture), 4 (processed foods), 12 (trade) and 14 (transportation) are the key sectors of DRC economy. These four potential key sectors represent 54.9% of total production and are responsible of 80.6% of employment. Sector 3 (mining), 5 (textiles), 7 (chemicals), 8 (non-metals), and 11

(construction) are weak sectors. Finally, it is important to notice that there is no forward oriented sector.

Figure 3-2: Key sector analysis



Source: Author's calculations.

3.4.3. Synergetic sectoral interactions

Table 3-3 presents the top twenty analytically important coefficients. This analysis aims at defining sectors where policy intervention will generate the largest volume change in RDC economy. Table 3-3 indicates that sector 4 (processed food) is responsible for most of important field of influence of changes. As can been seen, these coefficients link sector 4 (processed food) to the rest of sectors except for sectors 3 (mining), 5 (textiles), 7 (chemicals), 8 (non-metals), 9 (other manufacturing), 10 (utilities), 11 (construction) and 14 (transportation). Table 3-3 further indicates that sector 1 (agriculture) is the second sector with most of important coefficients. These coefficients are found between agriculture and sectors 2

(forestry), 4 (processed food), 6 (wood), 12 (trade), 15 (education and health), 16 (financial intermediation), 17 (other services), and 19 (personal services). It is worth mentioning that processed food and agriculture are responsible for the top twenty coefficients with the greater field of influence. For the policy standpoint, this indicates that productivity increase in agro-food industry will have a profound effect on the rest of the economy.

Table 3-3: Inverse important coefficient (top twenty)

Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1		■		■		■						■			■	■	■		■
2																			
3																			
4	■	■		■		■			■			■	■		■	■	■	■	■
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			

Source: Author's calculations.

In Table 3-4, I present the matrix of synergetic interactions that would create the largest change in the production process. Recall that these synergetic effects are generated by a simultaneous change in two coefficients of the inverse matrix. The principal diagonal elements of Table 3-4 represent the additional scale effect. The upper triangular elements are identical to the upper triangular element of the bilateral balances matrix **S**, whereas the lower triangular elements are equal to the lower triangular elements of the bilateral imbalances matrix $\mathbf{S_a}$.

Table 3-4: Synergetic interactions between Sectors: $(S_a/D/S)$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0.99	-0.04	-0.05	**0.10**	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.06	-0.05	-0.04	-0.08	-0.03	-0.07	-0.05	-0.05	-0.02
2	0.00	0.96	-0.04	-0.03	-0.04	0.00	-0.04	-0.04	-0.03	-0.04	-0.04	-0.06	-0.02	-0.04	-0.04	-0.05	-0.02	-0.04	-0.04
3	-0.01	-0.01	0.96	-0.04	-0.04	-0.05	0.09	-0.03	-0.04	-0.04	-0.02	-0.06	-0.04	-0.06	-0.04	-0.05	-0.04	-0.04	-0.05
4	**-0.13**	0.01	0.01	0.93	-0.04	-0.05	-0.04	-0.05	-0.04	-0.04	-0.06	-0.04	**0.10**	-0.06	-0.04	-0.07	-0.05	-0.05	-0.02
5	0.03	0.01	0.00	0.00	1.00	-0.03	-0.01	-0.04	-0.03	-0.04	-0.04	-0.05	0.01	-0.02	-0.04	-0.03	-0.04	-0.03	-0.04
6	0.01	-0.04	0.01	0.01	0.00	0.96	-0.04	-0.04	0.00	-0.04	-0.04	-0.05	-0.05	-0.01	-0.04	-0.05	-0.03	-0.04	-0.04
7	0.02	0.00	-0.10	0.00	0.03	0.00	0.97	-0.01	-0.03	0.00	-0.03	-0.06	-0.04	-0.03	-0.03	-0.04	-0.03	-0.03	-0.05
8	0.02	0.00	0.00	0.02	0.00	0.00	-0.02	1.00	-0.03	-0.04	0.01	-0.06	-0.04	0.01	-0.04	-0.05	-0.02	-0.04	-0.04
9	0.02	0.00	0.01	0.01	0.01	-0.03	0.00	0.00	0.98	-0.03	-0.03	-0.05	-0.01	0.00	-0.03	0.00	-0.04	-0.03	-0.04
10	0.00	0.00	-0.01	0.00	0.00	0.00	-0.05	0.00	-0.01	0.96	-0.04	-0.05	-0.05	-0.05	-0.04	-0.05	-0.03	-0.04	-0.05
11	0.01	0.00	-0.02	0.01	0.00	-0.01	-0.01	-0.04	-0.02	0.00	1.02	-0.05	-0.05	-0.06	-0.05	-0.05	-0.03	-0.04	-0.05
12	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	0.00	0.92	0.01	-0.07	-0.05	-0.07	-0.05	-0.05	-0.06
13	-0.01	0.03	0.02	**-0.14**	0.05	-0.01	0.00	-0.01	0.02	0.00	0.00	-0.05	0.94	-0.04	-0.05	-0.06	-0.05	-0.04	-0.05
14	-0.03	0.00	-0.02	-0.01	0.01	0.03	-0.04	0.05	0.03	0.00	-0.01	0.00	0.01	0.97	-0.06	0.07	-0.02	-0.01	-0.08
15	-0.01	0.00	0.00	-0.01	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.00	0.01	0.00	0.02	0.96	-0.05	-0.04	-0.04	-0.04
16	0.01	0.00	0.01	0.01	0.01	-0.01	0.00	-0.01	0.02	0.00	0.00	0.04	0.00	-0.12	0.00	**1.15**	-0.05	-0.05	-0.05
17	0.00	0.02	0.01	-0.01	0.00	0.01	0.01	0.01	-0.01	0.00	-0.02	0.03	-0.02	0.00	0.00	0.01	0.96	-0.01	-0.04
18	0.01	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.00	0.01	0.00	-0.03	0.00	0.00	-0.03	0.96	-0.04
19	-0.03	0.00	0.01	-0.03	-0.01	0.00	0.01	0.00	-0.01	0.00	0.01	0.01	0.01	0.04	0.00	0.01	0.00	0.00	0.95

Source: Author's calculations.

Note that the diagonal elements of $(S_a/D/S)$ are equal to the diagonal element of D. The lower triangular elements of $(S_a/D/S)$ are equal to the lower triangular elements of S_a. Upper triangular elements of $(S_a/D/S)$ are equal to upper triangular elements of S.

Table 3-4 reveals that sector 16 (intra-financial intermediation) has the highest additional scale effect. Since financial intermediation exhibits the highest sectoral self-influence, policies that promote its efficiency would have the highest potential to reinforce the impacts of agro-food development. With regard to the bilateral balances and imbalances, Table 3-4 illustrates that balance and imbalance effects are very small. Nevertheless, one can find potential pairs of sectors (4, 13: processed foods and hotels and catering) and (1, 4: agriculture and processed foods) that exhibit the largest positive bilateral balancing and imbalancing effects. The economic meaning is that these pairs can exert a significant impact in the economy through the push and pull linkages. This implies that the supply-push in agriculture will affect the output value in processed food, and a push in processed food will influence the production of hotels and catering. Inversely, a change in the final demand of

hotel and catering will exert a demand-pull effect on processed food industry. A similar perspective applies to processed food with agriculture.

3.5. Conclusion and policy implications

The central question in this chapter asked how the industrial structure can guide the choice of the development strategy in DRC. This paper analyzed the structural features of the DRC economy and quantified the strength of the intersectoral linkages. First, I applied the field of influence framework to define the economic landscape, identify key sectors, and examine the synergetic interactions between sectors.

The results indicate a coexistence of a rudimentary agriculture with a dynamic service sector. DRC mainly exports mineral with very limited value addition, and imports manufactured goods. 99.1% of mining production is exported, and it represents 69.1% of total exports. On the order hand, 64% of imports are composed by chemicals, other manufactures, and processed foods.

The study reveals that inter-industrial linkages are very low. Nonetheless, I identified agriculture, processed foods, trade, and transportation as four potential key sectors. More interestingly, the findings indicate that agriculture and processed food industries have the potential to produce the most significant volume change in DRC economy, and as a consequence, to enhance growth and create employment. From a policy standpoint, these results highlight the importance of creating agriculture value chains and establishing a productive and competitive agro-food industry. This suggests that DRC public policymakers promote agro-food industry and create markets for agriculture and food products. Strategies to create agro-food industry should prioritize increasing productivity and value addition in agriculture as it uses rudimentary and outdated techniques. Similar policies should also increase processing capacity in the food sector. Since productivity needs to be increased through adoption new technology or improved inputs, policymarkers should ensure the

provision of adequate seeds, fertilizers, chemicals, and machinery. Similarly, value addition should be made through cleaning, washing, sorting, separating, grading, processing, and packing. In addition, I found that the share of subsistence small-scale farmer is high. Therefore, an implication of this is the possibility to design specific policy support that help organize small-scale farmers into small networks to help them improve the quality of products and increase resilience to shocks.

To create a competitive agro-food industry, a strategy is needed to ensure that DRC become a good supplier of agriculture and food products. Thus, public policy should increase the efficiency of transportation and marketing infrastructure, and thus reduce transaction costs in agriculture and food products. Investment in trade and transportation should be given a priority as these sectors have above average backward and forward linkages. Investment in transportation through road construction, for example, should aim at improving distribution network and help to connect agriculture and food producers to local or foreign markets. With regard to trade sector, policies should aim at increasing market access through trade facilitation and the vulgarization of ICTs such as mobile phones. Moreover, as one might have seen from recent experience of some African countries, trade and marketing policies should aim at creating premium products. Accordingly, food industry deserves further attention as it faces high import competition. In this regard, trade and protection policies should target infant industries in the food sector while other policies help them increase competitiveness.

Finally, I found that financial intermediation has the greatest additional scale effect. This means that this sector has the highest potential to reinforce agro-food industry development. The policy implication that emerges from this finding is that public policy would have to increase farmers' access to credit and finance. Corollary, our analysis also pinpoints that although mining is a weakly oriented sector, it remains necessary for export expansion and economic growth in DRC. This implies that the creation of backward and forward linkages is essential for mining to play a major role in RDC industrialization. This is

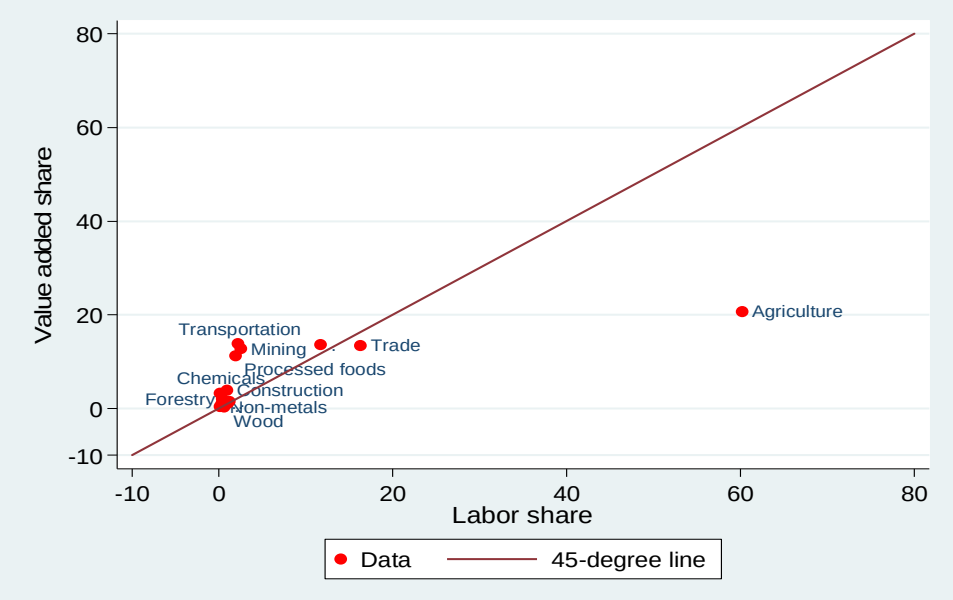
possible if mining rents are used to finance agro-food led industrialization. Connecting the mining sector to the domestic economy can be done by investing those rents in skills and industrial infrastructure development. This strategy has significant implications for moving mining from a weak to a key sector.

Chapter 4. Agricultural modernization, structural change and pro-poor growth: Policy options for the DRC

4.1. Introduction

The analysis in the previous chapter shows that agricultural transformation is essential for DRC because it has huge potential to spur growth and raise income. Agriculture employs most of the labor in DRC and produces the largest percentage of total value added. Figure 4-1 shows that agriculture employs 60.2 percent of the Congolese labor force and generates about 21 percent of total value added. Sectors such as textiles, chemicals, construction, and forestry only produce a small share of value added and contribute marginally to employment creation. Figure 4-1 further indicates that agriculture and trade sectors lie below the 45-degree line, meaning that the share of employment in these sectors is higher than the share of value added from these sectors. However, the largest gap between the contribution to value added and employment appears to be in agriculture. This indicates that agriculture has the lowest productivity in DRC's economy.

Figure 4-1: Profile of sectoral employment and value added (2005)



Source: Author's calculations based on DRC national accounts, INS (2008).

Agriculture is the most unproductive sector in DRC because of inconsistent and uncoordinated agricultural development strategies, coupled with conflict and the progressive withdrawal of the government from supporting agricultural activities. In fact, government policy implemented since 1966 led to the collapse of large-scale commercial agriculture, favored subsistence agriculture, and distorted economic incentives against agriculture. In addition to this, the government removed all subsidies and price support measures to agriculture in 2002. Consequently, farmers use a rudimentary agricultural technology mostly based on outdated production methods and inputs. Agriculture also faces high transaction costs due to the lack of infrastructure most of which was destroyed during political conflicts. Low productivity in agriculture entails unstable and low paid jobs. As a result, an overwhelming proportion of agricultural workers are poor. Four out of every five rural poor work in agriculture. In urban areas, agriculture accounts for one-third of the poor.

Nevertheless, agriculture is still attracting labor in both urban and rural areas. According to Herderschee et al. (2012), agriculture provided employment for 10 million people in 2005 and 15 million in 2010. Despite the low productivity, labor accrues in agriculture because it can produce the amount of food necessary for their subsistence. This implies that most of the farming activities are of a small scale and aim to increase food security. Given its low productivity, increasing the amount of labor and land is the only way to raise production in agriculture. Labor flows to subsistence farming as it uses essentially manual work, whereas large-scale farmers tend to expand land. Indeed, DRC is far from reaching the agriculture frontier, as it uses only 11 percent of the 80 million hectares of arable non-forest land for agriculture. However, in recent years, much of agricultural land has been developed for export-oriented large-scale commercial agriculture.[39] These agricultural

[39] According to http://foreignpolicy.com/2013/12/17/green-rush/, half of the DRC's agricultural lands are being leased to grow crops, including palm oil for the production of biofuels.

investments are made by foreign investors to secure their own food needs. This constrains access to land for small-scale farmers.

Against this background, agricultural productivity improvement is the fundamental policy to initiate agricultural transformation and raise income of the poor (Alvarez-Cuadrado and Poschke 2011; Ngai and Pissarides 2007). The reason is that productivity improvement "pushes" labor out of agriculture and increases farmers' real wages; "pulls" jobs in sectors that use agriculture as inputs; and increase supply of affordable food in the economy. The empirical literature reports strong and robust effects of agriculture productivity on poverty (Thirtle et al. 2003; Irz et al. 2001; de Janvry and Sadoulet 2010). However, the magnitude of poverty reduction due to agricultural productivity growth varies largely across countries, depending on the way they developed and used new technologies (de Janvry and Sadoulet 2010).

The literature documents a range of policies to increase agriculture productivity and enhance income-increasing structural change.[40] Among them, technological change has been acknowledged as the principal driver of productivity growth (OECD 2012; Morris et al. 2007; DFID 2006). However, it is worth mentioning that the innovation, selection, and adoption of new technologies depend on the agriculture frontier, factor endowment, and market imperfections. Hayami and Ruttan (1970) used data on agriculture inputs to assess how endowment drove the direction of technical change in the US and Japan during 1880-1960. They found that land abundance in the US favored labor-saving technological change while the land scarcity in Japan led to the development and adoption of land-saving technologies. As a mechanization strategy, labor-saving technological change consists of using tractors and machinery, whereas land-saving technological change focuses on biological and chemical innovations. A recent successful case of land-saving technological change occurred during the

[40] There are policies within agriculture and outside agriculture. But this research focuses on policies within agriculture.

Green Revolution in Asia. The Green Revolution was an intensifying of input-based production characterized by the use of high-yielding and fertilizer-efficient new varieties of seed (rice and wheat). Policymakers initiated this type of agricultural transformation to increase food production and reduce hunger and malnutrition in the 1960s. Hence, it is conceptually clear that the Green Revolution increased agriculture and food production. Empirical results also indicate that it led to poverty reduction as it raised farmers' income and increased food affordability.

Though it is expected that agricultural productivity improvement tends to reduce poverty, the extent to which it reduces inequality and benefits small-scale farmers is still open to question. For instance, the pro-poorness of the Green Revolution has been disputed, since its effectiveness in reducing inequality is not straightforward. The main argument states that the Green Revolution worsened income distribution as it was biased in favor of larger farmers and missed the poorer subsistence small-scale farmers (Das 1998; Griffin 1979; Freebairn 1995; Goldman and Smith 1995). Furthermore, it increased landless farmers and the demand for unskilled labor, which in turn lowered wage laborers (Hazell and Ramasamy 1991; Glaeser 1987; Cleaver 1972).

Despite this, the experience of Asia points to a clear consensus on the role of strong public policies and investment in creating a pro-poor Green Revolution (Eicher 1995; Smale 1995; Hazell 2009). These policies include agricultural research and development, irrigation, rural roads, access to credit, and price support policies. In addition, those policies had been successful when they have been implemented together. However, there is no empirical assessment on the pro-poorness of technological change and the complementary rural development policies in Africa, especially in DRC.

This paper thus aims to assess what are the better and worse models for agricultural modernization in DRC. Agricultural transformation is qualified as a better model only if it is centered on small-scale farmers as most of them are poor and have limited resource

endowment relative to other farmers. To put it differently, a better model for agricultural modernization produces pro-poor effects where poor households gain relative to the richer ones. Several recent studies have looked at the pro-poor effects of policies, particularly using CGE-microsimulation model (Boccanfuso et al. 2013a, 2011; Boccanfuso et al. 2013b; Annabi et al. 2008; Ravallion and Lokshin 2008). Most of the studies do not show factors behind the differences in the impacts of policy on pro-poor growth or decompose the changes in poverty into growth and distribution components, but rather show how poor benefit/lose relative to rich segments of the population. Boccanfuso and Kaboré (2004), however, did find that the relationship between poverty, growth, and inequality relationship is heterogeneous and conditional on context.

To look at the pro-poorness of different strategies for modernizing agriculture, I combine three techniques, namely a computable general equilibrium model, a household-survey based microsimulation, and least square regressions. I adopt a sequential approach that can be described in four steps. In the first step, I evaluate the effects of agricultural modernization strategies on employment, wages, and rents, and the price of goods and services. I use a CGE-microsimulation model that captures various links through which agricultural modernization affects households. These links include the return to labor and land, the price of goods, the impact on non-agriculture sector, and sectoral labor mobility. Then I feed the changes from the CGE model into a microsimulation model, which takes into account household heterogeneity in terms of factor endowments and consumption patterns, to generate welfare gains or losses at the household level. Using these welfare changes, in the third step I apply the pro-poor growth framework to assess which of the agricultural modernization strategies is pro-poor and the extent to which growth and redistribution contribute to welfare changes. Finally, I select a strategy that produced pro-poor welfare gains in the previous stage, and use a least square regression to quantify the determinants of pro-poor agricultural modernization at the household level.

The rest of the paper is organized as follows. Section 4.2 discusses some stylized facts on agriculture in DRC. Section 4.3 presents the theoretical framework of agricultural modernization, while Section 4.4 explains the features of the CGE-microsimulation model and presents an analytical framework for pro-poor analysis. Section 4.5 discusses and presents the results of policy experiments. Finally, Section 4.6 provides a summary of the results and lessons for policymakers.

4.2. Overview of the Congolese agricultural sector

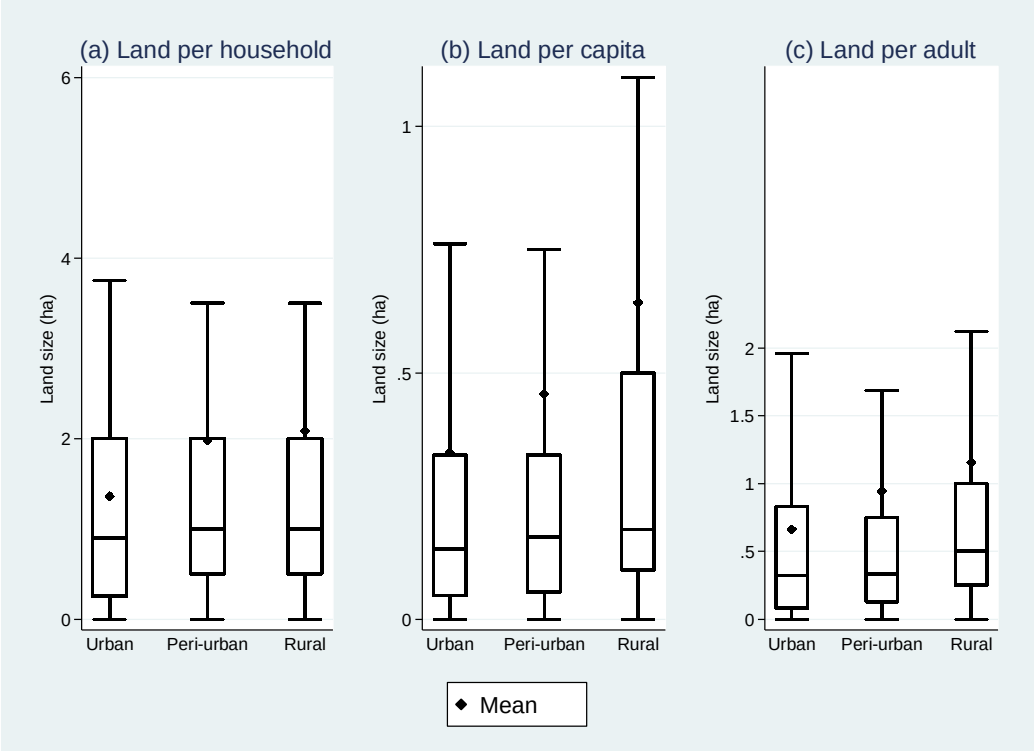
The Congolese economy depends on the agricultural sector, which contributes more than 20 percent of the country's GDP. However, it is important to note that the importance of agriculture is not a result of improved agricultural production. Rather, it is due to the marked reduction of mining production, which declined faster than agriculture. In recent years, agriculture became an urban phenomenon, especially for food security reasons and proximity to markets. Urban or peri-urban farming in the DRC is not only a response to the rise in food insecurity; it also serves as an income-generating activity because of the increasing demand for vegetables in cities and soaring food prices. As a result, the agricultural sector has become the second largest employer for urban workers after the trade sector. This section describes some key characteristics and features of agriculture in DRC, relevant to the problems under review. These are (a) land size and distribution; (b) fertilizer use; (c) production and productivity; (d) agricultural trade patterns; and (e) agriculture's contribution to poverty.

4.2.1. Land size and distribution

Land is a very important asset for DRC farmers for its economic, cultural and spiritual significance. Due to bad governance (corrupted judiciary system, weaken traditional land rights, flawed land law (uncertain land rights, outdated land registry), however, land has become the key driver of conflict in the eastern part of the country (Vlassenroot and Huggins

2005; Huggins 2010). The most core issue in conflicts over land concerns limited access to land, land succession problem, and inequitable distribution. There are other factors behind land issues in DRC, such as colonization, land grab, migration, and climate change (Long 2011; Chausse et al. 2012; African Union et al. 2012). The consequences of these measures and events are visible in all their extent: increased landless and reduced average land size.

Figure 4-2: Boxplots for land size



Source: Author's calculations based on the *Enquête 1-2-3*, DRC (2005).

For instance, the highly skewed nature of land distribution in DRC is evident if one looks at Figure 4-2 where I plot the value of land per household, per capita and per adult across three locations, namely urban, peri-urban, and rural areas. The figures indicates that farms are very small; the average land holding per household is in order of 1.3 hectare (ha) in urban areas and around 2 ha in peri-urban and rural areas, whereas the median of land per household is 0.8 in urban areas, and 1 ha in peri-urban and rural areas. The median are about 50 percent lower than the mean, implying the existence of high land inequality. Moving to the per capita

distribution, Panel (b) of Figure 4-2 shows that average land per capita is 0.3 hectares in urban areas, while it is 0.4 and 0.6 hectares in peri-urban and rural areas. Despite the dominance of small farms, it is interesting to note that the average land per capita is not much of issue as it ranks DRC among countries with more than an average of potential agricultural land. On average, land per adult is a bit more than half a hectare in urban areas but nearly 1 hectare in peri-urban and 1.15 hectares in rural areas. As one would expect, the average land per adult is significantly higher in rural areas because of migration to urban areas.

The significant discrepancies between mean and median land size suggest the limitation of the figures to assess land distribution in DRC. Therefore, I complement the land distribution analysis by decomposing the Gini coefficient of inequality between urban, peri-urban, and rural areas. In this study, I decompose the Gini coefficient into three components, namely a within-group inequality term, a between-group inequality term, and an overlap term. The within-group inequality term is a weighted sum of the inequalities calculated for each area (urban, peri-urban, rural), whereas weights depend on the population and land share of each area. The between-group inequality term is calculated on the total population where the land size of each person in the area is replaced by the average land size in the area where he lives. This component of inequality thus indicates the mean difference across areas. The overlap term is a residual term that arises because the areas' land size ranges overlap. It reflects the interaction effect among groups.[41]

Furthermore, Table 4-1 indicates that land distribution is more unequal in rural area, as the Gini of rural area is higher for land per household, land per capital, or land per adult. Similarly, rural area is the most responsible of land inequality, as it contributes to 61 percent of total land inequality. This leads the within-area inequality become high in explaining land

[41] For a discussion on the interaction effect, see Mookherjee and Shorrocks (1982), Lambert and Aronson (1993), and Lambert and Decoster (2005).

inequality than the between-area inequality. The high share of within-sector term calls for attention in reducing land inequality in rural sector.

Table 4-1: Land distribution in DRC

Areas	Land per household			Land per capita			Land per adult		
	Gini index	Absolute contribution	Relative contribution	Gini index	Absolute contribution	Relative contribution	Gini index	Absolute contribution	Relative contribution
Urban	0.459	0.003	0.007	0.548	0.004	0.007	0.459	0.003	0.007
	(0.011)	(0.000)	(0.001)	(0.027)	(0.001)	(0.001)	(0.012)	(0.000)	(0.001)
Peri-urban	0.453	0.007	0.015	0.539	0.008	0.014	0.453	0.008	0.016
	(0.012)	(0.001)	(0.002)	(0.024)	(0.001)	(0.002)	(0.012)	(0.001)	(0.002)
Rural	0.467	0.285	0.613	0.564	0.359	0.640	0.463	0.288	0.622
	(0.005)	(0.006)	(0.012)	(0.008)	(0.009)	(0.014)	(0.005)	(0.007)	(0.013)
Within	---	0.296	0.635	---	0.370	0.660	---	0.298	0.645
Between	---	0.027	0.059	---	0.030	0.053	---	0.026	0.055
Overlap	---	0.143	0.307	---	0.161	0.287	---	0.139	0.300
National	0.466	0.466	1.000	0.561	0.561	1.000	0.463	0.463	1.000
	(0.004)	(0.004)	(0.000)	(0.007)	(0.007)	(0.000)	(0.004)	(0.004)	(0.000)

Source: Author's calculations based on the *Enquête 1-2-3*, DRC (2005).

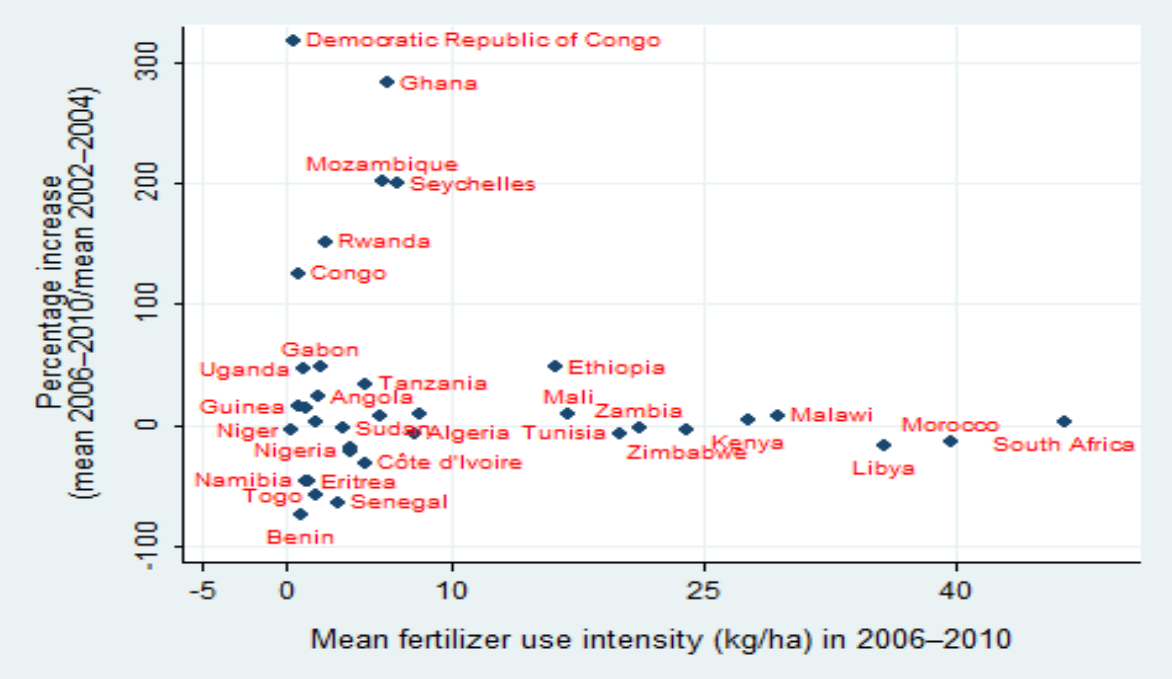
4.2.2. Fertilizer use

Now, I turn to the use of fertilizer in DRC. Figure 4-3 compares the use of fertilizers in DRC and some African countries. One can see that DRC uses less fertilizer than its neighboring countries. Between 2006 and 2010, the average intensity of fertilizer use in DRC was only 0.47 kg/ha, while it reached 46.51 and 36.69 kg/ha in South Africa and Morocco. High cost of fertilizers is the main reason that limits the fertilizer use in DRC. Most of these costs are due to imports and transportation costs, as DRC imports about 10,000 metric tons of fertilizer annually. According to Nweke et al. (2000), most of farmers in DRC have low incentive to invest in fertilizer because imported wheat and rice are available at competitive price in nearby commercial markets. Unavailability of credit and support price measures for dealers and farmers plays a major role in limited use of fertilizer. In fact, fertilizer import business in DRC is too small and unstable to ensure its survival.

The other factors for low fertilizer use are the lack of adequate knowledge about fertilizers, bad quality of available fertilizers, poor extension services, and local farming

practice. Mumvwela (2004) stated that farmers in western DRC use also less of the livestock manure which indeed is available. Despite the low intensity of fertilizer use, it is interesting to see that DRC is rapidly increasing the amount of fertilizer. Figure 4-3 also shows that DRC increased by 300 percent the use of fertilizer between 2006-2010 and 2002-2004. Nevertheless, there is still much to do, as yields have not responded yet to the increase of fertilizers.

Figure 4-3: Fertilizer use



Source: Author's calculations based on FAOSTAT database, FAO (2014).

4.2.3. Agricultural production and productivity trends

Table 4-2 shows the growth rates of production of the main agricultural products in the DRC between 1960 and 2010. The main food crops (cassava, plantains, and maize) accounted for 80 per cent of total agricultural production, while cash crops represented less than 15 percent. Data in Table 4-2 reveal a widely varying pattern of production growth rates among the different agricultural products over 1960-2010. This is the result of uncoordinated agricultural

development strategies, coupled with conflict and the progressive withdrawal of the government from supporting agricultural activities.

Table 4-2: Agricultural growth rates and area harvested (percent)

	Per cent of agriculture production in 2011	Growth rates of agriculture production					Growth rates of area harvested				
		1960-70	1970-80	1980-90	1990-00	2000-10	1960-70	1970-80	1980-90	1990-00	2000-10
Food crops											
Cassava	67.48	17.51	26.14	14.07	-18.72	1.20	-0.77	0.52	1.10	0.24	-1.90
Plantains	6.73	22.82	23.48	-4.75	-41.13	14.35	-35.47	-58.59	-4.96	14.77	3.27
Maize	5.83	21.18	35.81	31.97	4.37	7.29	3.70	13.54	21.70	19.64	4.38
Bananas	1.77	17.58	20.20	-6.53	-15.21	13.42	-0.70	-7.48	-22.62	3.18	10.70
Rice, paddy	1.53	53.24	31.36	21.85	-18.97	4.93	5.71	-3.07	-20.57	-18.60	11.66
Sweet potatoes	1.13	11.12	19.63	2.20	-60.37	8.95	37.11	37.15	37.43	23.44	23.29
Soybeans	0.09	48.52	53.34	45.64	8.89	25.62	42.87	7.54	10.05	0.03	1.95
Cash crops											
Palm oil	0.81	-10.88	-17.74	8.81	-1.43	6.21					
Wheat	0.04	-6.55	39.67	49.62	-8.42	9.17	-8.59	-8.25	-12.56	-34.76	6.10

Source: Author's calculations based on the FAOSTAT database, FAO (2014).

Cash crops were the backbone of DRC agriculture in the 1960s. In particular, palm oil generated half of total export earnings and made the DRC the second largest exporter of this crop in the world. As a result of a succession of policy strategies and measures, however, the production of cash crops (rubber, sugar, coffee, and cotton, in addition to palm oil) declined starting in the early 1970s. For instance, the production of palm oil fell from 224,000 metric tons in 1961 to 187,000 metric tons in 2011. This coincided with the implementation of goal no. 80 of a 10-year plan of industrialization through domestic and external loans. The collapse of cash crop production was accelerated by "Zaïrianization" (1973-1974), a policy of expropriation of foreign-owned production units by the government, which then handed them over to nationals. This policy led to the collapse of large-scale commercial agriculture, favored subsistence agriculture, distorted economic incentives against agriculture (Otchia 2013), and led to conflicts. Growth in palm oil production resumed in the 1990s as a result of

another agricultural and rural development plan, *Le Plan Directeur,*[42] but could not be sustained because of looting (1991-1993) and war (1998-2002).

War and civil conflict in the 1990s negatively affected production of food crops as well. Table 4-2 indicates that sweet potatoes, plantains, rice, cassava, and bananas experienced a large drop during 1990–2000. In spite of this decline, the agricultural sector has continued to serve as the backbone of the Congolese economy. Growth of agricultural production, especially food crops, resumed during 2000-2010. Production of soybeans – which are grown extensively for their nutritional qualities – grew by 25.6 percent while that of plantains and bananas grew by 14.4 and 13.4 percent, respectively. However, as long as production technology remains rudimentary and producers lack improved varieties and inputs, the growth of food crop production continues to depend on available quantities of the basic production factors of land and labor. For example, the harvested area of sweet potatoes and paddy rice grew by 23.3 and 11.7 percent, respectively, from 2000 to 2010.

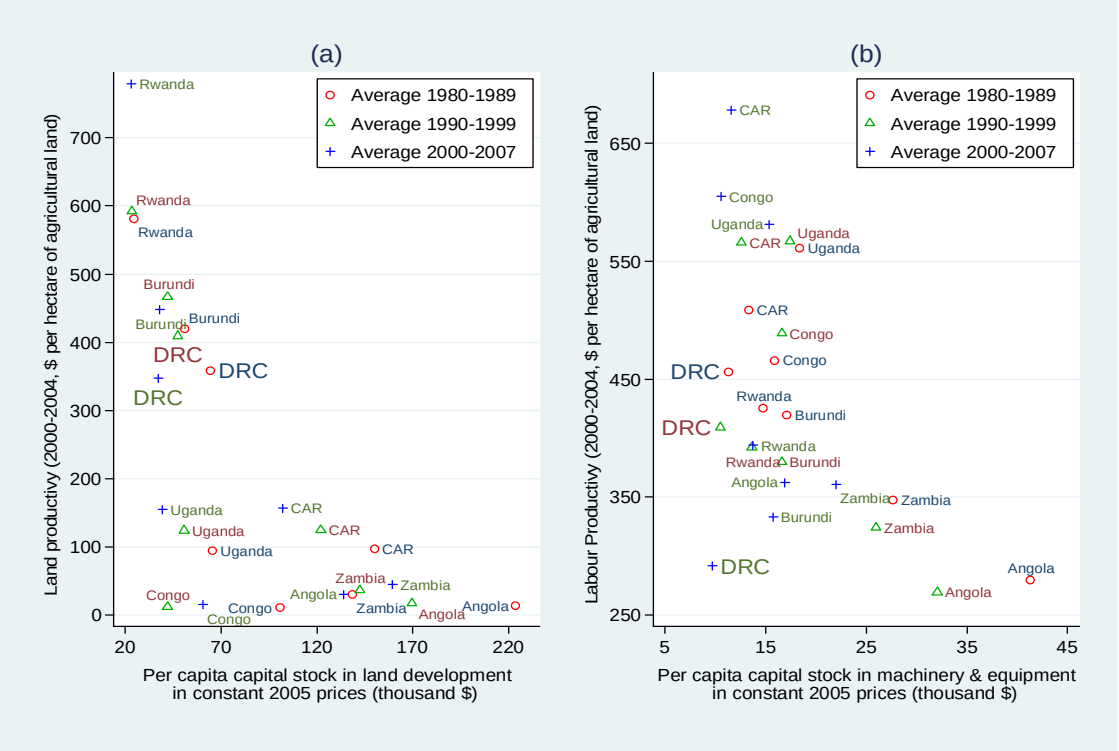
Concerning agricultural productivity, panel (a) of Figure 4-4 displays agricultural land productivity and the per capita capital stock in land development, while panel (b) plots agricultural labor productivity and per capita capital stock in machinery and equipment. [43] As can be seen, land productivity increased between 1980-1989 and 1990-1999, but dropped afterward due to the collapse of infrastructure and frequent displacement of farmers during the war period. Labor productivity, on the other hand, decreased continuously starting in 1980-1989, and then fell drastically between 1990-1999 and 2000-2007. Land and labor productivities in DRC are low and decreasing for various reasons, including the lack of investment in accumulating capabilities, low fertilizer use, land size, war and displacement, the informal character of agriculture, and the rudimentary nature of technology used in this

[42] This plan aimed to design regional and sectoral strategies to promote food security, and to define the role of the state and the private sector.

[43] Land productivity indicates the total output per hectare of agricultural land, whereas labor productivity is expressed as the value of agricultural production per agricultural worker. Both land and labor productivity are expressed in 2004-2006 US$.

sector. For instance, Figure 4-4 indicates that per capita stock in land, and machinery and equipment development is decreasing since 1980-1989.

Figure 4-4: Labor and land productivity in the RDC and neighboring countries



Source: Author's calculations based on FAOSTAT database, FAO (2014).

4.2.4. Agricultural trade patterns

Exports from the DRC, after having more than doubled from 1961-1980, decreased sharply during 1980-2000, as shown in Table 4-3. The reason is that the development policies implemented during the latter period, such as Zaïrianization, undermined the viability of large-scale agricultural projects and disrupted the maintenance of rural infrastructure and support services, as discussed in the previous section. Exports of palm oil, rubber, and cotton collapsed in the 1990s, and in later years DRC agricultural exports came to be dominated by bran of wheat and coffee, which amounted to 62.8 per cent of such exports in 2010.

Table 4-3: Agricultural exports, selected years

	1961	1970	1980	1990	2000	2010
Total agricultural exports (thousand constant $)	107,340	112,196	234,839	139,080	39,308	75,120
Export share in total agricultural exports (per cent)						
Bran of wheat	0.00	0.00	16.25	14.63	41.12	52.09
Cocoa beans	1.23	1.43	2.26	3.28	4.84	2.09
Coffee, green	8.27	16.74	40.16	63.54	50.02	10.75
Cotton lint	3.71	2.48	1.19	0.00	0.34	0.00
Palm oil	37.62	34.08	5.42	0.00	0.00	0.90
Rubber nat dry	9.18	9.86	10.55	4.25	0.27	1.03
Tea	1.23	1.73	0.79	1.59	0.15	0.16
Other	38.76	33.69	23.37	12.71	3.25	32.98
Total	100	100	100	100	100	100

Source: Author's calculations based on FAOSTAT database, FAO (2014).

Since the level of food production is low, the DRC dependency on imported food has increased. Table 4-4 indicates that food imports increased approximately 40-fold between 1960 and 2010, from US$23 million in 1960 to US$977 million in 2010. Major imports included flours of wheat and maize, sugar, palm oil, and meat. As can also be seen in the table, the DRC only started to import significant amounts of maize, sugar, and palm oil in 2000.

Table 4-4: Food imports, selected years

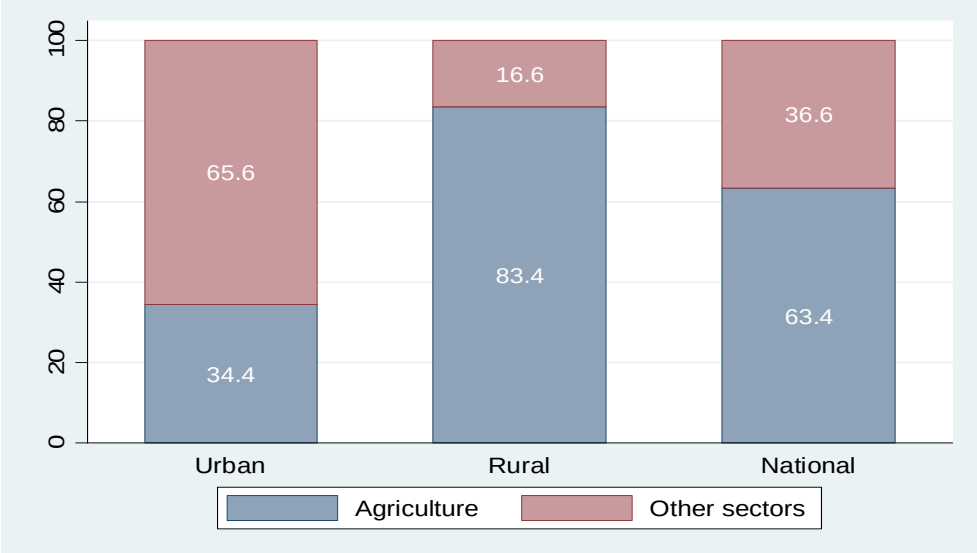
	1961	1970	1980	1990	2000	2010
Total food imports (thousand constant $)	22,792	61,887	156,900	241,393	214,424	977,293
Import share in total agricultural imports (%)						
Wheat	0.03	0.00	39.60	29.36	21.34	28.66
Flour of maize	0.00	0.00	0.00	0.00	7.47	13.18
Flour of wheat	32.47	27.82	1.76	11.37	18.03	9.68
Sugar raw centrifugal	0.00	0.00	0.00	0.00	7.79	8.95
Palm oil	0.00	0.00	0.00	0.00	0.94	5.61
Chicken meat	0.65	0.41	0.95	4.30	2.52	4.19
Rice – total (rice milled equivalent)	14.81	8.52	6.19	16.60	10.95	3.41
Malt	15.43	12.43	4.76	4.88	3.14	3.31
Other	36.60	50.82	46.74	33.49	27.83	23.01
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Author's calculations based on FAOSTAT database, FAO (2014).

4.2.5. Agriculture and poverty

Figure 4-5 plots the breakdown of the poverty headcount by sectors of activity,[44] i.e. agriculture and other sectors, and compares it across urban and rural areas. This allows for evaluating the contribution of agriculture to poverty reduction. The figure clearly shows that the agricultural sector is home to the poor. In rural areas, where the poverty rate is extremely high, 83.4 per cent of poor households work in agriculture, while only 16.6 percent of the rural poor work in other sectors. In urban areas, the agricultural sector accounts for 34.4 per cent of the poor population, which is still very high compared to the trade and transportation sectors.[45] At the national level, the share of poor households that work in agriculture is 63.4 per cent. It can thus be concluded that high poverty rates and the recent rise in rural poverty are at least partly related to the fall in labor and land productivity in agriculture described in Section 4.2.3.

Figure 4-5: Distribution of poverty by economic sector in 2005 (percent)



Source: Author's calculations based on the *Enquête 1-2-3*, DRC (2005).

[44] The consumption per adult equivalent used in this study was adjusted using FAO's adult equivalent scale from FAO/WHO/UNU (2004) and Collier et al. (2008).

[45] In the DRC, the trade and transportation sectors account for 20.7 and 9.1 per cent, respectively, of employment of the urban poor.

Turning to the structure of budget shares and their distribution across groups, Table 4-5 reports a product-disaggregated breakdown of consumption expenditure by deciles of the income distribution. Here the interest is in examining how the expenditure allocation across different consumption items evolves with the income level of the household. Several points are worth noting. Looking first at food expenditure, it is important to highlight the importance of food consumption in Congolese households' expenditure. Table 4-5 shows that Congolese households allocate the highest share of their expenditure to food consumption, and that this share decreases for rich households, following Engel's Law. Apart from food consumption, the category that includes housing, electricity, gas, and water represents the second largest expenditure item. The share of this category is almost homogeneous across all households, averaging 14 percent of total expenditure. The expenditure breakdown implies that after households cover their needs in food and housing, they have little money left for other services such as education and medical care. This is especially true for poor households: as can be seen, the share of education in total expenditure for the three lowest deciles is close to 1 percent.

Table 4-5: Distribution of consumption by expenditure group (percent)

Products	Expenditure group (decile)									
	1	2	3	4	5	6	7	8	9	10
Food consumption	72.1	72.0	71.8	71.1	70.2	68.9	71.3	68.0	64.8	52.7
Marketed	40.1	40.2	41.8	42.3	43.9	47.1	51.7	51.5	54.8	48.5
Home-produced consumption	32.0	31.8	30.0	28.8	26.3	21.8	19.6	16.5	10.0	4.2
Beverage and tobacco	2.7	2.4	2.3	2.2	2.3	2.1	2.8	2.2	2.8	1.9
Clothing & footwear	3.5	3.9	4.8	4.8	4.7	4.6	4.2	4.7	4.3	6.0
Housing, electricity, gas, water	15.8	14.3	13.6	12.9	14.0	13.7	12.3	13.2	13.8	16.2
Medical care	2.8	2.7	2.6	2.6	2.6	3.1	2.5	3.0	2.9	4.2
Transportation & communications	0.2	0.7	0.8	1.3	1.5	2.1	1.7	2.8	3.9	8.6
Education	0.8	1.1	1.1	1.3	1.3	1.7	1.5	1.6	1.7	3.0
Recreation & culture	0.2	0.4	0.4	0.4	0.5	0.6	0.5	0.7	0.8	1.2
Restaurant & hotels	0.9	0.7	0.5	1.1	0.8	1.0	0.8	1.3	2.2	2.8
Other services	1.1	1.9	1.9	2.2	2.1	2.3	2.2	2.4	2.8	3.3
Total	100	100	100	100	100	100	100	100	100	100

Source: Author's calculations based on the *Enquête 1-2-3*, DRC (2005).

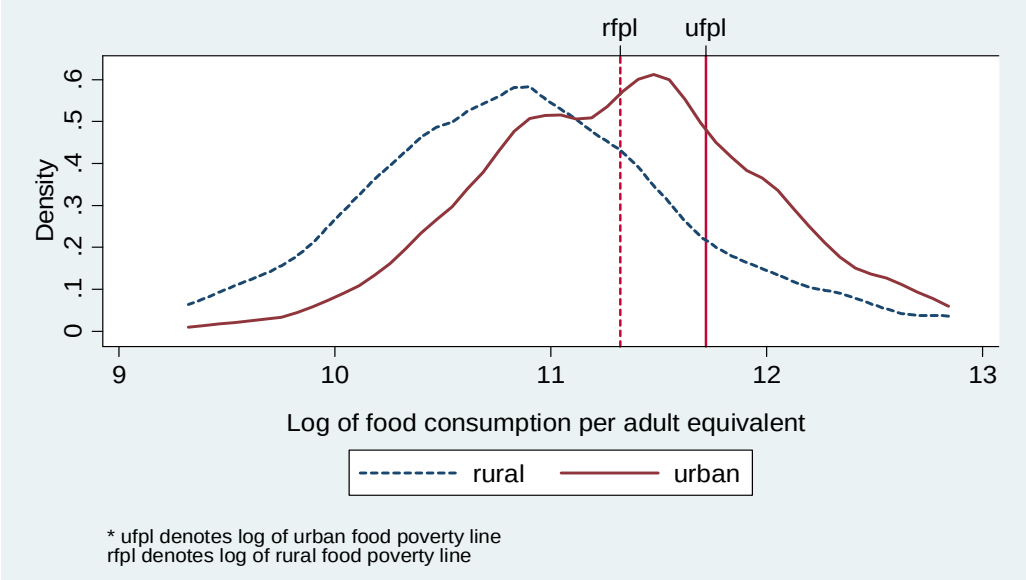
In order to obtain more detailed information on food consumption patterns, Table 4-5 disaggregates food expenditure into market goods consumption and home-produced consumption. The food consumption pattern varies significantly using this disaggregation. Market food consumption represents 40 percent of poor households' expenditure, and this share increases with income. This means that rich households spend a larger share of their income on market goods than poor households. Looking at the home-produced consumption pattern also provides some important insights for policymakers. Home-produced consumption represents 32 percent of total expenditure for the poorest decile, which is approximately half of their food consumption expenditure, but this share declines significantly with income. It is 26.3 percent for the fifth income group decile, 10 percent for the ninth decile, and 4 per cent for the richest decile.

Figure 4-6 extends the expenditure analysis by plotting the kernel density estimates of urban and rural households for food consumption.[46] The figure plots the estimated density function of food consumption per adult equivalent for urban and rural households. It can be clearly seen that the distribution of the log of food consumption per adult equivalent for urban households is skewed to the left, while for rural households, the distribution is slightly skewed to the right. Two vertical lines represent the food expenditure poverty line for urban and rural areas.[47] This enables one to assess the potential impact of growth on poverty reduction.

[46] In this study, I apply kernel density instead of a regression of food expenditure on income per capita in urban and rural areas because our main focus is to analyze the distribution of food expenditure relative to the poverty line.

[47] The food expenditure poverty lines were taken from the National Statistics Institute, which established the food expenditure poverty line at 123,070 CDF for urban areas, and at 82,755 CDF for rural areas. I thus represent the log of the urban food expenditure poverty line by the solid vertical line at the value of 11.72 and the log of the rural food expenditure poverty line by the dashed vertical line at 11.32.

Figure 4-6: Kernel density function of households food consumption



Source: Author's calculations based on the *Enquête 1-2-3*, DRC (2005).

The figure shows that the distance between the poverty line and the mode of urban per capita expenditure distribution is not large. From a poverty reduction policy perspective, this implies that it would require only a very small increase in per adult equivalent food consumption to move many households out of poverty in urban areas. In rural areas, however, the mode of the density function is quite far from the rural food poverty line. This indicates the need for poverty reduction policies capable of increasing incomes of the poor more in the rural sector than in the urban sector in order to achieve similar reductions in poverty rates.

4.3. Theoretical background

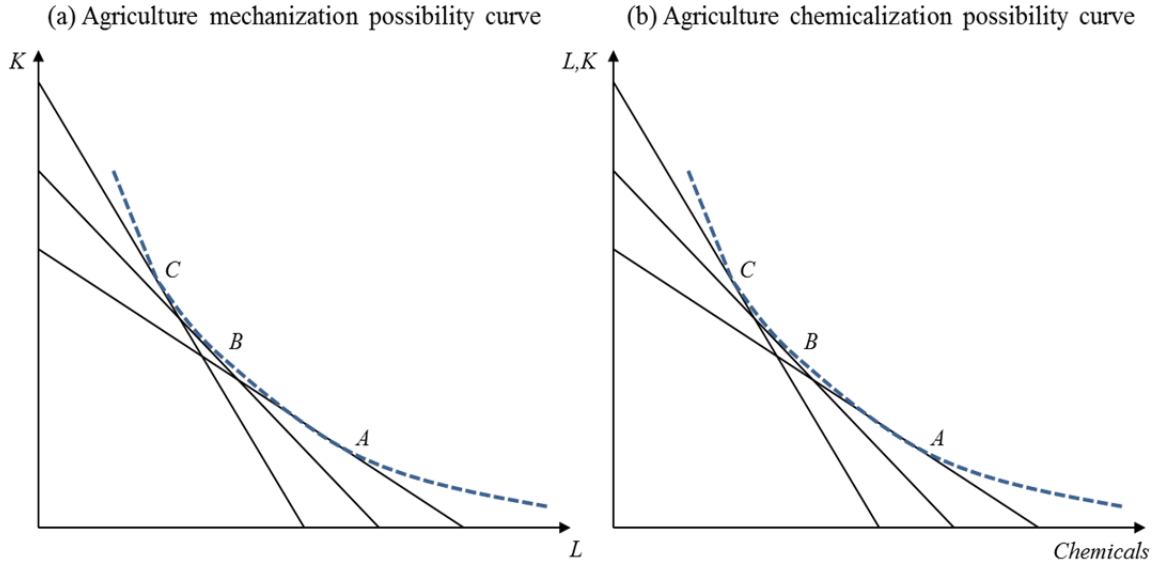
The literature on technological change in agriculture documents that countries tend to adopt the technology that can raise the productivity of the scarce factor or the factor with the lowest quality. Countries with scarce labor but abundant land and capital tend to adopt labor-saving technologies such as tractors and machinery. Countries with scarce land but abundant labor tend to adopt land-saving types of technologies such as chemical and biological high-yield technologies. Hayami and Ruttan (1985) provide a theoretical framework of this type of

biased technological change based on the induced innovation hypothesis. According to this theory, innovation is induced as a response to changes in relative prices, which push firms to innovate in order to use less of the resource that has become more expensive. However, the hypothesis of biased technical change as hypothesized by Hayami and Ruttan may not hold in low income and sub-Saharan countries (Cuffaro 1997). In most of these countries, land and labor are abundant, but capital is scarce, and land inequality is high so that most of the farmers are smallholders. Thus, the theory of induced innovation cannot hold for the following reasons: (i) demand for innovation for small- and large-scale farms is different; (2) small and large-scale farm have different influence on public research; (3) imported technology is absent in induced innovation theory.

In this study, I propose a theoretical framework for pro-poor agricultural modernization. The concept of pro-poor agricultural modernization refers to the advancement of agriculture technologies and institutions that improve the poor and small-scale farmers' welfare relative to rich large-scale farmers. This means that agricultural modernization includes mechanization strategy as part of technological change and the modernization of agriculture behavior, structure and institutions. The choice of the technology, which depends on the factor price and public policies, must be centered on the technological need of small-scale farmers.

I illustrate the process of agriculture modernization in Figure 4-7. The left hand side depicts the Mechanization Possibility Curve (MPC) as the envelope representing the various technological choices available for producers. Different points thus represent the process of mechanization. Point A represents a labor-using technology that raises output proportionally with the rise of labor. In contrast, producers at point C adopt a capital-using technology as it increases output in the same way as capital rises. According to this framework, an advanced mechanized economy is highly capital intensive.

Figure 4-7: Models for agriculture modernization



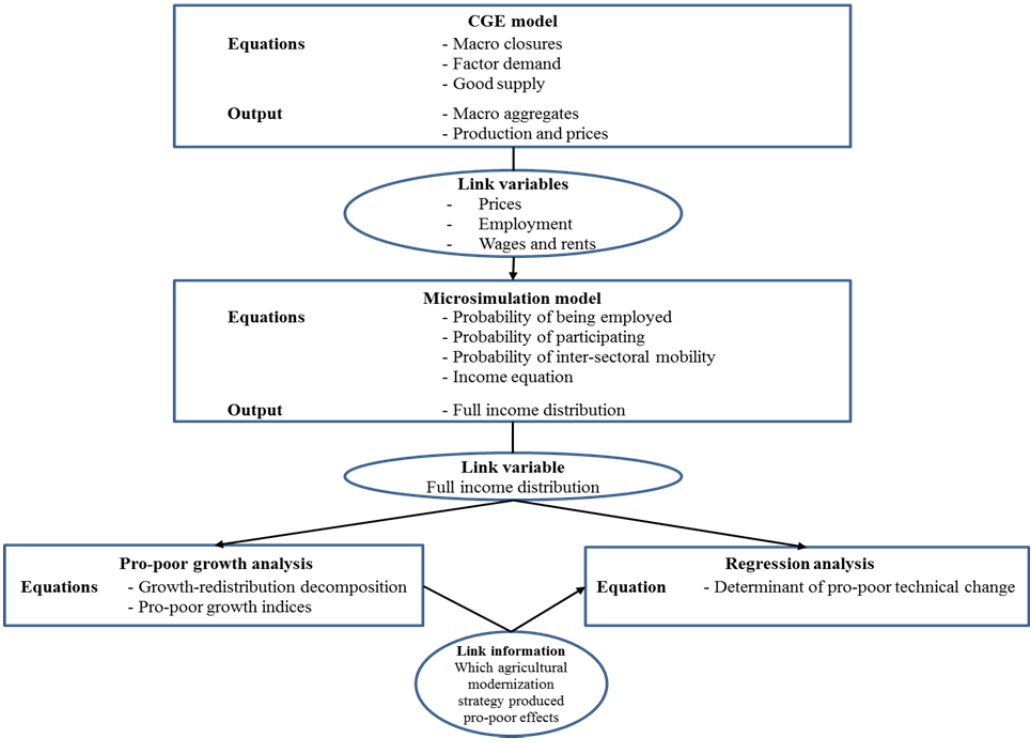
Source: Author's creation.

Similarly, the right hand side of Figure 4-7 displays the agriculture Chemicalization Possibility Curve (CPC). In point C, for example, farmers adopt practices that increase the efficiency in the use of fertilizer and factor requirements to produce a certain level of outputs. This scheme refers to organic farming that maintains soil fertility to avoid the overuse of chemicals. Given the actual price and subsidies level, this technological path enables farmers to make effective and efficient use of the limited amount of fertilizer. These practices include crop rotation or integrated livestock crop rotation, intercropping, cover cropping or green manure, and composting waste materials. Finally, it is worth noting that achieving agricultural mechanization requires institutional changes that increase trust and encourage the private sector to adapt progressively proven technologies to local practices and production modes (Thirtle et al. 1998). In the case of DRC, public interventions are required to improve access to markets for inputs, outputs and finance, as transaction costs are very high.

4.4. Modelling framework

To evaluate the pro-poorness of agricultural modernization-led growth, I adopt a sequential approach that combines a CGE model to a microsimulation model augmented to incorporate a pro-poor growth framework. The empirical strategy proceeds in four steps, as Figure 4-8 depicts.

Figure 4-8: CGE-microsimulatiom augmented with pro-poor growth framework



Source: Author's creation.

I first use the CGE model to generate the effects of agricultural modernization strategies on employment, wages and rents, and the price of goods and services. Then I transmit these changes into a microsimulation model, which takes into account household heterogeneity in terms of factor endowments and consumption patterns, to generate welfare gains or losses at the household level. Using these changes in welfare, I apply the pro-poor growth framework to assess which of the agricultural modernization strategies is pro-poor, and the extent to which growth and redistribution contribute to welfare changes. Finally, I select a strategy that

produced pro-poor welfare gains in the previous stage, and use a least square regression to explain its characteristics.

4.4.1. CGE-microsimulation model

To assess the distributional and poverty effects of agricultural modernization in the DRC, I developed a CGE-microsimulation framework. A top-down approach is used to combine the CGE model (top module of the framework) and the microsimulation model (bottom module). The top module models all the interactions registered in the DRC's SAM and delivers changes in factor and goods prices. Using those changes in prices, the bottom module takes into account household heterogeneity in terms of factor endowments and consumption patterns to simulate the welfare distribution across households. The general specification of the Congolese CGE model follows the basic structure of the single-country model as described in Chapter 2.

The microsimulation model includes 12,098 households from the *Enquête 1-2-3*. My framework posits that agricultural technological change affects household income through channels such as changes in price of goods and services, changes in employment, and changes in the return to factors of production. The microsimulation model has two building blocks: a labor participation model and an accounting equation. Based on Magnac (1991b) and Cogneau and Robilliard (2001), I specify a labor participation model to estimate changes in the labor conditions. Specifically, I use the labor participation equations to estimate the probability to participate in the labor market. Later, I use these probabilities to allocate labor in the microsimulation model based on changes in employment levels from the CGE model. The second component of the microsimulation transmits changes in commodity and factor prices following the model in Chapter 2

The labor participation model has four components: (1) a Probit model of the decision to participate in the labor market, (2) a multinomial Probit model of the allocation of

workers across sectors, (3) a bivariate Probit model of the sectoral labor mobility, and (4) a rule for labor allocation and wage determination. The model assumes that workers can move from unemployment to employment status (or the opposite) and can move from across sectors.[48] In the first stage, I estimate the choice of individuals to participate or not in the labor market. I run a Probit model of employment to predict these probabilities, based on individual and households characteristics. The equation of the model is

$$\lambda_i = \text{prob}(I_i = 1|\boldsymbol{z_i}) = f(\boldsymbol{z_i}\boldsymbol{\alpha} + u_i) \quad (4\text{-}1)$$

where $\boldsymbol{z_i}$ represents individual and household characteristics of the household head such as age, gender, education, household composition; I_i is a binary variable which takes 1 if the household head is employed and 0 otherwise; and u_i is an error term. Similarly, I use a multinomial probit model to estimate the probability to be employed in each of the economic sectors, relative to the probability to be unemployed.

The second stage of the microsimulation model uses a bivariate probit model to estimate the decision of current workers to move from one sector to another. This model estimates the probability of workers to be employed in the new sector given their current employment status.

In the third step, I transmit employment levels taken from the CGE model into the microsimulation and determine which households are affected based on the job queuing approach (Bibi et al. 2010). I rank the unemployed households by the decreasing order of their probability of being employed. Then I use the changes in employment from the CGE model to simulate the number of households who will be employed, starting from households with higher probability. The number of workers is calculated by multiplying the variation from the CGE model to sectoral employment and their labor income is the sectoral and skill

[48] This is consistent with the labor market assumption in the CGE model, where labor moves to equalize wage.

level average. For sectors where employment shrinks, I rank employed households by the decreasing order to their probability of being unemployed. Given the changes from CGE model, I assign them the status of unemployed and their wage is set to zero.

When the demand for labor in one sector is higher than the supply from unemployment, I allow employed households to move to the sector with lack of supply based on their probability to move to other sectors. There is no cost of entry to the new sector as the CGE model assumed that labor moves to equalize wage.

In the final stage, I feed the changes in factor income (dw_l/w_l), marketed commodities prices (dp_g/p_g), and producer prices (dp_{hg}/p_{hg}) obtained from the CGE model into the accounting equation to determine welfare gains or losses of each of the 12098 households. The first-order welfare change function dW_h/y_h is given as

$$dW_h/y_h = \sum_l \emptyset_h^l (dw_l/w_l) - \sum_g \theta_h^g \left(dp_g/p_g\right) - \sum_{hg} \theta_h^{hg} \left(dp_{hg}/p_{hg}\right) \qquad (4\text{-}2)$$

where $\emptyset_h^l$ is the share of factor l in factor income of household h, θ_h^g is the share of marketed good g in the total consumption expenditure of household h, θ_h^{hg} is the share of home-produced good g in the total consumption expenditure of household h, and y_h is the household income.

4.4.2 Growth-redistribution decomposition and pro-poor growth analysis

In this study, I apply the pro-poor growth framework on the welfare changes from the microsimulation to assess the pro-poorness of agricultural modernization strategies. I follow Kakwani and Pernia (2000) to decompose the total changes in welfare into two components: the pure growth effect and the pure inequality effect. Let L_B denote the distribution of

income before agricultural modernization and L_A, the distribution of income after agricultural modernization. Then I write the growth rate in the mean income γ as

$$\gamma = \frac{\mu_A - \mu_B}{\mu_B} \tag{4-3}$$

where μ_B and μ_A are the mean of income before and after agricultural modernization. Thus, I define the pure growth effects G as the proportional change in welfare when the mean income changes but the distribution remains unchanged. The expression for the growth effects G is

$$G = P(\mu_A, L_A) - P(\mu_B, L_A), \tag{4-4}$$

or alternatively

$$G = P(\mu_A, L_B) - P(\mu_B, L_B). \tag{4-5}$$

Equivalently, the income effect depicts the change in welfare when inequality changes, but the mean income remains constant. This can be expressed as

$$R = P(\mu_B, L_A) - P(\mu_B, L_B), \tag{4-6}$$

or as

$$R = P(\mu_A, L_A) - P(\mu_B, L_A). \tag{4-7}$$

Following Kakwani (2000), I decompose the changes in welfare $P^A - P^B$ as

$$P^A - P^B = 0.5[P(\mu_A, L_A) - P(\mu_B, L_A) + P(\mu_A, L_B) - P(\mu_B, L_B)] + 0.5[(\mu_B, L_A) - P(\mu_B, L_B) + P(\mu_A, L_A) - P(\mu_B, L_A)] \quad (4\text{-}8)$$

and then as

$$P^A - P^B = G + R \quad (4\text{-}9)$$

where G is the average growth effect, and R is the average income effect.

Based on this expression, Kakwani and Pernia (2000) introduced a pro-poor growth index to assess to what extent growth enables the poor to actively participate in and significantly benefit from it. This index is called the Kakwani and Pernia (2000) pro-poor index, Φ, and it is expressed as the ratio of the changes in poverty to the change that would have been observed if inequality did not change. Algebraically, this index is given by

$$\Phi = \frac{P^A - P^B}{G}. \quad (4\text{-}10)$$

Depending on the values of γ and Φ, the Kakwani and Pernia (2000) index can be used to assess two types of pro-poor growth, namely, absolute pro-poor growth and relative pro-poor growth. Table 4-6 summarizes the decision matrix for the Kakwani and Pernia index.

Table 4-6: Decision matrix for the Kakwani and Pernia index

γ	Φ	Decision
Positive	Positive	Absolute pro-poor growth
Positive	Negative	Absolute non pro-poor growth
Positive	Larger than 1	Relatively pro-poor growth
Positive	Lower than 1	Relatively non pro-poor growth

Source: Author's creation.

Based on Kakwani and Pernia (2000) pro-poor index, Kakwani et al. (2003) further developed a pro-poor index, the Poverty Equivalent Growth Rate (PEGR) index, that adjusts for the change in the growth rate. The PEGR is thus defined as the growth rate that will result in the same observed level of poverty change had the actual growth process not been accompanied by any change in inequality. Algebraically, the PEGR is given by the product of Kakwani and Pernia (2000) pro-poor index (Φ) and the growth in average income (γ). It can, therefore, be written as

$$\gamma^* = \Phi\gamma. \tag{4-11}$$

According to this expression, growth is absolutely pro-poor if the PERG index is positive. Similarly, growth is relatively pro-poor if the PERG index exceeds the growth rate in average income. In the same way, Ravallion and Chen (2003b) propose a measure of pro-poor growth using the mean growth rate of the poor as a measurement variable for the rate of pro-poor growth. They define the mean growth rate of the poor as the average growth in income of households below the poverty line. Thus, the Ravallion and Chen (2003b) pro-poor index can be calculated as the mean of the growth rate of each percentile of the income distribution up to the headcount index, divided by the headcount index. This measure is equivalent to the

actual growth rate multiplied by the ratio of the actual change in the Watts index to the change in the same index that would have occurred had growth been distribution neutral.

4.4.3 Determinants of pro-poor growth

The pro-poor growth framework described in the previous section is highly descriptive and has limited policy implications. The reason is that this framework helps only to identify the sources of poverty changes, and policies that can produce pro-poor effects. In order to design a comprehensive policy package for agricultural transformation, I go a step further by ascertaining the relative contribution of specific factors that can potentially increase the pro-poorness of agricultural modernization. I proceed as follows. I select one of the agricultural modernization strategies that produced pro-poor effects, and run regressions on its welfare changes. The regression model includes variables that capture the heterogeneity of agriculture production, such as household socioeconomic characteristics, farm structure, and farming system.[49] This is because the sole purpose of these regressions is to describe the profile of pro-poor technological changes at the household level. I estimate separate regressions for households in rural and urban areas, as the determinants of pro-poor welfare gains, as well as the policy implications, might be different in these two areas. The empirical specification of the pro-poor technological change, dW_h/y_h, is

$$dW_h/y_h = \beta_0 + \beta_1 X_{1h} + \beta_2 X_{2h} + \beta_3 X_{3h} + \varepsilon_i, \quad (4\text{-}12)$$

where X_{1h} refers to household socioeconomic characteristics, X_{2h} represents the farm structure, and X_{3h} is a vector of other control variables. The vector of household socioeconomic characteristics includes household composition, the share of household members participating in off-farm activities, and some characteristics of the household head

[49] Including those variables may increase the risk of endogeneity and produce biased and inconsistent OLS estimator.

such as age and education. Farm structure is a vector of variables related to farm-labor relationship, gender and access to land, farm tools, and access to credit. In the model, I allow for interaction effects between farm tools and access to credit (farm tools#credit). This simultaneous effect of credit and farm tools intuitively indicates the role of credit for purchasing farm machineries and implements. Finally, I use three variables to control for household heterogeneity at regional level. These include farming system, household index, and regional unemployment rate. Farming system is a binary variable which classifies regions according to the production of cassava, the leading crop in DRC. It takes a value of 1 if the region contributes less than 10 percent of total production of cassava, and 0 otherwise.[50] Household index is a composite variable estimated by applying a factor analysis. It includes household assets and building materials, access to cleaned water, proximity to school and hospital, among others.

4.5. Results and discussion

This section experiments and analyzes agricultural modernization strategies using the methodology presented in the previous section. While the impacts of these policies on pro-poor growth will be the focus of this analysis, it is important that we discuss first the macroeconomic and sectoral effects of the experiments. Section 4.5.1 describes the policies considered in this study, Sections 4.5.2 and 4.5.3 present the results of the CGE model on the macroeconomic and sectoral variables, and Sections 4.5.4 and 4.5.5 present the pro-poor effects.

4.5.1. Policy experiments

I design experiments to examine policy options for the DRC to modernize its agriculture and increase the income and welfare of households. In addition to their impact on income, I

[50] These regions are Kasaï Occidental, Kasaï Oriental, Maniema, South-Kivu, North-Kivu, and Kinshasa.

analyze if those policy experiments are pro-poor. As I noted in the theoretical framework, there are two schemes to modernize agriculture. These are agricultural mechanization and chemicalization. On the order hand, I complement this analysis with two scenarios of institutional changes that lead to an increase in the supply of inputs. This is because institutional change is a key to the success of agricultural modernization in DRC as transaction costs within the input supply system are very high and there are no subsidies for inputs. Table 4.7 summarizes the policies simulated under the five scenarios.

I conduct two sets of experiments to evaluate the pro-poorness of different agricultural modernization strategies. The first set of experiments focuses on technological change and includes three scenarios, of which two put emphasis on the mechanization policies that change the factor intensities in the production of agriculture goods, and one on the chemicalization policies that improve the efficiency in the use of chemicals. In Scenario 1, I assume that DRC adopts a capital-using technology in agriculture, increasing the capital intensity by 3 percent. Scenario 2 models the effects of a labor-using technology that increases the labor intensity by 10 percent. In Scenario 3, I implement a strategy for agriculture chemicalization. This scenario implies that DRC farmers apply organic chemicals and best practices to increase the effectiveness and efficiency of chemicals. This simulation also means that farmers invest in soil and water management to increase the effectiveness in the use of chemicals. Consequently, they can avoid the overuse of very expensive chemicals and increase their time or frequency on the farm. Technically, I implement this scenario as a joint simulation of a 10 percent reduction in the use of chemicals per unit of aggregate intermediate input and 20 percent increase in the factor requirement per agriculture output.

Table 4-7: Design of policy experiments

Scenarios	Description	Design
1	Capital-using technical change	Increase of capital intensity (3%) in agriculture
2	Labor-using technical change	Increase of labor intensity (10%) in agriculture
3	Improving the agricultural resource base (teach farmers how to better use fertilizer)	Reduction (10%) of chemicals per unit of aggregate intermediate input); Reduction (20%) of the aggregate intermediate input per unit of output
4	Reducing fertilizer sourcing costs	Reduction (50%) of import trade margins for chemicals; Reduction (50%) of domestic trade margins for chemicals
5	Reducing fertilizer distribution costs	Reduction (50%) in import transportation costs for chemicals; Reduction (50%) in domestic transportation costs for chemicals

Source: Author's construction.

The second set of experiments considers a change in input markets related institutions. New institutions improve farmers' ability to access fertilizers and chemicals by reducing transaction costs in the procurement of inputs. The first experiment (Scenario 4) consists of reducing the fertilizers and pesticides sourcing costs by lowering imports and domestic trade margins by 50 percent. This can be achieved by cutting out the middlemen or breaking the monopoly in the distribution of agriculture inputs. Lastly, Scenario 5 models the effects of reducing fertilizers and pesticides transportation costs through the improvement of road and rail infrastructure and conditioning of products. In the model, I simulate the reduced fertilizer distribution costs scenario by assuming a 50 percent reduction in imports and domestic transportation costs of fertilizer.

In these scenarios, I assume that the direct tax rates are fixed and government savings adjust endogenously to ensure that government accounts balance. For the saving-investment account, the balanced closure specifies aggregate investment and government consumption as fixed shares of total domestic absorption. To keep investment fixed as a proportion of total

absorption, the marginal savings propensities of households and enterprises move freely and maintain balance between investment and savings. Under this closure, agricultural modernization affects investment, consumption and savings evenly to absorb the full effect of the shock. Thus, the magnitude of the change of household consumption depends on the magnitude of the shock on savings, which in turn depends on the changes in investment and government consumption. The foreign exchange closure assumes a flexible exchange rate maintains a fixed level of foreign savings, which is consistent with the floating exchange rate system adopted in the DRC. Labor is unemployed and mobile across sectors, given high unemployment rate among all labor categories. This assumption is justified, as there is an excess supply of labor. In this case, real wage is fixed and the level of employment adjusts to restore the equilibrium in the labor market. Capital, in turn, is sector-specific but fully employed. Finally, the producer price index of non-traded domestic output is the numéraire.

4.5.2. Macroeconomic and sector effects

Table 4-8 reports the macro results of policy experiments described in the previous section. As expected, the impact of agricultural modernization is an increase in the size of the Congolese economy. Under capital-using technological change (Scenario 1), real GDP increases by 1.83 percent and total absorption by 1.80 percent. Because of the saving-investment balanced closure, the increased total absorption forces total investment and government consumption to rise by 0.59 and 0.58 percent. The increase of total investment depends also on the increase in government savings (1.99), as public investment accounts for 41 percent of total investment. At the same time, enterprise and household saving rates decrease by 0.17 and 1.08 percent, respectively, to match the value of investment. Private consumption increases by 2.04 percent while household and enterprise savings increase by 0.42 and 2.01 percent. Despite the fall in household and enterprise saving rate, savings by these domestic non-governmental institutions increase because of the impact of capital-using technological change on income.

As a result of increased absorption, imports and exports rise, leading to an appreciation of the exchange rate.

Labor-using technological change (Scenario 2) leads to a 2.19 percent increase in GDP. Under this scenario, private and government consumption increase by 2.44 and 0.36 percent, respectively. Contrary to capital-using technological change, labor-using technological change would cause an increase in household saving rate by 0.45 percent and firm saving rate by 0.07 percent. From a policy perspective, the increase in household saving rate implies more private sector involvement in economic activity. In the case of agricultural households, savings can be invested in non-farming activities as well as in fertilizers and seeds. Finally, the simulation reveals that the real exchange rate appreciates by 1.75 percent, while exports and imports increase by 0.59 and 0.55 percent.

Scenario 3 indicates the potential impact of an improved agricultural resource base. The first thing to observe is that GDP and total absorption increase by 1 and 0.98 percent. As expected, total investment, household and government consumption also increase, due to the balanced closure. However, government savings decrease by 1.07 percent to balance government account because of fixed tax rates. Hence, only household and enterprise savings fuel total investment. Household savings increase significantly, reaching 3.71 percent, while firm savings increase by 2.25 percent. The remarkable change in household savings is mainly due to the increase in household savings rate (+2.36%) as opposed to 0.36 percent for enterprises. Under this scenario, exports and imports fall by 0.34 and 0.32 percent, respectively.

A reduced chemical sourcing costs and reduced fertilizer distribution costs (Scenarios 4 and 5) yield quite similar macroeconomic results. However, the reduced chemicals sourcing costs scenario gives better impacts, mainly in terms of GDP, private consumption and total investment. The simulation exercise reveals that GDP increases by 0.46 and 0.35 percent in both scenarios. Further, reduced chemicals sourcing costs (Scenario 4) raises private

consumption and total investment by 0.44 and 0.52 percent, while, under reduced chemicals distribution costs (Scenario 5), one can observe a 0.32 percent increase of private consumption and a 40 percent increase in total investment.

Table 4-8: Impacts on macroeconomic variables

	Scenario 1: Capital-using technical change	Scenario 2: Labor-using technical	Scenario 3: Improved agricultural resource base	Scenario 4: Reduced chemicals sourcing costs	Scenario 5: Reduced chemicals distribution costs
GDP	1.83	2.19	1.00	0.46	0.35
Absorption	1.80	2.15	0.98	0.45	0.34
Private consumption	2.04	2.44	0.98	0.44	0.32
Government consumption	0.58	0.69	1.07	0.32	0.49
Total investment	0.59	0.69	1.00	0.52	0.40
Savings					
Enterprises	2.01	1.23	2.25	0.55	0.59
Households	0.42	2.32	3.71	0.37	0.97
Government	1.99	1.97	-1.07	-0.30	-0.29
Foreign sector	1.48	1.75	-0.18	-0.84	-0.37
Total	1.56	1.84	1.22	0.12	0.31
Marginal propensity to save					
Enterprises	-0.17	0.07	0.36	0.04	0.10
Households	-1.08	0.45	2.36	0.24	0.64
Exports	0.50	0.59	-0.34	0.92	0.25
Imports	0.46	0.55	-0.32	0.85	0.23
Exchange rate	1.48	1.75	-0.18	-0.84	-0.37
Consumer price index	0.28	0.32	0.18	-0.52	-0.05

Source: Author's calculation using DRC CGE-microsimulation model.

At a disaggregated level, capital-using and labor-using technological changes in agriculture (Scenarios 1 and 2) generate spillover and lead to the expansion of other sectors in the Congolese economy. Nevertheless, it is worth mentioning that agro-industry related sectors benefit less from agriculture technological change than manufacturing and service related sectors. For example, Table 4-9 indicates that under capital-using technological change the value added of processed food and textiles increases by 0.46 and 0.47 percent as opposed to 2.19, 1.40, and 0.73 percent for wood products, utilities, and education and health. The small expansion of agro-industries is due to weak forward linkages from agriculture and high transaction costs. This result reflects the dual characteristic of DRC economy where

agriculture and service sectors have strong linkages and play a more active role in the economy.

Table 4-9: Changes in the value added

Sectors	Scenario 1: Tariff cuts to reduce chemicals price	Scenario 2: Strengthed agricultural research and extension	Scenario 3: Improved agricultural resource base	Scenario 4: Reduced chemicals sourcing costs	Scenario 5: Reduced chemicals distribution costs
Agriculture	6.92	8.31	0.27	0.03	0.02
Forestry	0.75	0.88	0.63	0.06	0.19
Mining	1.02	1.20	0.02	-0.48	-0.13
Processed foods	0.46	0.54	0.20	0.13	0.06
Textiles	0.47	0.56	-0.14	0.25	0.21
Wood	2.19	2.58	0.03	-1.53	-0.04
Chemicals	0.61	0.72	-1.36	0.83	0.48
Non-metals	0.68	0.80	0.64	0.07	0.30
Other manufacture	0.60	0.70	0.61	0.52	0.40
Utilities	1.40	1.66	0.88	0.01	0.42
Construction	0.57	0.67	0.93	0.46	0.37
Trade	0.33	0.39	-0.03	-1.00	0.32
Hotels and catering	0.73	0.86	0.01	0.24	0.17
Transportation	0.24	0.29	0.03	0.58	-0.37
Education and health	0.76	0.89	0.96	0.27	0.36
Other services	0.18	0.22	0.08	-0.05	0.04

Source: Author's calculation using DRC CGE-microsimulation model.

Concerning improved agricultural resource base (Scenario 3), Table 4-9 shows that the contraction of the chemical sector is very pronounced compared to textile and trade. When I reduce chemical sourcing costs (Scenario 4), the value added of wood, trade, and mining decrease by 1.53, 1, and 48 percent. Similarly, reducing chemical distribution costs (Scenario 5) causes a contraction of the transportation (-0.37%) and mining sectors (-0.13%). Note that these two scenarios produce a very small increase in agricultural value added. Agricultural value added increases by around 0.03 percent under reduced chemicals sourcing costs and around 0.02 percent under reduced chemicals distribution costs.

4.5.3. Impacts on factor income and consumption

Table 4-10 indicates the impact of agricultural modernization on factor income. Results show that capital-using technological change (Scenario 1) is skill-biased as it favors workers with higher skill. Since I allow for unemployment and sectoral labor mobility, changes in factor

income are a response to the change in employment. This result indicates that mechanization reduces the demand for rural low-skilled and semi-skilled workers and increases the demand for rural high-skilled workers. In rural areas, capital and high skill appear to be complementary as capital-intensive technology increases the demand for high-skilled workers. High-skilled workers are needed to operate tractors or to spray chemical as manual work is less needed. Thus, the remuneration for rural unskilled and semi-skilled labor decreases by 3.12 and 1.35 percent, while rural workers with high skill levels see their remuneration increase by 1.74 percent.

Labor-using technological change (Scenario 2) influences labor income by increasing the intensity of workers on the farm and, therefore, raising working hours and the frequency of work throughout the year. Scenario 2 in Table 4-9 indicates that labor-using technological change raises the returns for all factors involved in the production process. As expected, rural workers capture higher benefits. However, it is interesting to see that many of the gains go to workers with lower skills. This is because agriculture uses low-skilled workers intensively. In addition, this scenario has important implications for income distribution in both rural and urban areas, as gain differences in favor of workers with lower skill are non-negligible. For example, the remuneration of rural low-skilled workers increased by 8.48 percent whereas the return for semi-skilled and high-skilled laborers increased by 6.33 and 4.35 percent.

With regard to the improved agricultural resource base scenario, one can see that the results are qualitatively similar with labor-using technological change. Returns to labor are higher among rural workers than urban workers with similar skills. Under this scenario, urban low-skilled workers gain more than urban semi-skilled and high-skilled workers do. Table 4-10 shows that returns to urban low-skilled labor increased by 0.92 percent while the returns for semi-skilled and high-skilled workers increased by 0.45 and 0.24 percent, respectively.

Table 4-10: Impact on factor income

		Scenario 1: Capital-using technical change	Scenario 2: Labor-using technical change	Scenario 3: Improved agricultural resource base	Scenario 4: Reduced chemicals sourcing costs	Scenario 5: Reduced chemicals distribution costs
Urban labor	Unskilled	2.26	2.87	0.92	-0.79	0.52
	Semiskilled	2.25	2.70	0.45	-0.16	0.27
	Skilled	2.25	2.66	0.24	0.07	0.31
Rural labor	Unskilled	-3.12	8.48	1.38	-0.48	0.29
	Semiskilled	-1.35	6.33	1.14	-0.63	0.27
	Skilled	1.74	4.35	1.25	-0.55	0.59
Capital		1.85	1.09	1.47	0.25	0.34
Land		1.37	0.87	1.31	0.38	0.45

Source: Author's calculation using DRC CGE-microsimulation model.

Turning our attention to the institutional changes scenarios, simulation results show that reducing fertilizer sourcing costs (Scenario 4) decreases the factor income for all labor categories, except for urban high-skilled labor. Reducing trade margins for fertilizers and pesticides lowers the price for agriculture intermediate inputs and increases agriculture producer price. Rising producer price in agriculture, in principle, should lead to an increase in factor income of rural workers as they are intensively employed in agriculture. However, the simulation indicates the fall of factor income. Income for urban low-skilled and semi-skilled labor falls by 0.79 and 0.16 percent, respectively. In rural areas, the remuneration for unskilled and semi-skilled labor drops by 0.48 and 0.65 percent, respectively, while high-skilled workers see their remuneration fall by 0.55 percent. There are two reasons for this. First, the impact of reduced fertilizer sourcing costs on agriculture value-added is marginal, as agriculture uses outdated technology. From a policy standpoint, this indicates that technological changes play an important role in boosting agriculture output and productivity. Second and most importantly, lowering trade margins leads to a reduction of the producer price in the trade sector. This is due to the adjustment costs that occur when the Congolese marketing system transforms to a modern sector. Reduced producer price lowers the value-added price and thus wages of most of the labor categories since this sector is the

second employer after agriculture. To counterbalance those negative effects on labor income, policies that break the monopoly of intermediaries in agricultural trade should also aim to increase operational efficiency by focusing on reducing the costs of inputs. This can be done when DRC public policymakers aim to improve ICT services to farmers by removing administrative barriers that prevent the development of mobile banking, mobile remittance and the exchange of agricultural input price information.

If improving institutions lowers the fertilizer distribution costs, as in Scenario 5, then the income of all production factors will increase. Under this scenario, the changes in income of rural workers are higher than those of urban areas. The highest increase is attributed to unskilled rural workers whose income increases by 1.38 percent whereas urban high-skilled labor's income increases only by 0.24 percent. Meanwhile, returns to capital and land are also high and reach 1.47 and 1.31 percent, respectively.

Moving on to the consumption effects of agriculture products, Table 4-11 indicates that mechanization of agriculture (Scenarios 1 and 2), leads to a decrease of the price of agricultural products and an increase in the competitiveness of domestic products. Improving the agricultural resource base (Scenario 3) raises the market price of agricultural products, but this leads to an insignificant fall in sales. On the other hand, lowering chemicals sourcing costs (Scenario 4) reduces the market price of domestic production marginally, whereas reduced chemicals distribution costs (Scenario 5) increases the market price.

Table 4-11: Impacts on consumption of agricultural products

	Scenario 1: Capital-using technical change	Scenario 2: Labor-using technical change	Scenario 3: Improved agricultural resource base	Scenario 4: Reduced chemicals sourcing costs	Scenario 5: Reduced chemicals distribution costs
Price for domestically produced and sold goods	-6.32	-7.46	0.15	-0.09	0.25
Price of composite goods	-5.77	-6.82	0.12	-0.20	0.23
Quantity of domestic sales	5.21	6.23	-0.05	0.12	0.04
Quantity of aggregate marketed ouptut	5.49	6.58	-0.06	0.10	0.03
Quantity of marketed consumption	7.99	9.55	1.13	0.37	0.06
Quantity of home consumption	10.10	12.11	0.99	-0.12	0.01

Source: Author's calculation using DRC CGE-microsimulation model.

Looking at consumption changes in Table 4-11, one can see that agricultural mechanization (Scenarios 1 and 2) increases household consumption of agricultural products from the market and their own production. Changes from home-produced consumption are significantly higher than the changes in consumption from the market. This is due to the high rate of subsistence agriculture and significant price differences due to transaction costs. It is interesting to see that in the case of an improved agricultural resource base (Scenario 3), home-produced consumption increases to a lesser extent than marketed consumption. Finally, lowered chemical sourcing costs (Scenario 4) reduces the consumption from own production and increases consumption from markets. In this scenario, home-produced consumption decreases by 0.12 percent while marketed consumption increases by 0.37 percent. For the reduced chemicals distribution costs scenario (Scenario 5), one can see that agriculture consumption from market and home production increases marginally. However, it is important to note that market consumption increases more than home-produced consumption.

4.5.4. Pro-poor growth and growth-redistribution decomposition

In order to understand how inclusive the different schemes of technological and institutional changes are, in this section I apply the framework of pro-poor growth analysis on the welfare gains from the CGE results. Table 4-12 gives the estimates of the growth in average income

and six pro-poor indices. The pro-poor indices include the Ravallion and Chen (2003) index, the Ravallion and Chen (2003) index minus γ, the Kakwani and Pernia (2003) index, the Kakwani and Pernia (2003) index minus 1, the poverty-equivalent growth rate (PEGR) index[51], and the poverty-equivalent growth rate (PEGR) index minus γ. The Ravallion and Chen index, the Kakwani and Pernia index, and PEGR index constitute the absolute pro-poorness indices. They indicate whether the income of the poor has grown sufficiently after agricultural modernization for absolute poverty indices to fall. Therefore, a positive value of these indices indicates that growth led by agricultural modernization is absolutely pro-poor. The other three indices, the Ravallion and Chen index minus γ, the Kakwani and Pernia index minus 1, and PEGR index minus γ, depicts the relative pro-poorness of agricultural modernization. They demonstrate whether the income of the poor has grown sufficiently after agricultural modernization to follow the overall increase in average income (γ). In this case, agricultural modernization is relatively pro-poor if these indices take positive values.

Table 4-12: Pro-poor analysis

Indices	Scenario 1: Capital-using technical change	Scenario 2: Labor-using technical change	Scenario 3: Improved agricultural resource base	Scenario 4: Reduced chemicals sourcing costs	Scenario 5: Reduced chemicals distribution costs
Growth rate (γ)	3.06	4.89	0.42	0.28	0.15
Rav-Chen (2003)	-0.24	3.31	0.28	0.03	0.12
Rav-Chen (2003) - γ	-3.30	-1.58	-0.14	-0.25	-0.04
Kakw-Pernia (2000)	-0.16	1.89	1.25	0.07	0.90
Kakw-Pernia (2000) - 1	-1.16	0.89	0.25	-0.93	-0.10
PEGR	-0.49	8.29	0.53	0.02	0.14
PEGR - γ	-3.55	3.40	0.11	-0.26	-0.02

Source: Author's calculation using DRC CGE-microsimulation model.

Table 4-12 shows that all the three scenarios of agriculture modernization (Scenarios 1, 2, and 3) lead to an increase in average income. This result is consistent with the macro effects

[51] This index is also called Kakwani, Khandker and Son (2003).

discussed in the previous section. Table 4-12 further indicates that capital-using technological change (Scenario 1) is neither absolutely pro-poor nor relative pro-poor, as all of the six indices are negative. This implies that agriculture growth led by capital-using technological change decreases significantly the poor's relative shares in total consumption. In contrast, labor-using technological change (Scenario 2) is absolutely pro-poor. This is indicated by the positive sign of the Ravallion and Chen index, the Kakwani and Pernia index, and PEGR index. In terms of relative pro-poor effects, the Kakwani and Pernia index minus 1 and the PEGR index minus γ show that the growth rate of the poor's income is enough to follow the growth rate in average income. This gives evidence that labor-using technical change-led growth is relatively pro-poor.

An improved agricultural resource base (Scenario 3), on the other hand, is absolutely pro-poor as all the three indices are greater than zero. Looking at this in a relative perspective, one can find that this policy is also pro-poor as the two relative pro-poor indices are positive. Turning our attention to the reduced chemical sourcing costs (Scenario 4), the absolute pro-poor indices are positive but not significant. However, the results on the relative pro-poor indices indicate that reduced chemical sourcing costs are not relatively pro-poor. Finally, the last column of Table 4-12 presents the pro-poorness of reduced chemical distribution costs (Scenario 5). The findings indicate that this scenario is absolutely pro-poor, but I have little evidence to conclude about the relative pro-poorness.

Next, I am interested in understanding the source of changes in poverty due to agricultural modernization. For this purpose, I decompose changes in poverty headcount ratio in terms of the effect of growth and changes in redistribution. The first column of Table 4-13 presents the growth-redistribution decomposition of the impact of capital-using technological change (Scenario 1). Under this policy scenario, poverty headcount ratio increases by 2.07 percent. However, it is interesting to see that without any changes in inequality, capital-using technological change would reduce poverty by 1.05 percent. The increase in inequality

(+3.15%) cancels out the beneficial effect of capital-using technological change-led growth on poverty reduction. Thus, capital-using technological change leads to immiserizing growth. This finding corroborates the ideas that poverty reduction due to growth led by large-scale investment in agriculture depends on the initial level of inequality in income or distribution of assets. This is in line with previous research (Bourguignon and Morrisson 1998; de Janvry and Sadoulet 1996; Timmer 1997; Ravallion 1997; World Bank 2000), suggesting that the distribution of assets matters as it affects how well the poor connect to the growth process.

In contrast, labor-using technological change (Scenario 2) causes a reduction in the poverty headcount by 3.47 percent. 2.91 percent points of the 3.74 percentage point fall in poverty headcount are due to the growth effect. This means that if inequality did not change, poverty would be reduced by 2.91 percent. Thus, redistribution was responsible for 0.56 percentage points of poverty reduction. This finding is consistent with a view widely held among development economists that unskilled labor-intensive agricultural activities have higher poverty-reducing capacity compared to high-skilled, capital-intensive activities (de Janvry and Sadoulet 2010; Loayza and Raddatz 2010). Furthermore, an improved agricultural resource base (Scenario 3) reduces poverty by 2.71 percent. The growth effect contributes to 1.76 percentage points in poverty changes while the income distribution effect contributes to 0.94 percentage point.

Table 4-13: Growth-redistribution decomposition

	Scenario 1: Capital-using technical change	Scenario 2: Labor-using technical change	Scenario 3: Improved agricultural resource base	Scenario 4: Reduced chemicals sourcing costs	Scenario 5: Reduced chemicals distribution costs
Changes in poverty index	2.07	-3.47	-2.71	-0.13	-1.13
Growth	-1.05	-2.91	-1.76	-2.55	-1.15
Redistribution	3.12	-0.56	-0.94	2.43	0.02

Source: Author's calculation using DRC CGE-microsimulation model.

Concerning the growth-redistribution decomposition of reduced chemicals sourcing and distribution costs (Scenarios 4 and 5), one can observe in Table 4-13 that these scenarios have the same qualitative effects. They both lead to poverty reduction as would be expected. The growth effects of these policy scenarios contribute to reducing poverty whereas the redistribution effects contribute to increasing poverty. Nonetheless, the contribution of the redistribution effects is very low under reduced chemicals distribution costs compared to reduced chemical sourcing costs.

4.5.5. Explaining pro-poor technological change

I extend the pro-poor growth analysis by looking at the determinants of pro-poor technological change at household level. Recall from the previous section, I found that labor-using technological change (Scenario 2) is absolutely and relatively pro-poor. Therefore, I run regressions on its predicted welfare gains to ascertain the relative contribution of relevant observed characteristics that can potentially increase the pro-poorness of technological change. Table 4-14 gives summary statistics on the predictors used in the regressions, broken down in rural and urban areas. In order to reduce any potential endogeneity problems of some of the predictors, I choose to include in the regressions only explanatory variables of potential relevance to agricultural and rural development policies in DRC. The first set of variables consist of household characteristics such household composition and the head's education and age. I also use the share of household members participating in off-farm activities as a proxy to measure the importance of off-farm activities and thus household income diversification. The second group of predictors is made up of farm structure variables such as farm-labor relationship, access to credit, farm tools possession, and rights on land. Finally, I use farming system, household index, and regional unemployment rate to control household heterogeneity at regional level. I define these predictors such that a positive sign implies better pro-poor welfare gains.

Table 4-14: Summary statistics on predictors in the regression analysis

Variable	Rural		Urban		National	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Household composition						
Household size (log)	1.576	0.62	1.493	0.60	1.531	0.61
Share of kids in the household	0.181	0.18	0.195	0.18	0.189	0.18
Share of young in the household	0.454	0.25	0.460	0.25	0.457	0.25
Share of adults in the household	0.505	0.25	0.493	0.25	0.499	0.25
Participation in off-farm activities (share)	0.578	0.28	0.888	0.21	0.720	0.29
Age of household head (log)	3.741	0.31	3.699	0.33	3.718	0.32
Squared age (log)	14.095	2.33	13.794	2.44	13.932	2.40
years of education (log)	2.099	0.53	1.758	0.59	1.923	0.59
Squared years of education (log)	4.687	1.90	3.438	1.83	4.043	1.96
Farm structure						
Farm-labor relationship						
Household head or spouse (reference)	0.250	binary	0.632	binary	0.457	binary
Other household members	0.025	binary	0.027	binary	0.026	binary
Wage workers	0.005	binary	0.008	binary	0.006	binary
Sharecropper	0.000	binary	0.002	binary	0.001	binary
Other	0.003	binary	0.003	binary	0.003	binary
Male head with spouse without rights on land	0.803	binary	0.834	binary	0.820	binary
Female head holding rights on land	0.003	binary	0.001	binary	0.002	binary
Male head with spouse with rights on land	0.004	binary	0.007	binary	0.005	binary
Farm tools	0.816	binary	0.985	binary	0.908	binary
Credit	0.092	binary	0.118	binary	0.106	binary
Regional characteristics						
Farming system	0.333	binary	0.154	binary	0.236	binary
Household index	0.835	1.10	-0.382	0.47	0.174	1.02
Unemployment rate	5.654	4.68	3.539	2.30	4.506	3.74

Source: Author's computation using data from *Enquête 1-2-3*, DRC (2005).

Table 4-15 shows the results on the determinants of pro-poor technological change derived from the regression model outlined in equation 4-12. They indicate that pro-poor welfare gains increase with household size in both rural and urban areas. However, the results suggest a strong negative and significant relationship between pro-poor welfare gains and household composition, especially concerning younger household members. For example, I find that rural and urban households with a larger share of kids tend to have lower welfare gains. This implies that the number of children also affects women's choice to work on the farm, as women are responsible for most of the on-farm tasks. Interestingly, I find that participation in

off-farm activities is positively correlated with pro-poor welfare gains in rural areas and negatively in urban areas. This indicates that participation in off-farm activities has positive spillover effects on pro-poor agricultural technological change in rural areas. An important reason for this is that in rural areas, off-farm income is usually invested in modern inputs and insurance. This finding is in line with other studies that found that investment in non-farm activities can benefit the agricultural sector (Dorward et al. 2004; de Janvry et al. 2005).

Table 4-15: Explaining pro-poor technological change led growth

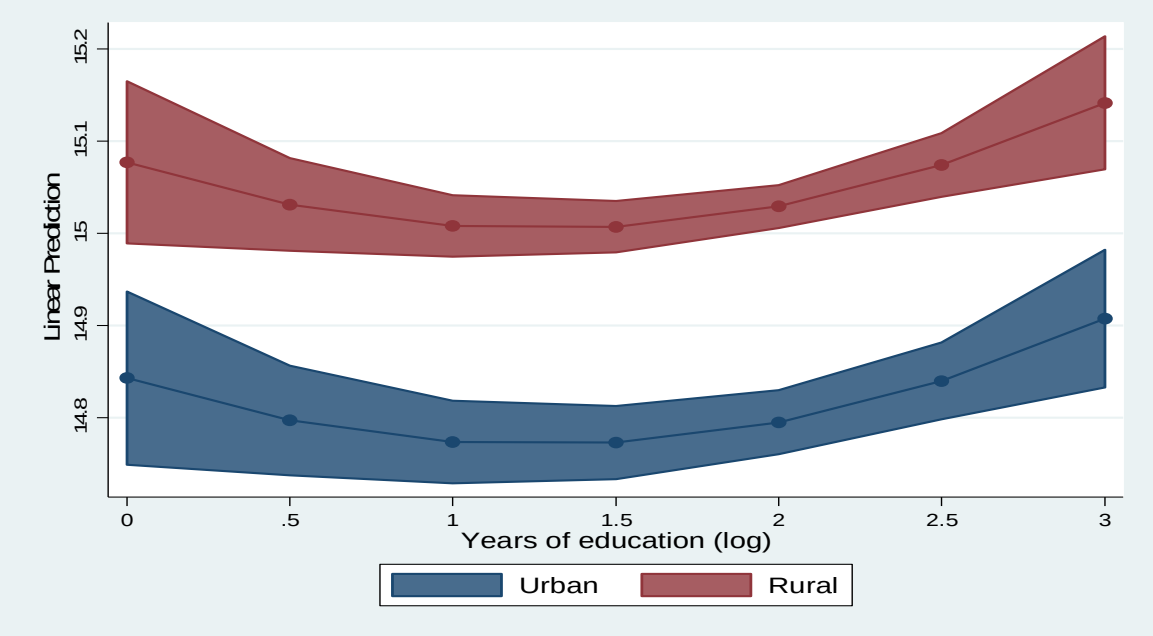
	Rural	Urban
Household composition		
Household size (log)	0.262**	0.327**
Share of kids in the household	-0.216**	-0.308**
Share of young in the household	-0.463**	-0.021
Share of adults in the household	-0.381**	0.112
Participation in off-farm activities (share)	0.219**	-0.181**
Age of household head (log)	7.549**	7.029**
Squared age (log)	-1.030**	-0.916**
years of education (log)	0.007	-0.237+
Squared years of education (log)	-0.010	0.098*
Farm structure		
Farm-labor relationship		
Household head or spouse (reference)		
Other household members	0.027	0.054
Wage workers	0.415**	-0.060
Sharecropper	0.213	0.813
Other	0.174	-0.472+
Male head with spouse without rights on land	0.100**	0.137**
Female head holding rights on land	0.004	0.351
Male head with spouse with rights on land	0.183+	0.454+
Farm tools	0.124	-0.543
Credit	0.166*	0.495**
Farm tools#Credit (interaction term)	0.171*	0.571**
Regional characteristics		
Farming system	-2.606**	-0.660**
Household index	0.189**	0.133**
Unemployment rate	0.452**	0.127**
Observations	4767	2192
Adjusted R^2	0.898	0.897

+ p<0.10, * p<0.05, ** p<0.01
Source: Author's estimations.

In addition, I found that pro-poor welfare gains are inverted U-shaped in age of household head in both rural and urban areas. This indicates that age has diminishing returns, meaning

that it is beneficial for pro-poor growth until 39 in rural areas and 46 in urban areas, after which increases in age will decrease pro-poor welfare gains. The results for the years of education of the head are mixed. I find that education of the head has a very small and non-significant inverted U-shape effect in rural areas, but a significant U-shape effect in urban areas.[52] To clearly highlight the substantive significance of education, I estimate and present in Figure 4-9 the predictive margins for the years of education of the head in both rural and urban areas. Perhaps most striking from Figure 4-10, compared to the sign in Table 4-14, is the steady decline in pro-poor welfare gains until approximately 5 years of education. From a policy perspective, this finding means that every advance in post-primary education leads to higher pro-poor welfare gains.

Figure 4-9: Predicative margins of education of the head



Source: Author's estimations using data from the *Enquête* 1-2-3, DRC (2005).

With regard to farm structure, Table 4-15 indicates the importance of land tenure system, especially in favor of women. Results show that welfare gains tend to be higher when women

[52] For further details on marginal effects, see Cameron and Trivedi (2010).

hold rights on land. As can be seen, welfare gains increase by 0.183 percent when the head of household is a male and the spouse holds rights on the land. When the spouse does not hold rights on land, the increase in welfare gains is only 0.1 percent. It should be worth mentioning that this result is consistent in both rural and urban areas, with a higher magnitude for urban areas. Further, farm tools have opposite sign in rural and urban areas but I fail to find any significant effect. However, what is interesting to notice from the estimation results is that the interaction between farm tools and credit is positive and significant. It is also worth mentioning that the coefficient of the interaction between farm tools and credit is larger than the effect of credit alone. Intuitively, this indicates the importance of establishing a specific credit for purchasing farm tools.

4.5.6. Sensitivity analysis

A common feature of CGE model results is that they depend on assumptions made. In this section, I conduct a sensitivity analysis of the CGE model to ensure the robustness of the results. In the sensitivity analysis, I show the comparison for the simulation of capital-using and labor-using technical change with respect to the change of the production factor elasticities. Table 16 presents some of the results obtained when production elasticities of substitution increase or decrease by 5 percent.

I expected the magnitude of the results to differ because the nature of technical change and the assumption on the elasticities of substitution are the main drivers of model results.[53] Nonetheless, the qualitative results and the signs are robust to the changes in elasticities. Nevertheless, it is worth mentioning that the capital-using simulation appears to be less robust to higher production elasticities of substitution.

[53] See also Dawkins et al. (2001)

Table 4-16: Sensitivity analysis

	Capital-using technical change		Labor-using technical change	
	ρ^p decreases by 5%	ρ^p increases by 5%	ρ^p decreases by 5%	ρ^p increases by 5%
GDP	2.61	0.37	2.66	1.80
Absorption	2.57	0.37	2.61	1.77
Private consumption	2.92	0.41	2.97	1.97
Government consumption	0.77	0.17	0.78	0.77
Total investment	0.78	0.16	0.79	0.74
Exports	0.67	0.14	0.68	0.67
Imports	0.62	0.13	0.63	0.63

Source: Author's calculation using DRC CGE-microsimulation model.

4.6. Conclusions and policy implications

In analyzing what are the better or worse models for agriculture modernization, this paper found that the adoption of capital-using technology leads to immiserizing growth through the redistribution effects. Results indicate that growth effects under this technological change reduced poverty slightly, while the redistribution effects canceled out the positive growth effects. This is because capital-using technological change increased output in all the sectors, but lowered rural unskilled and semi-skilled income so that there was an overall increase in inequality. Rising inequality between rural workers with lower skill and the rest of workers emerged, a key factor explaining the anti-poor effects of capital-using technological change.

In contrast, labor-using technological change is found to be effective in producing pro-poor effects in both absolute and relative terms. The analysis also pinpoints the importance of labor-using technological change in improving urban-rural income disparities. Despite the large income change in favor of rural workers with lower skills, this result is partly due to the increase of home-produced consumption relative to the marketed consumption. The findings on poverty decomposition demonstrate that growth was responsible for more of the poverty changes than redistribution. This finding suggests that labor-using technological change can be independently sufficient in reducing poverty via the

income growth effects. Under this scenario, I found that household and firm savings also increased. This can be an indication of future private investment in non-farm or fertilizer related activities. The improved agricultural resource base scenario produced similar pro-poor effects to those in labor-using technological change. Nonetheless, improved agricultural resource base has a limited potential to enhance growth outside agriculture.

In addition, I tested two scenarios of institutional changes that lead to an increase in supply of agriculture inputs. Firstly, the reduction of chemical sourcing costs implies lower income for most of the labor types and produces insignificant absolute pro-poor gains. From a policy perspective, this finding suggests that reducing trade margins should be implemented simultaneously with institutions and policies that increase farmers' market power and improve marketing efficiency. Secondly, reducing chemicals' distribution costs increases access to market for both producers and consumers, and it leads to an increase in income for all labor types. Consistently, this policy scenario produces absolute pro-poor effect but does not lead to income convergence.

I continued the analysis by investigating quantitatively the determinants of pro-poor growth, using welfare changes from labor-using technological change. Doing so, I found that participation in off-farm activities is statistically significant and strong determinant of pro-poor technological change in agriculture. Working as a wage worker improves pro-poor welfare gains only in rural areas. Other important findings show that women's land rights emerged as an important determinant of pro-poor welfare gains. Credit is positive and significant in rural and urban areas but I have not found significant effects for farm tools. Nonetheless, I found that there exist significant interactions between access to credit and farm tools in producing pro-poor welfare gains.

This research has intuitive findings for design and implementation of a pro-poor agriculture modernization strategy. The key policy recommendations arising from the paper are the following:

1. Public policymakers should promote the adoption of labor-using technologies to enable the use of cheap labor to intensify agriculture (See appendix 2 for details).
2. Public policymakers should increase farmers' capacity to evaluate, adapt, and disseminate proven technologies.
3. Public policymakers should increase investment in soil and water management methods, and in agriculture research and extension, to improve farmer's ability to use fertilizer efficiently.
4. Public policymakers should secure tenure among small-scale farmers and improve access to land, especially for women.
5. Public policymakers should help farmers organize themselves into cooperatives, break monopolies and cut rent seekers in seed supply and increase marketing efficiency.
6. Public policymakers should reform input supply networks and increase investment in input storage and road infrastructure. These steps should be implemented together with policies and institutions to remove credit constraint and increase farmers' ability to acquire tools and inputs.

Chapter 5. Institutions and economic policies to create value and foster competition in the agro-food sector: Experiments for the DRC

5.1. Introduction

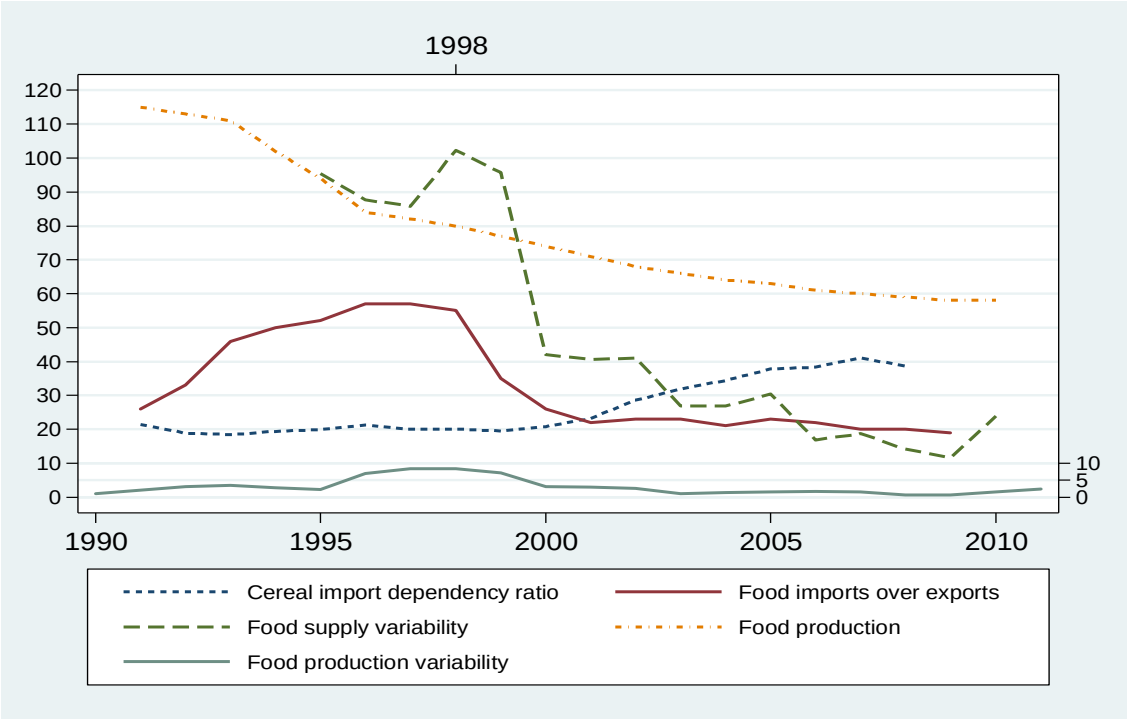
The previous chapters have found clear evidence of the importance of creating agricultural value chains and establishing a competitive agro-food industry in DRC. The analysis suggested that increasing value addition in and processing capacity of agricultural products will generate the most important volume change in the economy, and improving the efficiency of financial intermediation will have an important additional scale effect. On the other hand, the findings pinpointed the role of investment in transportation infrastructure and trade institutions in creating domestic and regional markets for competitive agro-food products. This chapter extends the previous analysis by examining the core underlying factors that can foster DRC's competitiveness and efficiency to produce and export high value agro-food products. These factors include upgrading and transforming the structure of production, upgrading the skill, and boosting the efficiency in the service industries.

In this new era of globalization, characterized by a multipolar world and international fragmentation of production,[54] it is becoming increasingly difficult to ignore the key role of competitive agro-food sectors in creating employment, reducing poverty and food security. The need to increase food production and productivity has become a central issue due to the recent global food price crisis and financial crisis. In relation to this renewing interest, the World Development Report 2008: Agriculture for Development (World Bank 2007) emphasizes the role of high-value agricultural products and the non-farm economy in sustaining development. In this context, Elliott (2008) identified, among supply-side and

[54] See Hummels et al. (2001), Feenstra and Hanson (1999), and Los et al. (2013) for a discussion on the concept and measurement of international fragmentation of production.

demand-side related factors influencing the global food production, an increase in consumer purchasing power in developing countries due to rising incomes. Indeed in Africa, for example, the size and the income of the middle income rose to 34 percent within the population in 2010, from 27 percent in 2000, where it had remained since 1980 (AfDB 2011).

Figure 5-1: Food production and imports



Source: Author's calculation based on FAOSTAT database, FAO (2014).

In addition to sustaining growth and jobs, food production has the potential to increase food access, which also leads to a reduction of food security concerns (The World Bank Group 2011). Food access is of particular interest to the DRC, where 70 percent of the population lacks access to adequate food, and more than 5 million children under 5 years of age are malnourished. Food availability depends on three factors: production, distribution, and exchange (Capone et al. 2014). According to the World Food Programme, DRC is a food production deficit country, estimated at 30-40 percent. Food production is limited and has been decreasing since 1991, for which data are available (Figure 5-1). Food production per

capita decreased from US$115 in 1991 to US$58 in 2008, when the food price picked up. Food supply drastically declined by about 76 percent between 1999 and 2010. As a result, cereal import dependency doubled, from 19.5 percent in 1999 to 38.6 percent in 2008. Since the end of 2010, RDC's cereal import dependency ratio is much higher than the world average, estimated at 15.7 percent.

The next section of this chapter starts by looking at the key stylized facts of the agro-food industry in DRC. This section concludes that DRC is at a factor-driven stage in which industries concentrate in low valued-added activities, labor is less productive and uneducated, and markets are not integrated. To build a competitive agro-food industry, this chapter hypothesizes that it is necessary for DRC to upgrade its production structure and promote the competitiveness of the domestic industry. The third section of this chapter defines a framework for policy analysis, while Section 4 presents the model and datasets. The following sections present and discuss the results, and the last section concludes.

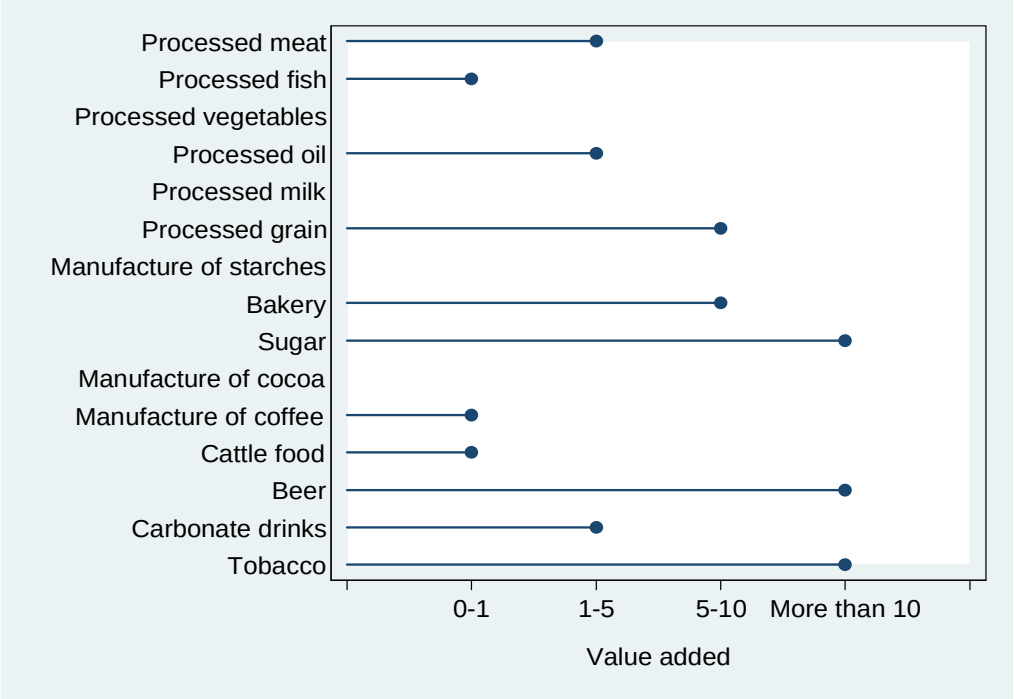
5.2. Key stylized facts on the agro-food industry: value added, productivity, comparative advantage, and market fragmentation

This section provides background information on the Congolese agro-food industry. In this study, the concept of the agro-food sector covers a broad area of postharvest activities, packaged agricultural raw materials, industrial and technology intensive processing of intermediate goods, and fabrication of final products derived from agriculture. Subsection 5.2.1 aims at examining the structure and prospects of the agro-industry in the DRC by looking at the structure of the industry in terms of value added and labor productivity levels. The following subsection describes the recent performance of the comparative advantage within the industry.

5.2.1. Value added and productivity

The Congolese agro-food industry constitutes the largest industry within the manufacturing sector, contributing to over a 70 percent of total value added. Beer, tobacco, and sugar makes up the largest industry group, followed by bakery and processed grain. Figure 5-2 shows the relative contribution of each of the agro-food industry constituents in terms of value added. These figures confirm the dominance of low value-added activities within the agro-industry. For example, the bakery and manufacture of grain account for 5 to 10 percent of value added in the agro-food industry, while the manufacture of meat and oil represents between 1 to 5 percent. This reflects the lack of domestic and competitive domestic industry.

Figure 5-2: Food sector value-added in the agro-food industry



Source: Author's computations based on DRC (2011).

The Congolese agro-food industry comprises two disparate groups, the formal and informal feed sectors. This study emphasizes two criteria in the definition of informality, namely the lack of registration with the government and maintenance of honest and complete accounts. Table 5-1 presents the distribution of the agro-food industry in terms of the nature of their

activity. The figures indicate that 90 percent of manufactures of meat operate in the informal sector, compared to 97 percent of manufactures of fish and 61 percent of manufactures of fat and oil. 11 percent of the manufacturing of cereal-based food products, whose contribution to the food industry is between 5 and 10 percent, are represented by the informal sector. The rise and large share of informal activities is a consequence of the massive looting of formal firms in 1991 and 1993. According to the data released by the Congolese daily newspaper Le Phare (n°180; October 20, 1992), approximately 924 firms and 90,517 jobs were destroyed during the 1991 looting.

Table 5-1: Distribution agro-food industry by formal or informal status

	Informal	Formal
Processing and preserving of meat	90	10
Processing and preserving of fish, crustaceans and molluscs	97	3
Manufacturing of fat	61	39
Processing of grains	0	100
Manufucating of cereal-based food products	11	89
Manufacturing of sugar	0	100
Manufacturing of beverages	0	100
Manufacturing of beer	0	100
Manufacturing of tabacco-based products	0	100

Source: Author's computations based on DRC (2011).

The data reported in Table 5-1 and Figure 5-2 indicates that the differences in the value-added contribution of agro-food industry are closely linked to the share of informality in the branches. It confirms the tendency of the informal sector to dominate in the low value-added activities, which in turn leads to low productivity. The evidence from the literature suggests that informality generally prevents firms from upgrading skills and technology, which further reduces productivity. Previous research has also shown a negative link between informality and productivity (Steel and Snodgrass 2008; Gelb et al. 2009) and recent work by Benjamin and Mbaye (2012) in West Africa underscores the significant correlation between informality,

low growth, and low productivity. With regard to the factor underlining the productivity gaps, Steel and Snodgrass (2008) illuminate the unequal access to public service, and Gelb et al. (2009) stress the quality of the business environment and the enforcement of rules.

Table 5-2 presents the average productivity of labor (henceforth, labor productivity) across sectors in 2006. Labor productivity is constructed as the ratio of the annual total sales (in log) to total employment. The industries analyzed here include four from the manufacturing sector (food, textile, wood, other manufacturing) and three from the service sector (retail, wholesale, other services). The figures indicate that there are significant variations in productivity levels across sectors. These variations are remarkably wide if one compares the 0.72 of labor productivity in the wood sector to the 2.29 of labor productivity in retail trade. The food sector ranks in the middle with regard to productivity at US$1.65 per worker in comparison to other sectors, falling behind the country average of US$1.89 per worker. However, it is important to note that the food sector, whose productivity is estimated at US$1.65 per worker, is the first in terms of productivity within the manufacturing sector, exceeding textile (US$1.54) and other manufacturing (US$1.62). Perhaps the most striking fact about labor productivity is that the service sector is relatively productive, particularly the retail and wholesale trade sectors, which were by far the most productive sectors in 2006.

In addition, there is a wide variation in productivity levels within the other service and food sectors. Table 5-2 indicates that the coefficient of variation in the other service sector is 127.79 percent and 113.64 percent in the food sector. On the other hand, the retail and wholesale trade sectors exhibit comparatively small variations, with a coefficient of variation of 64.93 percent in the retail trade sector and 69.29 percent in the wholesale trade sector. Interestingly, the findings from the retail/wholesale trade sectors show that the average productivity within sectors is linked to the amount of variability within the productive sectors.

Table 5-2: Labor productivity levels and growth rates

	Productivity levels		Growth rate	
	Average	Coefficient of variation (percent)	2006-2009	2009-2013
Food	1.65	113.64	0.26	0.23
Textile	1.54	84.72	0.25	0.28
Wood	0.72	75.34	-0.04	0.26
Other manufacture	1.62	76.65	0.28	0.00
Retail	2.29	64.93	0.28	0.18
Wholesale	2.28	69.29	0.14	0.13
Other Service	1.80	127.79	0.25	0.23
Total	1.89	90.36	0.24	0.16

Source: Author's calculations based on Enterprise Surveys, The World Bank (2013).

Furthermore, the table presents the growth rate of labor productivity for 2006-2009 and 2009-2013. It appears that labor productivity has grown at the annual rate of 0.24 percent during 2006-2009 and 0.16 percent during 2009-2013. During 2006-2009, labor productivity increased almost uniformly across all sectors, except for in the wholesale trade sector, and shrunk by 0.04 percent in the wood sector. Retail trade and other manufacturing grew the most in terms of productivity, with an annual growth rate of 0.28 percent as compared to 0.25 percent of the textile and other service sectors. Table 5-2 also indicates that, during 2006-2009 and 2009-2013, labor productivity grew only in the textile and wood sectors and declined in all of the other sectors. For example, labor productivity in the food sector increased by 0.26 percent during 2006-2009 but decreased by 0.23 percent during 2009-2013. This is an important observation to consider if DRC wants to succeed in its ambition to establish a competitive agro-food industry within the sub-region.

5.5.2. Comparative advantage and competitiveness

In light of the globalization and increasing competition in the food sector, it is important to ascertain where the comparative advantage of the Congolese agro-food industry lies. This

study examines the Congolese comparative advantage by using the concept of "revealed comparative advantage" (RCA), developed by Balassa (1965). The RCA reflects the relative trade performance of a country's particular industry relative to the world or some reference group countries (Balassa 1965; Balassa 1986; Bela 1997). The Balassa index is basically computed as the relative weight of a percentage of total export in a country over the percentage of world export in that commodity. This formulation implies that a country has a revealed comparative advantage in the export of an industry if the RCA for that industry is greater than 1. To compute the Balassa index, I use the UN Comtrade export data at the 4-digit level of the Standard International Trade Classification (SITC).

Table 5-3 summarizes the data by reporting the RCA index of the top fifteen agro-food industries for 2010 based on the Balassa index. The RCA index is greater than one in six sectors, namely unstripped tobacco, prepared animal feed, organic chemicals, wholly or partly stripped tobacco, tobacco refuse, and green and roasted coffee and coffee substitutes. The index value suggests that DRC holds a comparative advantage in the world in these sectors. Unstripped tobacco ranks at the top, with an index value of 10.16, and it is closely followed by prepared animal feed with an index value of 9.25. The RCA index gap between these two industries and the rest of industries with comparative advantage is quite large. In fact, Table 5-3 shows that the RCA index of organic chemicals is 4.51, while those of wholly or partly stripped tobacco, tobacco refuse, and green and roasted coffee and coffee substitutes are respectively 3.05, 2, and 1.64. Finally, the maximum numbers of sectors with comparative advantage in the world are concentrated in the tobacco industry, which contributes to nearly 50 percent of the total comparative advantage that DRC enjoys in the world market.

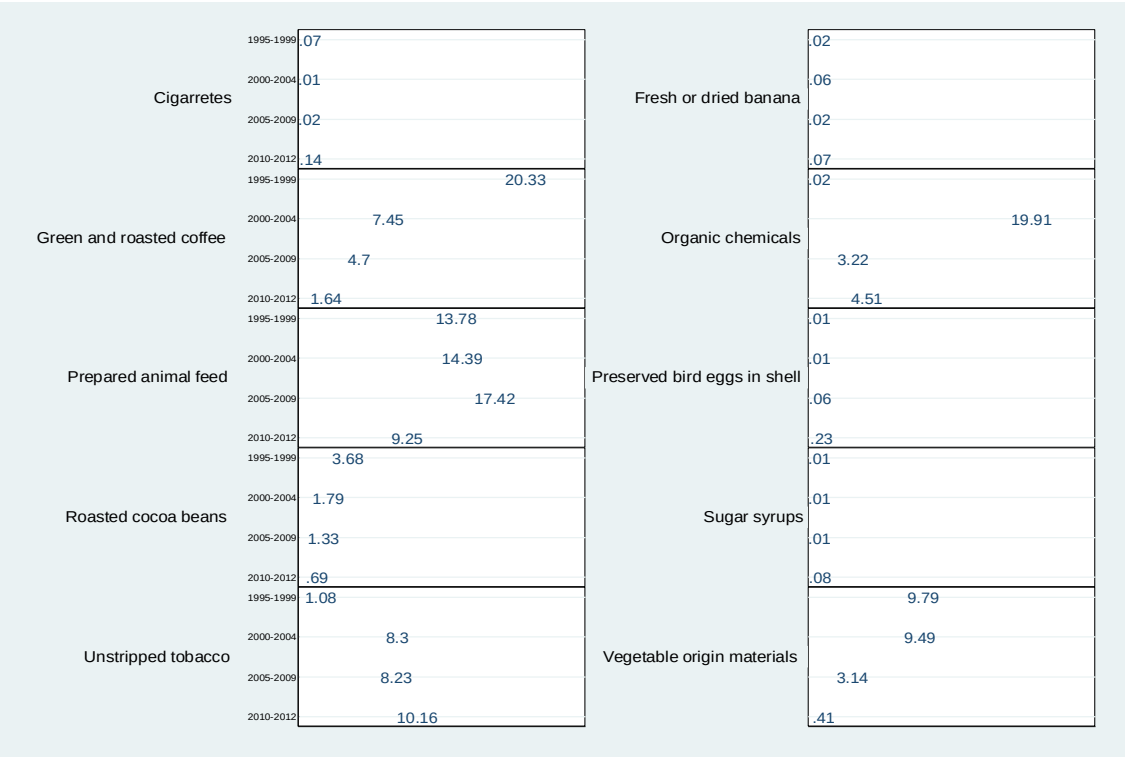
Table 5-3: Top fifteen sectors based on the revealed comparative advantage (RCA)

Rank	Description	RCA
1	Unstripped tobacco	10.16
2	Prepared animal feed	9.25
3	Organic chemicals	4.51
4	Wholly or partly stripped tobacco	3.05
5	Tobacco refuse	2.00
6	Green & roasted coffee & coffee substitutes	1.64
7	Raw & roasted cocoa beans	0.69
8	Vegetable origin materials	0.41
9	Prepared or preserved vegetables	0.26
10	Preserved bird eggs in shell	0.23
11	Cigarretes	0.14
12	Sugar syrups, caramel & artificial honey	0.08
13	Fresh or dried banana & plantains	0.07
15	Meals & flours from potatoes, fruits & vegetables	0.02

Source: Author's calculation based on UN Comtrade, United Nations Statistics Division (2014).

To study the dynamic of comparative advantage in the Congolese agro-food industry, Figure 5-3 presents the trend of the RCA index from 1995 to 2012 for 10 industries. Several interesting results are apparent in regard to the shift in the comparative advantage over time. First, DRC is losing its relative competitiveness in five industries, vis-à-vis the world. For example, DRC had a large comparative advantage in the green and roasted coffee industry in 1995-1999 until 2005-2009. The competitiveness decreased largely between 1995-1999 and 2000-2009, falling from 20.33 to 7.45. For roasted cocoa beans, DRC lost completely its comparative advantage starting from 2010. In four industries (cigarettes, fresh or dried banana and plantains, preserved bird eggs in shell, and sugar syrups), DRC is increasing in competitiveness, but the changes are very marginal, indicating no structural change in the comparative advantage of those industries. Interestingly, DRC is gaining competitiveness mainly for unstripped tobacco in which DRC had a comparative advantage since 1995-1999. This pattern of structural change shows that traditional exports-related industries lose their comparative advantage in favor of the tobacco-related industry due to FDI.

Figure 5-3: Comparative advantage



Source: Author's calculation based on UN Comtrade, United Nations Statistics Division (2014).

5.3. Policy framework for value capture and competition analysis

As the data presented in the previous section demonstrates, the DRC economy is at a factor-driven stage at which industries concentrate on low valued-added activities, labor is uneducated and less productive, and markets are not integrated. The problem is that DRC has neglected investment in basic infrastructure and skills, due to corruption and state failure. Based on the above background and in view of the three-stage model by Porter (Porter 1990; Porter et al. 2002), it is necessary for DRC to start the transition to the second stage of an efficiency-driven economy. The remainder of this section discusses a policy framework for DRC to improve efficiency in the agro-food industry.

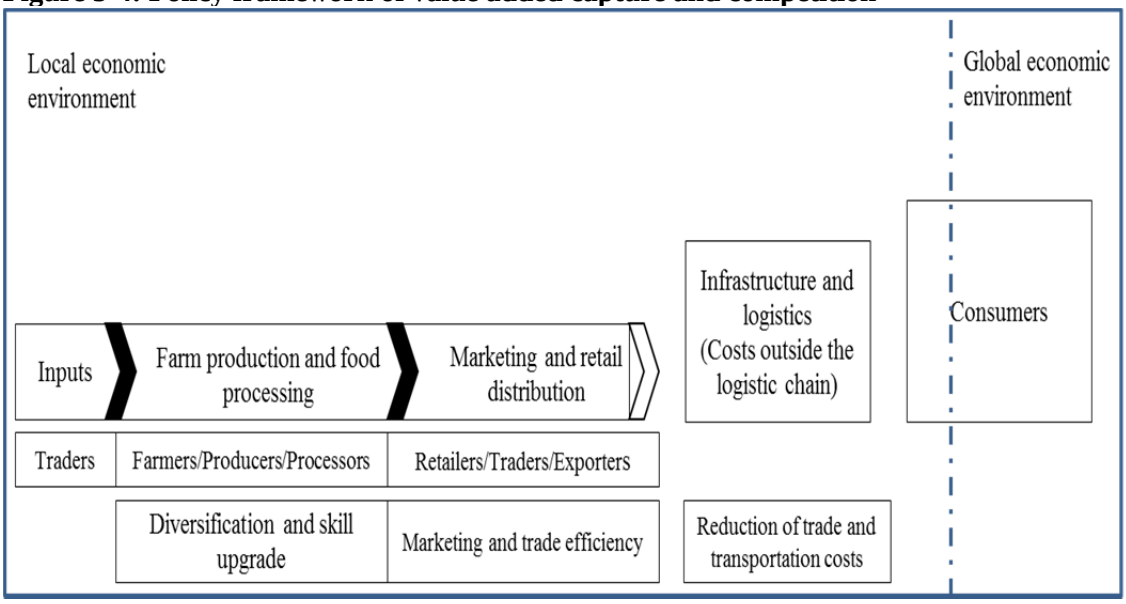
The policy framework identifies a set of policies and institutional arrangements to transform production structure into more efficient and higher value-added activities. The move into the second stage requires investment to upgrade the production structure, improve

production efficiency, and educate the workforce to be able to adapt in the subsequent technological development phase (Zoltan et al. 2008). According to UNCTAD (2013a), the development of productive capacities occurs through three closely related core economic processes that all countries have to undergo if they are to achieve sustained development. These are the investment necessary to build domestic capital stock (physical capital, human capital, and so forth), which economists refer to as capital accumulation; structural change (or structural transformation); and building of the capabilities in the domestic enterprise sector. The main hypothesis of this study is that developing productive capacities along local value chains can provide a meaningful approach to structural transformation and inclusive growth.

The conceptual framework for the empirical analysis draws upon value chain theory, the *filière* approach (Moustier and Leplaideur 1999; Hugon 1985; Duruflé G. et al. 1988), and the pro-poor growth framework. The filière approach is of particular interest, as it clarifies the dynamic of value capture and creation along local value chains. Figure 5-4 below illustrates the major stages of the value chain and identifies key stakeholders and policies to capture value at each stage. This study defines capturing a value as any process or service in the supply chain that involves adding or enhancing the market value of agricultural products to consumers. The concept of value capture within the value chain involves upgrading the product and the process, which can be attained by increasing productivity and value-added produced within the existing local value chain segments. This allows the producer to gain higher value and increases the profitability of traders. OECD (2013) noted that product upgrading implies the introduction of differentiated products in the market, while process upgrade means that the producers create value through gradual improvement in operation processes and adoption of new technologies. The two concepts of value creation have different practical implications. For example, differentiating products can be real or perceived. As can been seen, the process and product upgrade can have different policy implications in practice, but the key consideration is in the fact that they serve the same purpose, which is to

increase the product value added and the industry competiveness. In this study, diversification of the production structure is the policy measure to produce high-value products. Indeed, the literature emphasizes the role of diversification in boosting productivity.

Figure 5-4: Policy framework of value added capture and competition



Source: Author's creation.

Diversifying into higher value-added food products requires a lot of capabilities and country-specific policies. The most recurrent generic policies in the literature (Felipe et al. 2010; Page 2012) have highlighted policy intervention to address market failures by developing skills and infrastructure as a basis to manufacture and export high-value products. For example, Felipe et al. (2010) in their study on how rich countries became rich, in which they categorized 779 products based on their sophistication and connectivity to other products, found that DRC and 74 other countries belong to the "low product" trap as they mostly export unsophisticated and unconnected products. They conclude that countries in the "low product" need to acquire skills, technology, knowledge, and improve organizational capabilities. Similarly, Page (2012) discussed policies for African economies to reallocate resources to higher productivity activities in the agro-industry, manufacturing, or tradable services. He

argued that Africa should focus on pushing exports, building capabilities, and supporting agglomeration in addition to investment climate reforms that aim to reduce the skill and infrastructure gaps. In the same vein, Lin and Treichel (2012) argued that technological innovation, industrial diversification, and industrial upgrading are typically accompanied by changes in capital and skills requirements for firms as well as by changes in their market scope and infrastructure needs due to the evolving nature of production that is embodied in the process of innovation. Put differently, diversification is typically accompanied by changes in hard and soft infrastructure requirements.

Improved skills enable producers to gain higher value. For example, better technical skill can enable processors to reduce post-harvesting waste and master standard procedures about packaging. In the conceptual framework, labor quality improvements create value for agro-food processors.

The stage of distribution includes transportation, wholesaling, and retailing. Distributors – retailers, traders, and exporters – do not conduct significant physical transformation to the product. They contribute to connect producers to consumers through storage, transportation, and marketing services. The frame thinking on the role of wholesale and retail distribution of agro-food products considers the role of marketing and transportation efficiency. Food marketing includes topics such as segmentation, positioning, brand building, targeting, consumer research, and market-entry strategy. Food transportation deals mainly with a perishable product whose quality and availability varies as a function of the current harvest conditions. Food marketing and transportation efficiency refer to providing consumers with the desired levels of service at the lowest cost possible.

In the current economic environment, the distribution captures the most value in the chain, meaning that a large proportion of consumer price is added at the retail level. Some studies (Hortiwise and FlowerWatch 2012; Wilshaw 2013) have shown that Kenyan farmers get less than 5 percent of consumer price of the cut flower sold in Europe and that

transportation costs represent major expenses faced by Kenyan exports due to storage and transport networks. This implies that producer prices are low because of transaction costs that exist outside the logistic chain. In this study, I focus on improving the business climate and infrastructure as a measure to reduce transaction costs.

In fact, infrastructure development plays a vital role in achieving inclusive growth and has been heightened as a key factor for integrating global value chains. For example, Hummels (2007) demonstrated that lowered transportation costs top the list of factors that significantly raised the speed of international trade in the second era of globalization. In recent years, infrastructure development has become one of the most significant topics of discussion in African development. There are several reasons for this increasing interest, one of which is that sustained growth in Africa has failed to create jobs and enhance structural transformation, as growth is driven by volatile commodities prices. It has been argued that, to seize the opportunities generated by the current growth, Africa should promote investment in infrastructure to boost intraregional trade and diversify away from natural resource, as the size and income of the middle class in Africa have increased. Infrastructure development is also designed to improve the competitiveness of the private sector, constrained by high transactions and marketing costs and limited access to inputs and technology.

Consumers represent the last stage of the value chain, as they represent the end buyers concluding the chain. However, they play an important role as producers and distributors work for their need. This means that the consumer can act as “pull” factor through demand. Consumers represent an opportunity in favor of diversification as producers succeed in creating the perception of value, it is likely that consumers will pay a premium price for high-value products. Empirically, one can assess the effects of the demand pull factor through the changes in export prices. The change in price is particularly interesting, as it tells whether demand can be met by domestic substitute for products, for which domestic demand is increasing due to a rise in international prices.

Finally, the pro-poor growth framework is valuable to study the distribution of benefits in the economy. The analysis focuses on how the poor benefit relative to the rich as a contribution to the scarce literature on the pro-poorness of value chains. The section that follows presents the empirical methodology in terms of both the model and data and explains how the different economic incentives affect activities and households.

5.4. Methodology

This section introduces the analytical framework and data used to simulate the effects of institutional arrangements and policies to create value and foster competition in DRC. From a methodological perspective, this study applies a CGE-microsimulation model augmented to incorporate the concepts of diversification into higher-value products and pro-poor growth. The empirical approach proceeds in three steps. First, I assess the economy-wide impacts of policies to create value and foster competition on the Congolese economy using a CGE model that integrates the concept of diversification into higher value added. Second, I use the top-down/bottom-up approach to connect the CGE model with the microsimulation model and transmit the CGE output (changes in wages and prices) to the microsimulation model to simulate the welfare changes for all households. Finally, I apply the pro-poor growth framework on the welfare changes in order to address the pro-poorness of policy scenarios.

5.4.1. CGE model

This section describes the CGE model used in this study. The first subsection emphasizes the presentation of the most important features of the CGE model, which is the behavior of production activities that integrate the concept of diversification into higher value added. The next subsection focuses on the model database.

Description of the CGE model

The model applied in this chapter is a single-country, static CGE model for the DRC economy. The CGE model follows the description in Chapter 2 and introduces some changes, mostly in the production function, to incorporate the concept of diversification. It is worth mentioning that the empirical literature on economic diversification and growth is dominated by econometric analysis. However, only few studies have aimed to assess the economy-wide impact of export diversification. Among them, Naudé and Rossouw (2008) used a CGE model to analyze the impacts of greater export diversification versus greater export specialization on the South African economy. To simulate export diversification, the authors assumed that South Africa diversifies its exports to China's level. Thus, the simulation is implemented by simply increasing/decreasing the export share of non-traditional exports against traditional exports. The study concluded that export diversification positively affects growth and employment. However, it is likely to increase the overall inequality.

The relevance of the study by Naudé and Rossouw (2008) is important in that it links export diversification to inequality and identifies channels through which diversification affects growth. However, one of the drawbacks of their study is that they do not specify which policy brings about the export scenarios being modeled. Although it had been argued that the production system can be reflected in the export structure, the paper by Naudé and Rossouw completely ignored the production and industrial capabilities not associated with exports but which are nonetheless important.

Building upon the recent theoretical and empirical contribution on the relationship between diversification and growth, it is possible to integrate the concept of diversification into higher value-added products in the traditional CGE model as a determinant of a firm's TFP. In this study, the changes in the production function are inspired by the work of Hammouda et al. (2009). Using a sample of African countries from 1981-2000, the authors came to the conclusion that deepening diversification leads to an improvement of TFP, which

in turn affects economic growth. Thus, export diversification affects economic growth through its impact on TFP.

Inspired by these findings, the CGE model integrates diversification into higher-value products as an additional input to total productivity growth. Equation 5-1 shows that the TFP term α_a^p in the standard model is replaced by the composite term $DIV_a.\alpha_a^p$. The expression DIV_a indicates that productivity changes due to diversification. In other words, it means that productivity is enhanced by endogenous efficiency spillovers from learning by doing, in addition to the exogenous productivity parameter α_a^p. As can be seen, the exogenous productivity parameter is the component of TFP driven by factors other than diversification. The calibration corresponds to the TFP if diversification in higher value added has no impact on TFP.

$$QV_a = DIV_a.\alpha_a^p \sum_f \left(\delta_{fa}^p \cdot fpr_{fa} \cdot QF_{fa}^{-\rho_a^p}\right)^{-1/\rho_a^p} \tag{5-1}$$

On the other hand, DIV_a is modelled as the normalized Herfindahl-Hirschman index increased to the power of the elasticity of TFP growth with respect to export diversification, as expression 5-2 indicates.

$$DIV_a = \left(\frac{\sqrt{\sum_{i=1}^{n}\left(\frac{E_i}{X}\right)^2} - \sqrt{1/n}}{1-\sqrt{1/n}}\right)^{diver} \tag{5-2}$$

where E_i is the value of exports of products i , X the total export, n the number of products at the 3-digit SITC level, and $diver$ the elasticity of TFP growth with respect to

diversification. This elasticity of diversification $diver$ is calibrated using the econometric estimation by Hammouda et al. (2009) for Africa.

Model database

The database for the CGE model is the 2005 DRC SAM developed in Chapter 2. The construction of the SAM aimed to analyze the basic structure of the DRC economy; hence, the most interesting disaggregation is the production activities. To evaluate policies for establishing a competitive agro-food industry, I further extended the 2005 DRC SAM in two ways: in terms of trade and transportation service sectors and in terms of the labor market. The information used for this breakdown comes from various data sources and several informed judgments. The breakdown of the trade and transportation services consist of separating trade and transportation services used in wholesale and retail sales of agro-food products from all other trade and transportation services. The purpose of this breakdown is to identify agro-food value chain at the level of marketing and transportation services.

As for the disaggregation of labor, I used data from the 2005 *Enquête* 1-2-3. The labor classification in this chapter distinguishes three labor types: urban formal, urban informal, and rural. To disaggregate labor, I applied to the total labor value added to the estimated labor shares shown in Table 5-4. Upon review of the data, one can observe that processed foods, trade, and transportation are mainly urban informal activities.

Table 5-4: Sectoral labor shares

Sectors	Urban formal	Urban informal	Rural	Total
Agriculture	0.17	19.63	80.19	100
Forestry	10.48	33.33	56.19	100
Mining	12.50	38.15	49.35	100
Processed foods	11.27	55.74	32.99	100
Textiles	4.50	77.16	18.34	100
Wood	19.01	38.73	42.25	100
Chemicals	35.71	53.57	10.71	100
Non-metals	7.14	64.29	28.57	100
Other manufacture	11.16	63.22	25.62	100
Utilities	68.57	20.00	11.43	100
Construction	19.18	69.86	10.96	100
Agro-food trade	14.21	68.64	17.15	100
Other trade	4.04	83.42	12.54	100
Hotels and catering	16.08	62.24	21.68	100
Agro-food transportation	42.78	45.12	12.10	100
Other transportation	39.49	51.09	9.42	100
Education and health	53.34	7.63	39.03	100
Financial intermediation	53.73	43.28	2.99	100
Other services	38.46	51.65	9.89	100
Personal and other community services	83.82	3.05	13.13	100
Private households with employed persons	28.57	54.20	17.23	100
All	9.61	33.84	56.56	100

Source: Author's calculations based on the *Enquête 1-2-3*, DRC (2005).

Turning to the calibration of diversification, I needed information on the diversification level of agricultural and manufacturing sectors and the elasticities of productivity with respect to diversification. Using data from the National Institute of Statistics, I calculated the diversification levels using the Herfindahl-Hirschman index, as defined in expression 5-2. Data in this table reports the baseline level of economic diversification in DRC in 2005 and shows that the Herfindahl-Hirschman indices for wood, food, and agricultural products are the highest. This indicates that these three sectors are less diversified.

Table 5-5: Sectoral diversification in DRC (2005)

Sectors	Herfindahl-Hirschman index
Agriculture	0.8660
Forestry	0.2578
Mining	0.1764
Processed foods	0.9929
Textiles	0.8245
Wood	0.9986
Chemicals	0.5768
Non-metals	0.3474
Other manufacture	0.3398

Source: Author's calculations based on Banque Centrale du Congo (2007-2013).

The elasticities of productivity with respect to diversification comes from the study of Hammouda et al. (2009). Relying on a sample of African countries, they found that the elasticity of the total productivity of factors (TFPs) with respect to the diversification varies between -1.113 and -2.048.

Table 5-6: Elasticities of productivity with respect to diversification

Endogenous variable: TFP	Model I	Model II	Model III
Constant	25.495***	23.731***	22.473***
	(26.91)	(30.41)	(54.44)
Diversification	-2.048*	-2.121*	-1.113*
	(-1.78)	(-2.32)	(-1.65)
Human capital	-0.037	0.032*	-0.007*
	(-1.63)	(1.75)	(-0.68)
Openess: (exports + imports)/GDP	0.010*	-	0.005*
	(1.67)		(1.77)
Financial deepening: Credit2	-0.011	-0.002	-
	(-1.42)	(-0.27)	
Conflict (dummy =1 if var/strive is present)	-0.532*	-1.194*	-0.388*
	(-1.75)	(-4.28)	(-1.61)
R- squared (adjusted)	0.99	0.99	0.99
Number of cross-sections	20	24	22
Number of observations	80	96	88

Source: Hammouda et al. (2009).

5.4.2. Microsimulation model

The aim of the microsimulation model is to generate the distribution of income changes for the 12,098 households from the 2005 household and informal producer survey included in the simulation. The distributional change depends on household endowment and socioeconomic characteristics, the returns to these factors, and the behavior of socioeconomic agents with respect to resource allocation subject to institutional constraints (Bourguignon and Ferreira 2005; Essama-Nssah et al. 2007). To account for these effects, the microsimulation model has two components: an envelope model of household welfare and a labor participation model.

Labor participation model

I use the labor participation model to estimate a labor supply model on the rural and urban (formal and informal) markets and identify the main characteristics differentiating these

markets. The methodology for the labor market segmentation follows the non-competitive model proposed by Magnac (1991a), Savard (2003), Cogneau and Robilliard (2008), and more recently by Atuesta and Hewings (2012).

Table 5-7 presents the labor market characteristics. These results show that the rural sector accounts for most of the workers (54.03%). This is due to the importance of agriculture in DRC economy, from which most of the activities are located in rural areas. 7.44 percent of workers belong to the urban formal sector, while 38.53 percent belong to the urban informal sector. Table 5-7 also indicates the choices of workers to participate or not in the labor market. Workers can decide to participate in the urban formal sector, participate in the urban informal sector, or simply not participate in an urban sector. On the other hand, workers who don't participate in the urban labor market can decide to move and to be employed in rural areas.

Table 5-7: Distribution of employment by sector and labor market

Labor markets	Working hours	Log wage	Migrant (%)	Female (%)	Other job
Urban					
Formal	46.20	11.82	0.49	0.19	0.12
	(18.11)	(1.78)	(0.50)	(0.39)	(0.33)
Informal	43.44	10.94	0.63	0.55	0.11
	(20.77)	(2.24)	(0.48)	(0.50)	(0.31)
Rural	36.45	10.34	0.77	0.50	0.06
	(17.46)	(2.39)	(0.42)	(0.50)	(0.24)
Total	40.90	10.80	0.72	0.49	0.08
	(19.61)	(2.30)	(0.45)	(0.50)	(0.27)

Source: Author's calculations based on the *Enquête 1-2-3*, DRC (2005).

To estimate the potential wages for each labor market and the reservation wage for those who decide to be unemployed, I use the Heckman's sample selection model. This method is a two-step statistical approach to correct for selection bias. This study assumes that, in order to decide whether to work in the formal, informal, or rural labor market or simply to be unemployed, workers must first migrate to either urban or rural areas. Therefore, in the first

stage, I estimate a Bivariate Probit model for the joint decision to live in urban or rural areas and to participate in any of the intra-labor markets or to be unemployed. In addition to estimating the probability of a worker to choose a labor market or to be inactive, I calculate the Mills ratio to adjust the covariance matrix during the second stage. In the second stage, I run an OLS with the Mills ratio on the wage equations to estimate the labor supply in each market. Other predictors include household demographics and socioeconomic characteristics. Table 5-8 presents the results of the labor supply model.[55] The inverse Mills ratio is significant for the two markets, and therefore I cannot reject the absence of selection bias or the fact that the relationship between what is unobservable in the selection has negative effect on wages in either formal and informal markets.

Table 5-8: Labor supply model

	Urban informal	Urban formal	Rural employed	Reservation wage
Age	0.0166	0.0147	0.0206	0.0154
	(0.0136)	(0.0139)	(0.0134)	(0.0155)
Age square	-0.000253	-0.000213	-0.000282*	-0.000201
	(0.000163)	(0.000175)	(0.000150)	(0.000206)
Male	0.696***	0.608***	0.638***	0.513**
	(0.193)	(0.219)	(0.133)	(0.248)
Education (year)	-0.171***	-0.162**	-0.0857***	-0.131
	(0.0581)	(0.0725)	(0.0329)	(0.0831)
Education square	0.00672***	0.00700***	0.00154	0.00652***
	(0.00184)	(0.00199)	(0.00193)	(0.00208)
Married	0.00173	-0.0574	-0.0240	-0.0939
	(0.107)	(0.111)	(0.0847)	(0.124)
Household size	0.0322***	0.0369***	0.0326***	0.0402***
	(0.0119)	(0.0122)	(0.0109)	(0.0129)
Mills ratio	-1.659***	-1.287**	1.441***	-1.037
	(0.536)	(0.581)	(0.290)	(0.690)
Constant	12.07***	11.75***	9.163***	11.36***
	(0.685)	(0.783)	(0.355)	(0.864)
Observations	7,150	7,150	7,146	7,150
R-squared	0.021	0.020	0.022	0.020

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's estimations based on the *Enquête 1-2-3*, DRC (2005)

[55] Table A3 in the appendix present the results of the Bivariate Probit model.

Given the potential wages, the cost of entry, and the reservation wages computed using the microeconometric model, workers can choose to migrate to different labor markets based on the following set of conditions:

- rural sector if $w^R > w^E$;
- unemployed if $w^0 > w^E$, $w^0 > w^I$, and $w^0 > w^F - cost_f$
- informal sector if $w^I > w^R$, $w^I > w^0$, and $w^I > w^F - cost_f$
- formal sector if $w^F - cost_f > w^R$, $w^F - cost_f > w^0$, and $w^0 > w^F - cost_f > w^I$

(5-3)

where w^R is the rural potential wage of worker i; w^0 is the urban reservation wage of worker i; w^I is the informal potential wage of worker i; and $w^F - cost_f$ is the formal potential wage of worker i minus the cost of entry into the formal market, which is also estimated econometrically. The concept of expected wage used here follows Harris and Todaro (1970), as calculated by Atuesta and Hewings (2012), and it is computed as the product of urban wages and the probability of finding a job in urban areas. Finally, the labor supply is the sum of the workers in each labor market, weighted by the expansion factor of the household survey. They will serve as an input to the CGE model.

Envelope model of household welfare

It is assumed that policy change affects household welfare through the change in domestic market prices, producer prices, and factor income. This assumption in turn implies that the welfare effects depend on household consumption patterns and factor endowments. Changes in labor income (dw_l/w_l), marketed commodities prices (dp_g/p_g), and producer prices (dp_{hg}/p_{hg}) from the CGE model are fed into the microsimulation model to determine the welfare gains or losses of each of the 12,098 households. The first-order welfare change function dW_h/y_h is given as

$$dW_h/y_h = \sum_l \emptyset_h^l (dw_l/w_l) - \sum_g \theta_h^g (dp_g/p_g) - \sum_{hg} \theta_h^{hg} (dp_{hg}/p_{hg}) \quad (5\text{-}4)$$

where $\emptyset_h^l$ is the share of labor category l in labor income of household h,[56] θ_h^g is the share of marketed good g in the total consumption expenditure of household h, θ_h^{hg} is the share of home-produced good g in the total consumption expenditure of household h, and y_h is household income.

Macro-micro linkages

This study integrates the CGE model and the microsimulation module in a top-down/bottom-up fashion (Savard 2003). This method creates a bi-direction link between the CGE model and the microsimulation model, which brings consistency between macro and micro levels. This approach starts by solving the CGE model and transmits its output (changes in price and wages) to the microsimulation model. Once the microsimulation is solved, the output (labor supply and consumption demand) is brought back to the CGE model, and the interactions are done until the two models produce convergent results. In this case, the two models converged after 5 interactions.

5.4.3. Pro-poor growth analysis

This framework can be used to measure whether a policy change is absolute pro-poor or relative pro-poor. This study defines growth as pro-poor in relative terms if the proportional change in the incomes of the poor is no less than the growth rate in mean income. To be absolutely pro-poor, the incomes of the poor should grow by an absolute amount that is no less than zero. The theoretical framework applied for the pro-poor growth analysis follows the same approach as Duclos (2009) and Araar et al. (2009).

[56] Factor income of households includes income from labor, land, and capital. Production income of households does not go to households directly, but through production factors.

Let F_0 and F_1 denote the cumulative distribution function of income before and after a policy intervention. Also let $y_1(p) = F_1^{-1}(p)$ be the p-th quantile function for distribution F_1. Then the growth rate $g_1(p)$ of the p-th quantile after a policy change can be defined by:

$$g_1(p) = \frac{y_1(p)}{y_0(p)} - 1 \tag{5-5}$$

Now let us recall the FGT indices (Foster et al. 1984) as given by,

$$P_1(z;\alpha) = \int_0^{F_1(z)} (1 - y_1(p)/z)^{\alpha}\, dp \tag{5-6}$$

where z is the poverty threshold and α is the poverty aversion parameter. Let us define the poverty headcount index at z as $P_1(z;\alpha = 0)$ and the average poverty gap as $P_1(z;\alpha = 1)$. These poverty indices allow us to define the order of stochastic dominance as indicated in Table 5-9. Using FGT indices, Araar et al. (2009) show that growth is pro-poor in relative terms if the initial cumulative distribution is larger than the headcount index in the posterior cumulative distribution when that distribution is normalized by $1 + g$. Similarly, absolute pro-poor growth refers to a situation in which the poor gain in absolute terms. Thus, the pro-poor growth analysis can be summarized as Table 5-9.

Table 5-9: Pro-poor growth analysis

Type of growth	Order	Condition
Absolute pro-poor	First	$P_1(z;\alpha = 0) \leq P_0(z;\alpha = 0),\ \mathrm{z} \in [0, z^+]$
	Second	$P_1(z;\alpha = 1) \leq P_0(z;\alpha = 1),\ \mathrm{z} \in [0, z^+]$
Relative pro-poor	First	$P_1\big((1+g)z;\alpha = 0\big) \leq P_0(z;\alpha = 0),\ \mathrm{z} \in [0, z^+]$
	Second	$P_1\big((1+g)z;\alpha = 1\big) \leq P_0(z;\alpha = 1),\ \mathrm{z} \in [0, z^+]$

Source: Author's creation.

In the empirical analysis, I make use the growth incidence curve (GIC) (Ravallion and Chen 2003a) to assess the pro-poorness of policy experiments. The GIC basically plots the growth rate in the mean income for all percentile of income distribution. In this case, growth is pro-poor if the GIC lies above the null horizontal line for most of the distribution of the poor. In addition, if the slope of GIC is downward, then economic growth contributes to equalizing the distribution of income.

5.5. Upgrading of value-added production

5.5.1. Simulation scenarios

In order to investigate the pro-poor effects of industrial policies that aim to create and add value to agro-food products, I experiment with two different rounds of simulations. On one hand, there are simulations of the upgrading of value-added production, which can take the form of product upgrade or skill upgrade. The first policy experiment (Scenario 1) addresses the issue of diversification in higher value-added agro-food products. For the simulation, the diversification experiment posits that the Herfindahl-Hirschman indices in agriculture and food products decrease by 5 percent[57]. Diversification into high value-added products could occur by increased capabilities of the firm, better market mechanism and efficient institution. This rate is close to the actual diversification between 2006 and 2012. The second scenario simulates a policy intervention that aims to upgrade the skill of workers in the agriculture and food sectors. In the simulation, I depict the upskill scenario as a 50 percent increase in labor productivity.

On the other hand, I conduct simulations on the upgrading of value-added distribution. The first simulation (Scenario 3) assumes that DRC adopts innovative methods of marketing agro-food products which creates the perception of value to consumers. The

[57] See Appendix A4 for the sensitivity analysis of the diversification scenario based on different elasticities of productivity with respect to diversification.

innovative marketing activities aim also to capture value by creating on-farm stores, farmers markets, mail orders, or Internet sales. I implement this simulation as a 50 percent increase in agricultural marketing efficiency. Finally, in the last scenario, I assume that DRC adopts modern transportation technology to preserve perishable products and improve the transport logistics system. Policies to modernize the transportation system include refrigerated transport infrastructure, Internet connection, GPS systems, or the intense use of mobile phones in transportation planning, among others. Table 5-10 provides a summary of policy experiments.

Table 5-10: Simulation scenarios

Scenarios	Description	Design
1	Diversification	● 5% reduction in the Herfindahl-Hirschman index of agro-food sector
2	Skill upgrade	● 10% increase in labor productivity of agro-food sector
3	Marketing efficiency	● 50% increase in agro-food marketing efficiency
4	Transport Efficiency	● 50% increase in agro-food transport efficiency

Source: Author's construction.

5.5.2. Macroeconomic effects

Table 5-11 reports the economy-wide impacts of the four scenarios. Diversification (Scenario 1) has a positive effect on the economy, as expected. GDP and private consumption increase by 4.14 and 4.47 percent, respectively. Investment increases by 0.56 percent, while government consumption and exports increase by 1.17 and 1.78 percent, respectively. Imports increase by 1.66 percent, leading to an appreciation of the exchange rate. The increase in production generates an increase in the demand of inputs used in the production, especially labor. The demand for labor leads to an increase in the wage of urban and rural workers, but rural workers benefit less than workers in urban areas. Table 5-11 indicates that the wages of rural workers increase by 2.88 percent, whereas urban formal and urban informal wages

increase by 4.27 and 5.63 percent, respectively. Finally, the second significant outcome of this scenario is related to the return to land, which increased by 3.24 percent as compared to a 2.70 percent increase in capital return.

Table 5-11: Simulation results – Changes in macroeconomic variables

	Scenario 1: Diversification	Scenario 2: Labor productivity	Scenario 3: Marketing efficiency	Scenario 4: Transportation efficiency
Gross domestic product	4.14	0.84	0.95	0.54
Absorption	4.07	0.83	0.93	0.53
Private consumption	4.74	0.97	0.88	0.51
Investment	0.56	0.10	1.34	0.60
Government consumption	1.17	0.24	0.74	0.72
Exports	1.78	0.37	1.00	0.69
Imports	1.66	0.34	0.93	0.64
Exchange rate	1.66	0.41	1.16	-0.15
Urban formal	4.27	0.95	1.55	0.64
Urban informal	5.63	1.19	0.25	0.99
Rural	2.88	0.67	2.04	0.59
Capital	2.70	0.58	1.46	0.65
Land	3.24	0.46	0.61	0.21

Source: Author's calculations.

Scenario 2 postulates regarding the potential contribution of improving labor productivity in agro-food sectors. Improved labor productivity has the potential to reduce the effective wage and increase the demand for workers – relative to capital and land – for a given level of output. On the other hand, a fall in production costs due to increased productivity is passed to consumers through lower producer prices, which in turn leads to higher demand, production levels, and actual wages.[58] The results of the model indicate that labor productivity produces the expected positive effects on factor income, with higher benefit going to urban informal workers. The macro results in Table 5-11 show that a 10 percent improvement of labor productivity in agro-food sectors would increase the income of urban informal workers by 1.19 percent, while the income of urban formal and rural workers would increase by 0.95 and 0.67 percent, respectively. Under this scenario, capital return increases by 0.58 percent and

[58] See Burfisher (2011) for a theoretical analysis of the effect of an increase in labor productivity on employment and wage.

land return by 0.46 percent. Table 5-11 further indicates that DRC would see a 0.84 percent increase in GDP if labor productivity in the agro-food sector rises by 10 percent. It is worth mentioning that labor productivity improvement produces the same qualitative effects with diversification, with almost all effects moving in the same direction.

Scenario 3 stimulates the effects of marketing efficiency, which increases the total primary factor productivity in the production of wholesale and retail trade services used for food and agricultural products by 50 percent. Looking at changes in factor earnings in Table 5-11, one can see that improvement of marketing efficiency in agro-food sectors generates increases in wages and capital and land returns. The major improvements are found for rural workers (2.04%) and urban formal workers (1.55%) as well as capital return (1.46%). These significant changes in the factor income for the three factors are partly driven by the increase in the value-added prices of the trade sector, which is the second employer in the urban area and employs these factors intensively. Land used in agriculture benefits highly from marketing efficiency, as its return increases by 0.61 percent compared to the 0.25 percent increase in the wages of urban informal workers.

With regard to Scenario 4, which is a scenario of improvement of the transportation efficiency of agro-food products, Table 5-11 indicates that factor income generally increases in this scenario, but there is a little variation in the distribution across labor categories. The point of interest of this scenario is that it favors urban informal workers relative to formal workers and rural workers. For example, the income of urban informal workers improves by 0.99 percent, while urban formal and rural workers' income grows by 0.64 and 0.59 percent, respectively. In the same token, capital return increases by 0.65 percent and land return increases by 0.21 percent.

5.5.3. Sectoral effects

Moving on to the sectoral effects, Table 5-12 presents the results of the policy experiments on the commodity shown for agricultural products and processed food. Diversification in the higher value of agro-food products (Scenario 1) generates higher competitiveness gains for domestic producers, as it boost exports of agro-food products. Table 5-12 shows that agricultural exports increase by 113.16 percent and food exports by 91.98 percent. The combined effects of lower consumer price and higher income due to diversification lead to an increase in the composite commodity supply of agro-food products, which increase by 6.57 percent for agricultural products and 3.89 percent for processed food. Interestingly, the composite supply of agricultural products is fueled by domestic demand, because agricultural imports decrease by 2.46 percent.

Similarly, labor productivity growth in the agro-food sectors boosts agricultural products and processed food exports. Unlike diversification, agricultural exports increase to a lesser extent than processed food, which increase by 16 percent, as compared to 15.57 percent for agricultural products. Under this scenario, the composite supply of agricultural products and processed food increases respectively by 1.24 and 0.89 percent, while domestic demand of these commodities increases by 1.29 and 0.96 percent.

Table 5-12: Simulation scenarios

		Scenario 1: Diversification	Scenario 2: Labor productivity	Scenario 3: Marketing efficiency	Scenario 4: Transportation efficiency
Composite commodity	Agriculture	6.57	1.24	1.11	0.34
	Food	3.89	0.89	1.72	0.50
Domestic demand	Agriculture	6.87	1.29	1.11	0.32
	Food	4.17	0.96	1.85	0.48
Exports	Agriculture	113.16	15.75	-7.19	-4.87
	Food	91.98	16.00	-4.43	-3.41
Imports	Agriculture	-2.46	-0.51	1.02	1.10
	Food	2.40	0.52	0.99	0.62

Source: Author's calculations.

Table 5-12 also reports the results of Scenario 3, which is a simulation of marketing efficiency of agro-food products. According to the model results, domestic demand of agricultural and food products increases by 1.85 and 1.11 percent, respectively. This scenario also leads to an increase of agricultural and food imports by 1.02 and 0.99 percent, respectively. Surprisingly, agro-food marketing efficiency leads to a reduction of agricultural and food products. Concerning the transportation efficiency of agro-food products (Scenario 4), Table 5-12 indicates that improved agro-food marketing efficiency leads to an increase in domestic demand and imports and food and agricultural products as a result of increased income and lower consumer price. Composite supply of these commodities increases by 0.34 percent for agricultural products and 0.50 percent for food products.

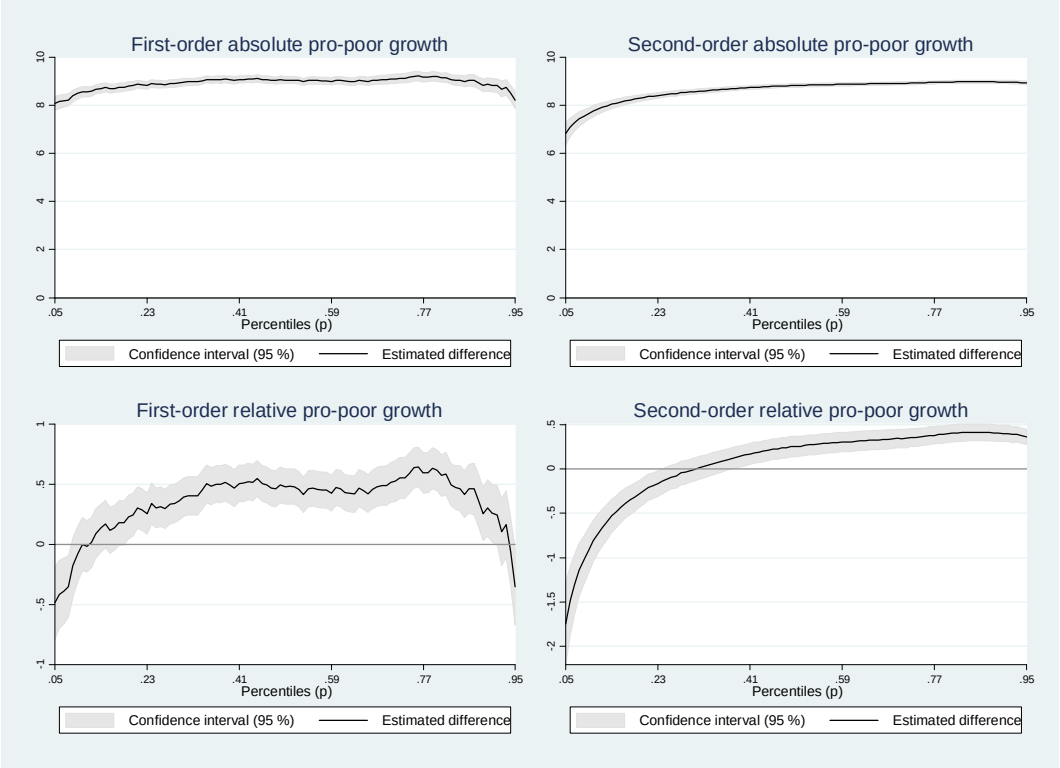
5.5.4. Distributional effects

I now turn the analysis to the pro-poorness of the policy experiments to test whether the policy experiments benefited lower percentiles in the income distribution more than upper percentiles. For this purpose, I make use of the GIC, which allows for plotting the growth rate of living standards across the entire range of percentile of income. In this context, one can conclude that a policy change is pro-poor when the income growth curves lie above the null horizontal line for the p-th lowest percentile of income distribution. In addition, if the slope of the distribution curve is downward, then the policy change leads to income convergence. For each policy experiment, I estimate the distributional effects for the absolutely and relatively pro-poor and conclude that growth is absolutely pro-poor if all percentiles undergo a rate of growth that is positive, while the relatively pro-poor occurs when the income growth of the households at the lowest tail of income distribution is larger than the growth rate in the mean income.

Figure 5-5 shows the pro-poor effects of diversifying into higher-value agro-food products (Scenario 1). Starting from the absolute pro-poor growth, one can see that the

income growth curve lies above the null horizontal line along the income distribution, because changes in income observed at all percentiles in the income distribution are positive. These findings indicate that diversification into higher-value agro-food products is first-order absolutely pro-poor. In addition, Figure 6 reveals that diversification into higher-value agro-food products is almost certainly first-order relatively pro-poor. The findings indicate that diversification-led growth is not first-order relatively pro-poor for the extremely poor below the 15th percentile. The GIC below the 20th percentile is significantly lower than zero, meaning that the mean growth rate of real income of the 20th percentile increases when the income of the very poor is lower than the average income growth. Based on these findings, we can conclude that redistribution is not effective to reduce poverty under diversification.

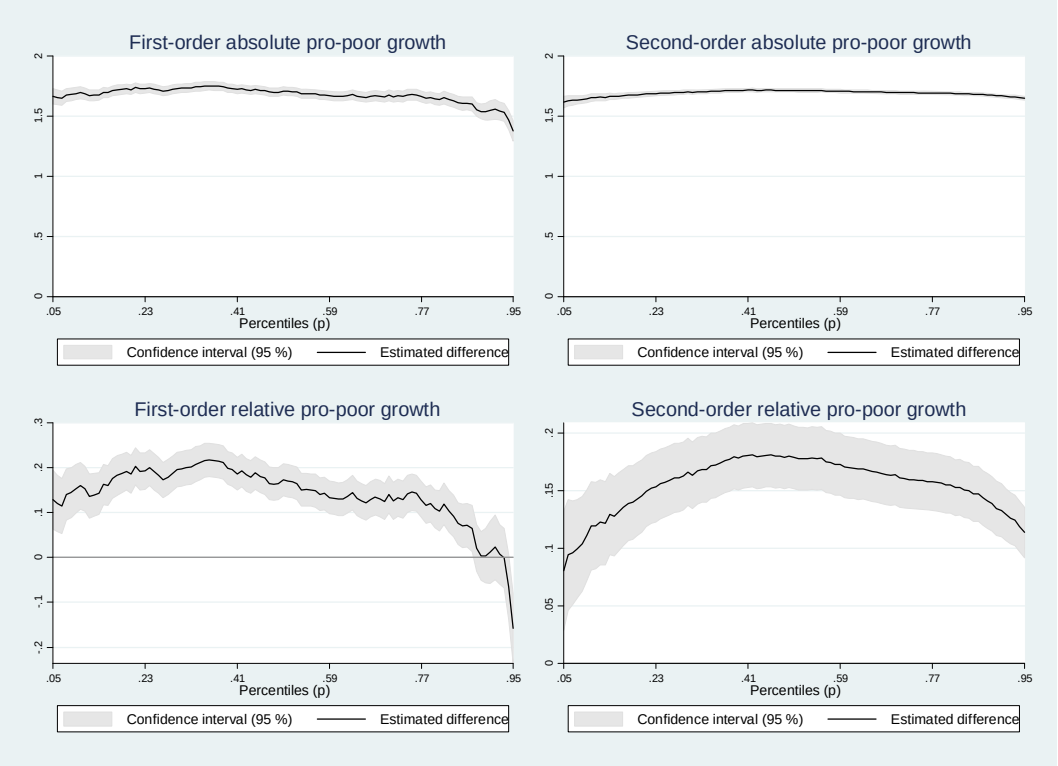
Figure 5-5: Pro-poor growth: Scenario 1



Source: Author's computations.

Moving now to the impacts of labor productivity, Figure 5-6 shows that the distributive change is first-order pro-poor in absolute terms. The mean income of the quantiles increases almost by the same proportion. This means that upgrading skill leads to inequality-neutral growth. In relative terms, Figure 5-6 reveals that upskilling labor in the agro-food sector leads almost certainly to income convergence. The GIC is positive along all income distribution and downward from the 37th percentile.

Figure 5-6: Pro-poor growth: Scenario 2

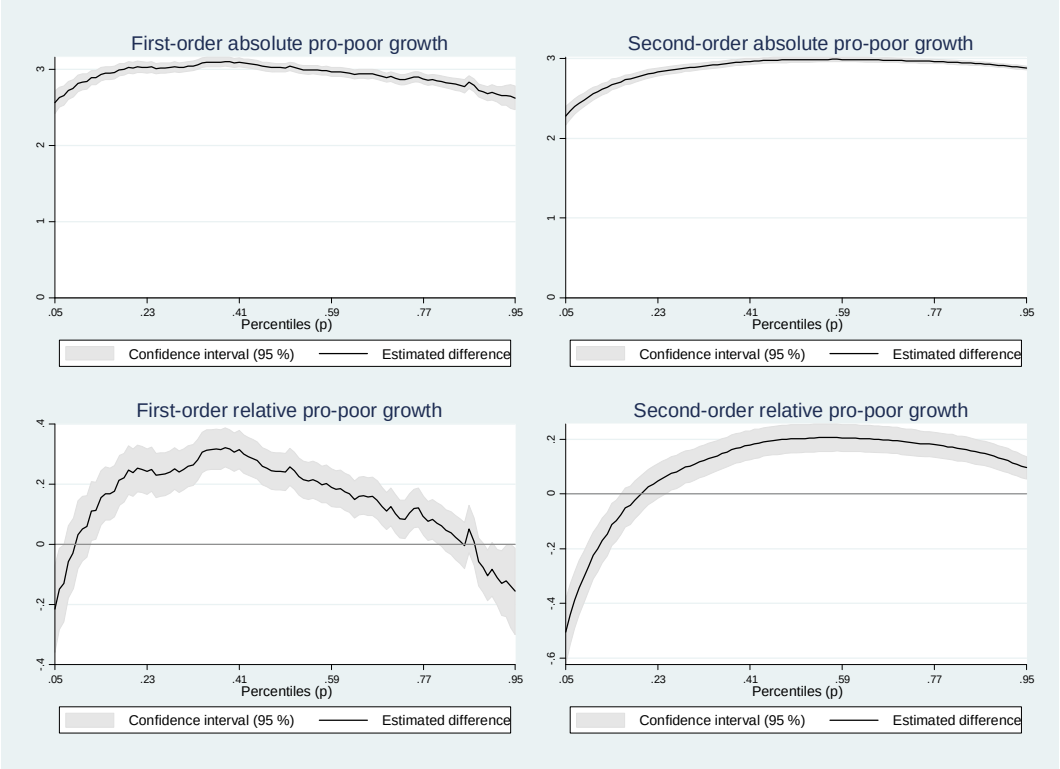


Source: Author's computations.

Figure 5-7 presents the pro-poor growth analysis of improving the marketing efficiency of agro-food products. The top panel of this figure, which depicts the first-order absolute pro-poor growth effects, indicates that the distributive changes are absolutely pro-poor. The mean growth rate of the percentile increases by more than 2.5 percent for all of the population. However, the distributive change due to marketing efficiency is not relatively first-order

pro-poor. In fact, the bottom panel of Figure 5-7 indicates that the GIC for the relative pro-poor judgment lies below the zero line for households below the 10th percentile. This means that the income growth of the households below the 10th percentile is lower than the mean income. This policy scenario benefits mostly households in the middle of the income distribution.

Figure 5-7: Pro-poor growth: Scenario 3

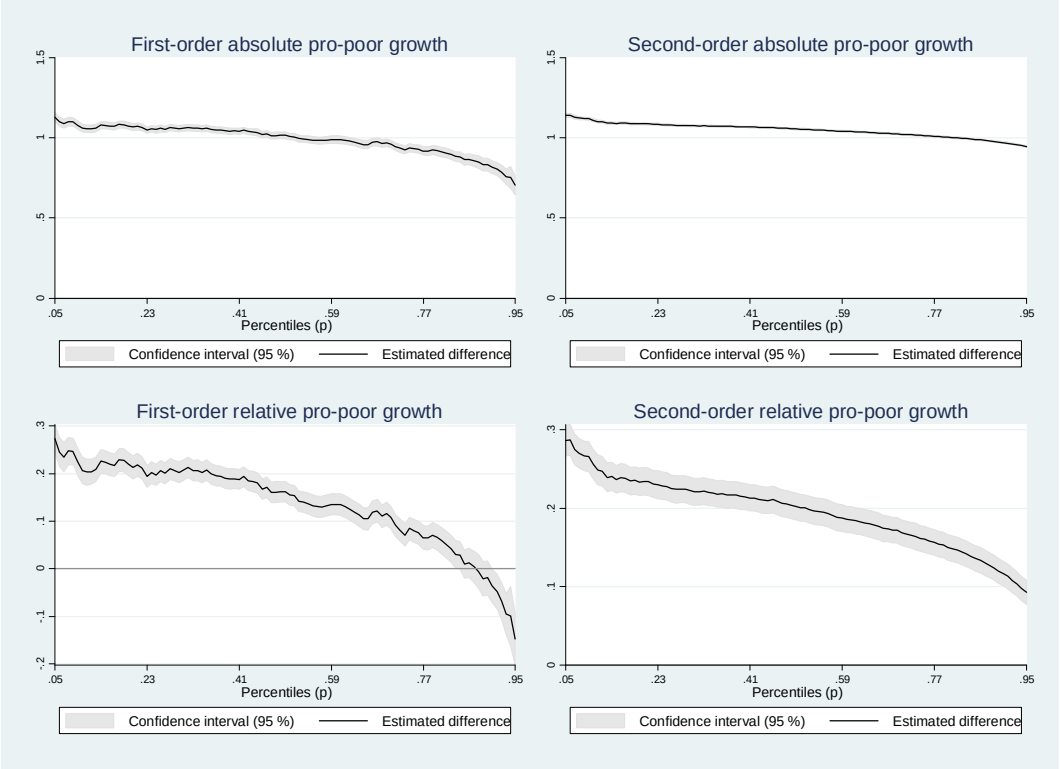


Source: Author's computations.

With regard to improving transportation efficiency for agro-food products, Figure 5-8 indicates that the distributive changes are relatively pro-poor as the change increases the incomes of the poor at a higher rate than that of the rest of the population. This is because the GIC lies below the zero line for households below the fiftieth percentile. In absolute terms, the graph portrays that improved agro-food transportation efficiency is pro-poor as the GIC

lies below the zero line. Furthermore, it leads to income convergence, since the slope of the GIC is downward.

Figure 5-8: Pro-poor growth: Scenario 4



Source: Author's computations.

5.6. Conclusions

This study used an analytical framework combining CGE and microsimulation models to analyze the growth and distributional implications of institutional arrangements and economic policies to create value and foster competition in DRC. The CGE model was linked to the microsimulation model through a top-down/bottom-up approach, where the CGE top model delivered changes in factor and goods prices to the microsimulation bottom model. Once the microsimulation is solved, the output (labor supply and consumption demand) is brought back to the CGE model, and the interactions are done until the two models produce convergent results. Unlike many other studies on policy experiments using CGE microsimulation, this

study went a step further by considering integrating into the CGE model the concept of diversification into higher value added and by augmenting the microsimulation model to incorporate the pro-poor growth framework.

The results suggest that reforms directed to agro-food sectors would be growth enhancing by making growth more inclusive and boosting consumption, which will also foster structural transformation. Likewise, measures to improve efficiency along agricultural local value chains generate strong pro-poor effects in absolute and in relative terms. The investigation of diversification into higher-value agro-food products has shown that this policy has strong absolute pro-poor and almost certainly first-order relatively pro-poor effects. Households below the 15th percentile benefit less than the average due to the impact of the policy in urban incomes and increase in demand of manufacturing products. The relevance of skill upgrading is clearly supported by the current findings. The evidence shows that labor upskill has not only produced strong absolute and relative pro-poor effects, but has also the potential to lead to income convergence, in which poor households' gains were higher than the richer ones.

Another major finding was that marketing efficiency favors the middle class and households at the 5th percentile benefit less than the average population. The reason for this is that improved marketing efficiency of agro-food products generates strong income growth that expanded the demand of food, other manufacturing products, and imports. Middle income groups benefited most due to the difference between domestic prices and import prices. This suggests that improving competition in the local agro-food chains is particularly effective in boosting food demand and imports.

In the case of transportation efficiency, the analysis found that efficiency growth in the transportation of agro-food products generates strong pro-poor effects in absolute and relative terms and is likely to be particularly effective in leading to income convergence. The analysis points to the fact that improved transportation efficiency has the potential not only to

increase income and employment, but also to provide positive price impacts for both agro-food producers and consumers and benefits to all households, particularly for low-income households.

The study also sought to identify whether additional effects may result from the interaction of policies and to understand the importance of sequencing and prioritizing reforms. This was done by running simulations of jointly implemented policies. The analysis points to a number of potential complementarity and synergetic effects that can be key drivers of effectiveness of measures to increase productivity and competition. The simulation also underscores the importance of sequencing reforms, as additional synergic effects may result from the interaction of policies. In particular, the results suggest that infrastructure development – aiming at reducing transportation costs – is a strong complement to diversification, as it produced synergetic effects in exports, investment, and capital return. Correspondingly, policies directed towards reducing marketing costs – such as cutting out the middle man – are likely to be complementary to diversification. However, the results at this stage suggest that agricultural trade liberalization may not be necessarily complementary to diversification, meaning that these two policies combined do not produce additional gains. In terms of policy priorities, the results of the analysis suggest that infrastructure development should be given the highest priority, followed by reducing marketing costs for agro-food products.

Chapter 6. Market integration and the role of infrastructure development in DRC: Focus on agriculture and food

6.1. Introduction

The results presented in earlier chapters highlighted the need to transform smallholder subsistence farmers to commercial farmers, build their capacity to produce high-value crops, and increase their access to markets. The findings also revealed the importance of efficient marketing and transportation infrastructure to capture value along the food supply chain. In a big country like DRC, with its immense territory and such a large population, it is important to understand how markets function and how price signals are transmitted between different markets or along different stages of the supply chain. This is because integrated and well-functioning markets make it possible to allocate endowment efficiently and serve as an engine of industrialization. Well-functioning markets enable farmers to allocate their resources based on their comparative advantage and modernize their production by investing in inputs. This phenomenon ensures that a regional balance occurs between food-deficit and food-surplus areas. On the other hand, non-integrated or imperfectly integrated markets lead to the transmission of wrong price information signals to producers, workers, buyers, and traders, resulting in incorrect decisions that reduce the gains from trade.

In this chapter, I will focus on the degree of market integration in the process of industrialization and the potential effect on infrastructure development to boost trade in DRC. In the continental sphere, there is indeed recognition that the intra-African trade is a fundamental factor for sustainable economic development, employment generation, and effective integration of Africa into the global economy. Recent data indicates that the trade within Africa represented about 11 percent of the continent's total trade in 2012, while the major part of the trade (89%) was with the rest of the world. In this context, infrastructure development plays a vital role in achieving inclusive growth and has been heightened as a

critical factor in integrating global value chains. In recent years, infrastructure development has become one of the most significant topics of discussion regarding African development.

There are several reasons for this increasing interest, one of which is that sustained growth in Africa has failed to create jobs and enhance structural transformation, as growth is driven by volatile commodity prices. It has been argued that, to seize the opportunities generated by the current growth, Africa should promote investment in infrastructure to boost intraregional trade and diversify away from natural resources, as the size and income of the middle class in Africa have increased. Infrastructure development is also designed to improve the competitiveness of the private sector, constrained by high transaction and marketing costs and limited access to inputs and technology.

Yet, despite this growing interest, studies neglect to link explicitly the degree of market integration to the improvement infrastructure in Africa. The research to date has tended to focus on either price transmission or infrastructure development; however, far too little attention has been paid to how infrastructure development affects price transmission and market integration, especially in Africa. In this chapter, the aim is to estimate the degree of market integration for agro-food products in DRC and assess the role of infrastructure development in improving export competitiveness, creating jobs, and promoting economic growth. Thus, this chapter attempts to bring these two concepts together into a unique framework which reconciles econometric evidence and endogenous model response.

This study contributes to the literature by offering input to the debate over two separate but related issues that figure prominently in development discussions: market integration and the role of infrastructure development. I proceed as follows: In the first section, I use cointegration techniques to analyze the degree of market integration in DRC by assessing the long-run relationship between international prices and domestic prices, between market pairs within DRC, and along the food supply chain in Kinshasa, the capital city of DRC. Then I use a CGE-microsimulation model to explore how infrastructure development –

which leads to lower transportation and transaction costs – affects domestic prices and welfare.

In particular, the study answers the following questions:

- Are DRC commodity markets spatially integrated? Is there a significant degree of co-movement between regional commodity prices?
- Are integrated markets efficient? Are changes in commodity price in one market similarly reflected in the change in the same commodity's price in another market?
- In which direction, how fast, and to what extent are prices transmitted along the food supply chain?
- What is the impact of transportation and trade costs on retail prices and producer prices?
- How does lowering trade and transportation costs affect the poor?

6.2. Market integration and price transmission

The next subsection reviews the literature on market integration, with a focus on Africa whenever possible. This is followed by the research framework for testing market integration and the description of the time series data which are used throughout the section. Finally, the remaining subsections discuss the findings.

6.2.1. Market integration: Types and causes

Market integration pertains to a situation in which two markets trade together or the price of any given commodity in one market is similarly reflected in changes in the price of the same commodity in the market. In such a case, markets are linked together through an arbitrage mechanism, implying that any shock that changes the price in one market will also be reflected in the price information of the other market. This definition implies that market integration can be assessed using trade volume or price data between two geographically separated markets or between different stages of the value chain within a single market.

However, since regional-level trade volume data on agricultural and food commodities are not usually reliable due to the substantial volumes of informal trade, while the prices of traded commodities are readily available and generally considered as the most reliable information in developing countries, price-based market integration studies have been central in understanding the extent of the integration of economic agents in the market process (Rapsomanikis et al. 2006).

A large body of research on price-based market integration has focused on the spatial price transmission both within the context of international price to domestic markets (Baltzer 2013; Minot 2011), between local price of the same commodity in different domestic regional markets (Cudjoe et al. 2008; Rapsomanikis et al. 2006; Acquah et al. 2012), or in cross-border trade (Mutambatsere et al. 2007; Brenton et al. 2014; Bonjean and Brunelin 2013; Versailles 2012; Acosta 2012). A few researchers (Kuiper et al. 2003) have studied the vertical price transmission along the value chain from producer to consumer. The most important areas of research in this field involve testing for the nature of price transmission and calculating the long-run and short-run elasticities as well as the speed of price transmission. These studies focused on the extent and speed of price transmission between different markets or within the value chain and have found a heterogeneous degree of price transmission. However, only few of them have attempted to estimate empirically the factors that influence the strength and speed of price transmission.

For example, Greb et al. (2012) reviewed the empirical findings of 31 studies of price transmission from international to domestic markets, with about 678 market pairs, which were conducted between 1996 and 2011. Despite the fact that these studies used different tests and levels of significance, Greb et al. (2012) concluded that 79 percent of market pairs were cointegrated. Africa exhibits the lowest rate of cointegration, with only 53 percent of cointegration in East Africa and 68 percent in West Africa, as compared to 90 percent in Latin America or 77 percent in the Asian Pacific. The results for Africa also indicate that the rice

and wheat markets are more integrated to world market than maize, with 40 to 90 percent of international price changes transmitted to the domestic markets. Note that Baquedano and Liefert (2014), using a sample of 60 country/commodity pairings, found that most consumer markets are cointegrated with world markets, but the transmission of price is not high. Rapsomanikis and Mugera (2011) also found a similar conclusion regarding the price transmission. In this regard, Baltzer (2013) noted that the degree of integration to world markets depends not only on whether the country is import reliant or self-sufficient for their main staples, but also on local factors and distorting policies. Nevertheless, these conclusions are country and time specific and thus cannot be generalized (Headey and Fan 2008).

Domestic spatial price transmission, particularly in Africa, has been addressed in fewer studies, but the majority of them find that domestic markets are well integrated among them. However, this integration depends largely on the physical distance between markets and the quality of domestic infrastructure (Rashid and Minot 2010; Ifejirika et al. 2013; Badiane and Shively 1998) as well as the type of commodities (Cudjoe et al. 2008; Acquah et al. 2012). Ifejirika et al. (2013), studying the empirically structural factors that affect rice market integration between urban and rural in Nigeria, found that processing cost, toll, and transportation and storage costs significantly affect the level of market integration. Puzzlingly, Nhate et al. (2013) found that the price of rice and the price of wheat in Maputo and Nampula (2000 km) are cointegrated, while Maputo and Neira are not cointegrated (721 Km). On the other hand, findings on commodity indicate that the domestic markets of maize and rice are more integrated than cassava. In the case of Ghana, for instance, Cudjoe et al. (2008) found limited price transmission in rice and maize markets, whereas Acquah et al. (2012) found no cointegration in cassava markets.

Another interesting finding from the literature concerns the asymmetry of price transmissions (Cramon-Taubadel 1998). There is an asymmetry in the price transmission when the price in one market (or one level of value chain) responds differently to a decrease

and increase in price in another market (or at a different level of value chain). This is generally due to the existence of market imperfections related to the existence of market power (presence of oligopoly and oligopsony[59]), policy intervention, and transaction costs, among others.[60] Findings from the African case study strongly suggest that price increases are transmitted faster and to a greater extent than price decreases (Ianchovichina et al. 2012; Abdulai 2000; Acosta 2012). For instance, Abdulai (2000) found that wholesale maize prices in local markets respond more swiftly to increases than to decreases in central market prices. Acosta (2012) showed that price increases in the South African white maize export market tend to be transmitted faster than decreases, implying that it takes about seven months for the domestic market in Mozambique to adjust to the new equilibrium when prices increase, and about 11 months when they decrease. This line of research has been most interestingly applied in the analysis of vertical price transmission along the value chain (Meyer and von Cramon-Taubadel 2004; Vavra and Goodwin 2005). This is because vertical price adjustments can be characterized by the speed, direction, and magnitude relative to the initial market shock, with the results in each case being determined by the underlying relationships among agents at different levels of activity.

The literature on price-based market integration provides tremendous insight for food security but is not robust in explaining the imperfections in transmission of price. This is because it assumes the existence of the market fundamentals (infrastructure, institution, information, and policies) responsible for market transactions. A logical step forward has been to extend the analysis of price transmission to incorporate structural factors responsible for market integration. According to Goletti et al. (1995), the identification of the structural factors that influence market integration may improve the design and implementation of policy oriented toward market development. The meta-analysis of market integration uses an

[59] It is worth noting that the presence of oligopoly and oligopsony power does not necessarily mean imperfect price transmission (Weldegebriel 2004).

[60] On the other hand, symmetric relationships often pertain to competitive markets.

empirical strategy that estimates the strength and speed of price transmission and regresses the measure of market integration on a number of structural factors (Goodwin and Schroeder 1991; Ismet et al. 1998; Varela et al. 2012; Goletti et al. 1995; Greb et al. 2012). In their analysis of the structural determinant of rice markets in Bangladesh, Goletti et al. (1995) found that, the distance between markets and the number of strikes negatively affect market integration, while the number of production shocks has a positive impact on market integration. Varela et al. (2012) recently performed a similar analysis using data for maize, soybeans, and cooking oil to study the market integration among Indonesian provinces. The authors reported that the remoteness and quality of transport infrastructure of a province are key factors responsible for integration. Greb et al. (2012) found that importing countries and countries trading maize and wheat have less price transmission, whereas trade openness improves integration into the world market. In their paper, Greb et al. (2012) also reported a negative but not significant effect for landlocked countries, while the existence of state trading enterprises significantly reduces integration into world markets.

Another vein of the meta-analysis of market integration focuses on the distance or cross-border effects on market integration (Mengel and Cramon-Taubadel 2014; Imbs et al. 2003; Trenkler and Wolf 2005). Mengel and Cramon-Taubadel (2014) have written the most complete piece to date, based on 1,189 cereal market pairs extracted from 57 studies in developing countries. Their findings indicate that borders reduce the probability of market integration by about 23 percent relative to markets located in the same country, while two markets at a distance of 1,000 kilometers have 13 percent lower probability of integration. Brenton et al. (2014) found comparable results for Central and Eastern Africa, suggesting the substantial effects of distance, paved roads, and borders on market integration. Their findings suggest that markets are more integrated within than between countries. This is partly explained by ethnic and language differences as well as internal and cross-border conflicts. Bonjean and Brunelin (2013), identifying barriers to agricultural trade in West and Central

Africa, showed that, when two countries share the same currency, the border effect tends to be lower than within the regional community (West African Economic and Monetary Union), where border crossing remains costly.

In this paper, I do not attempt to conduct the most comprehensive assessment of market integration in DRC. Leaving the determinant of price transmission aside, I address the classical question regarding the extent and the speed of market integration.

6.2.2. Market integration testing framework

The empirical literature on market integration is vast and is still growing due to the improvement in econometric techniques and the availability of data.[61] Indeed, there are various measures of integration applied to the literature of market integration. Such techniques include static correlation coefficient (Lele 1972; Jones 1972; Durojaiye and Aihonsu 1988; Amartya 1981), variance decomposition (Delgado 1986), seemingly unrelated regressions (Minten and Kyle 2000), dynamic models and Granger causality tests (Ravallion 1986; Timmer 1987), cointegration and error correction models (Palaskas and Harriss‐white 1993; Alexander and Wyeth 1994; Richardson 1978), parity bound models (Barrett and Li 2002; Sexton et al. 1991; Spiller and Wood 1988; Baulch 1997; Park et al. 2002), threshold error correction models (Goodwin and Piggott 2001; Meyer 2004; Sephton 2003), and Markov switching models (Brümmer and Zorya 2005). The rest of this subsection presents the market integration testing framework used in this study.

To study the degree of market integration in DRC, this study applies time series techniques of cointegration and error correction models (ECMs). Despite the tremendous evolution of time series techniques, classical tests for market integration based on cointegration analysis are still popular. One of the reasons for this is that sophisticated

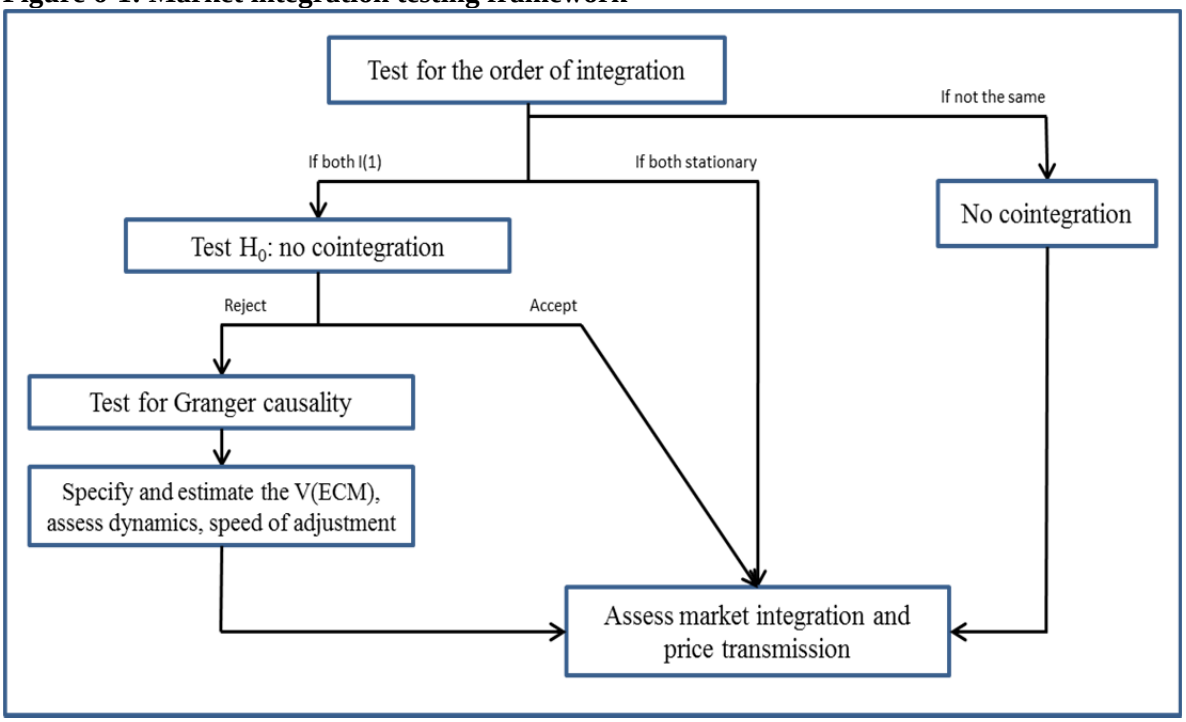
[61] Goletti et al. (1995) provide an excellent review of the literature on earlier studies on market integration. Fackler and Goodwin (2001) and Stephens et al. (2012) review the methodological issues related to spatial market integration analysis. Gardner (1975) discusses vertical price transmission under perfect competition while Lloyd et al. (2006) introduce the concept of vertical price transmission under imperfect competition.

techniques require real data on trade flows and transaction costs (Timmer 1996). Most of the studies using cointegration analysis apply either Engle and Granger (1987) or Johansen (1988) and Johansen and Juselius (1990) tests for cointegration. However, a major problem with this kind of standard application is the presence of structural breaks in the price that can substantially reduce the power of standard tests for the null hypothesis of no-cointegration (Gregory et al. 1996; Gregory and Hansen 1996). Sanjuán and Dawson (2003) used cointegration techniques (Johansen et al. 2000) that allow for structural breaks in their study on price transmission in the UK meat sector, based on monthly data from 1986–2000. They found the existence of a structural break in the long-run relationship between the producer and retail price of beef. This break occurred at the height of the bovine spongiform encephalopathy (BSE) crisis and increased the margin by £1.12/kg. Nevertheless, far too little attention has been paid to cointegration with structural breaks despite the growing number of price transmission studies during 2007-08 and 2010-11 crises.

This analysis contributes to the literature of price transmission by analysis market integration in the presence of structural breaks. Perron (2006) described the theoretical underpinnings of cointegration and unit roots tests with structural breaks. The testing framework applied in this study follows that suggested by Rapsomanikis et al. (2006) and is presented in Figure 6-1. I start the analysis with a package of pre-cointegration tests. First I perform a graphical analysis of price trends to set the general contextual information for the analysis. Descriptive statistics that follow provide some summary measurements, and I use pairwise correlation to assess the linkage between price variables. Given the potential presence of a structural break in price data in DRC due to the unstable political environment and fragile macroeconomic standard, I conduct a battery of traditional and non-standard unit roots tests. The usual tests used include the standard augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1979; Becketti 2013), the GLS detrended version of the ADF (DF-GLS) test (Elliott et al. 1996), and the Phillips-Perron test (Phillips and Perron 1988). The

non-traditional tests include some powerful new unit root tests with structural breaks such as that by Zivot and Andrews (1992) and Clemente et al. (1998).

Figure 6-1: Market integration testing framework



Source: Author's conception based on Rapsomanikis et al. (2006).

To test the hypothesis of the long-run equilibrium between prices, I apply a series of cointegration tests, which include the method of Johansen (1988) cointegration test and Gregory and Hansen (1996) test with structural break. In this context, two spatially separated markets (or stages of the value chain) are integrated if changes in one price are completely and instantaneously transmitted to the other price. In addition, this definition implies that, if price changes are not passed through instantaneously, after some time, price transmission is incomplete in the short run but complete in the long run, as implied by the spatial arbitrage condition. The distinction between short run and long run price transmission is important, and the speed by which prices adjust to their long-run relationship is essential to understand the extent to which markets are integrated in the short run. Changes in the price in one market

may need some time to be transmitted to other markets for various reasons, such as policies, the number of stages in marketing, and the corresponding contractual arrangements between economic agents, storage and inventory holding, delays caused in transportation or processing, or "price-levelling" practices. In case there is cointegration, the price in one market would commonly be shown to cause the price in the other market. To provide evidence for the direction of causality, I perform the causality test on cointegrated price series using the pairwise Granger causality tests (Granger 1969). Given the results of the Granger causality tests, I specify a single ECM as follows:

$$\Delta p_t^2 = \alpha + \theta(p_{t-1}^2 - \beta p_{t-1}^1) + \delta \Delta p_{t-1}^1 + \rho \Delta p_{t-1}^2 + \epsilon_t \quad (6\text{-}1)$$

where Δp_t^2 is the change in the price in market 2, α the constant, θ the speed of adjustment, β the long-run elasticity of price transmission, δ the short-run elasticity of price transmission, ρ the autoregressive term, and ϵ_t is the error term. The market integration consists of the local prices of rice, maize, and wheat between three cities (Bunia, Kinshasa, and Kisangani) and world prices. I test also for market integration between the rice, maize, and wheat in Bunia, Kinshasa, and Kisangani and the international market and between the wholesale and retail food price in Kinshasa. The next subsection gives more detail on the data.

6.2.3. Data

I use several data sources to study the degree of market integration in DRC. Table 6-1 describes the data used in the empirical analysis, including the variable definitions and relevant sources. World price comprises the monthly data of rice, maize, and wheat from the IMF (2014). I obtained the local retail price of rice, maize, wheat, cassava, and beans from the FAO-GIEWS price database from the Global Information and Early Warning System (2014). World price and local retail price of rice, maize, and wheat will serve for an international

integration analysis of DRC to the world market. To study the spatial transmission mechanism of commodities price in different regions of DRC, I use the local retail price of cassava and beans. I base the analysis on three markets (Kinshasa in the west, Kisangani in the north, and Bunia in the North East).

Table 6-1: Market integration and price transmission

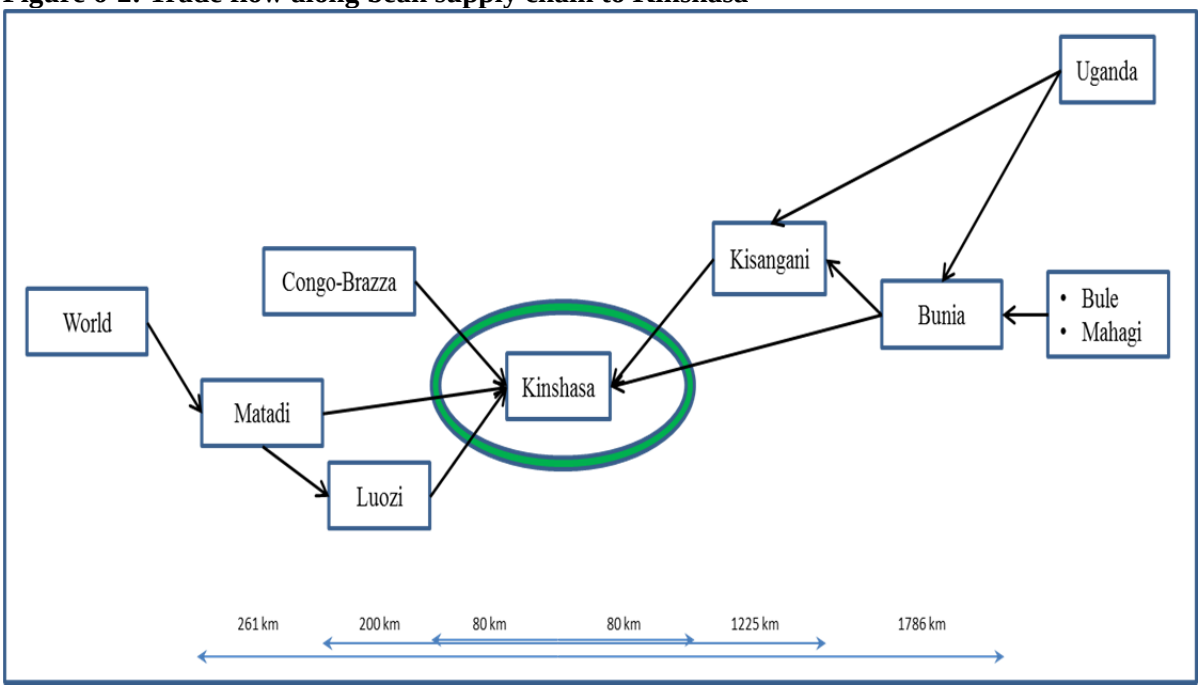
Variable	Description	Unit	Source
Wholesale and retail food price (Kinshasa)	Monthly wholesale and retail food price		DRC Central Bank
World rice	Rice, 5 percent broken milled white rice, Thailand nominal price quote	US$ per metric ton	IMF
World maize	Maize (corn), U.S. No.2 Yellow, FOB Gulf of Mexico, U.S. price	US$ per metric ton	IMF
World wheat	Wheat, No.1 Hard Red Winter, ordinary protein, FOB Gulf of Mexico	US$ per metric ton	IMF
Local price (Kinshasa, Kisangani, Bunia)	Retail monthly price of rice, maize, wheat, cassava, beans	US$/Kg	FAO Global Information and Early Warning System

Source: Author's creation.

To illustrate how these three markets trade, Figure 6-2 presents a diagram flow of beans trade with Kinshasa as a consumption center. Most of the imported food products enter DRC in the West (Matadi port) and are delivered to Kinshasa and other regional markets. Most of the domestic bean production in DRC comes from the Eastern part, which is specialized in "European style" vegetables (parsley, eggplant, green bean, lettuce, carrots, turnips, and cabbage), whereas the Western DRC produces more tomatoes, peppers, sweet potatoes, onions, and cassava (BEAU 1986). With regard to Eastern DRC, Bunia and Kisangani are entry points for regional production (Uganda, Rwanda via Boma) and also serve as marketing centers and transportation hubs for domestic production. For instance, beans and rice are

produced in the surrounding villages such as Kumano and are shipped to these cities before they are delivered to the Kinshasa market.

Figure 6-2: Trade flow along bean supply chain to Kinshasa



Source: Author's conception.

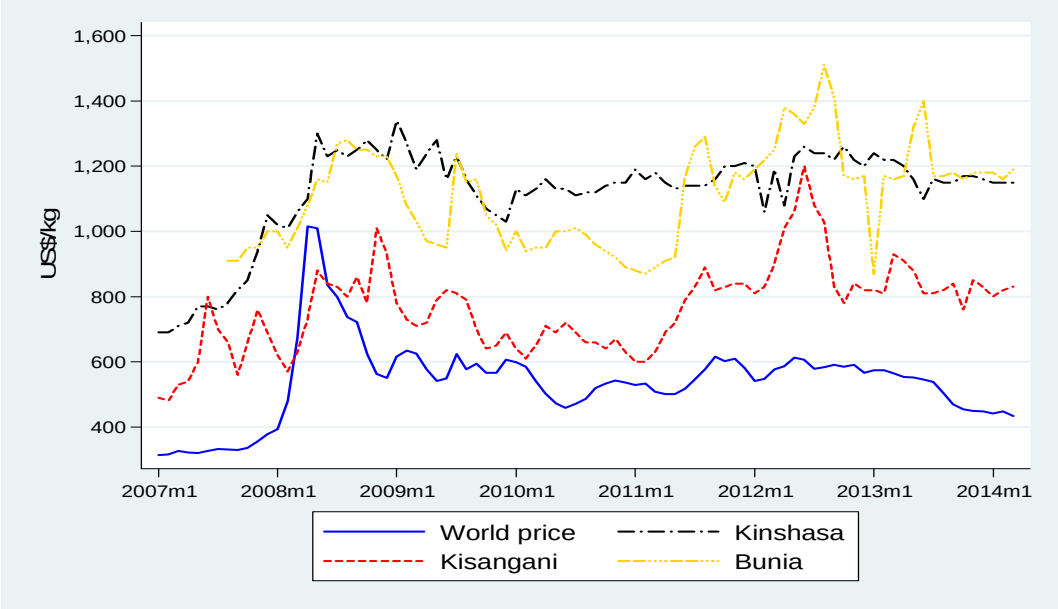
Furthermore, I use wholesale and retail food price data from DRC Central Bank (Banque Centrale du Congo 2007-2013), to analyze vertical price transmission. It is necessary to point out that vertical price transmission analysis includes all food production and omits the producer's stage due to data availability. In fact, there is no disaggregated data for the food industry, and the available data goes from wholesale to retail in the Kinshasa market. In the empirical analysis, I expressed all of the variables in natural logarithms to reduce the dispersion of data (Hamilton 1994) and interpret results in terms of percentage change. In the rest of this subsection, I present a preliminary analysis of the data based on the graph, summary statistics, and unit root tests.

6.2.4. Data exploration

Rice

Figure 6-3 plots the rice prices in Bunia, Kinshasa, and Kisangani as well as the world price. The world price of rice remained lower than the domestic price in DRC, except in early 2008, when the world price was higher than the price in Bunia. The data shows two main patterns; the rice price in Kinshasa seems to follow a trend in the world price while the rice prices in Bunia and Kisangani follow a more separate trend. Looking at the world price, which significantly and temporarily picked up in early 2008 and came down to remain constant, the difference is the largest with Kinshasa, but the Kinshasa price significantly picked up earlier in 2007, whereas the world price of rice rose significantly in 2008. The significant difference between the world price and price in Kinshasa implies the existence of high transaction costs.

Figure 6-3: Rice



Source: Author's computation using data described in Table 6.1.

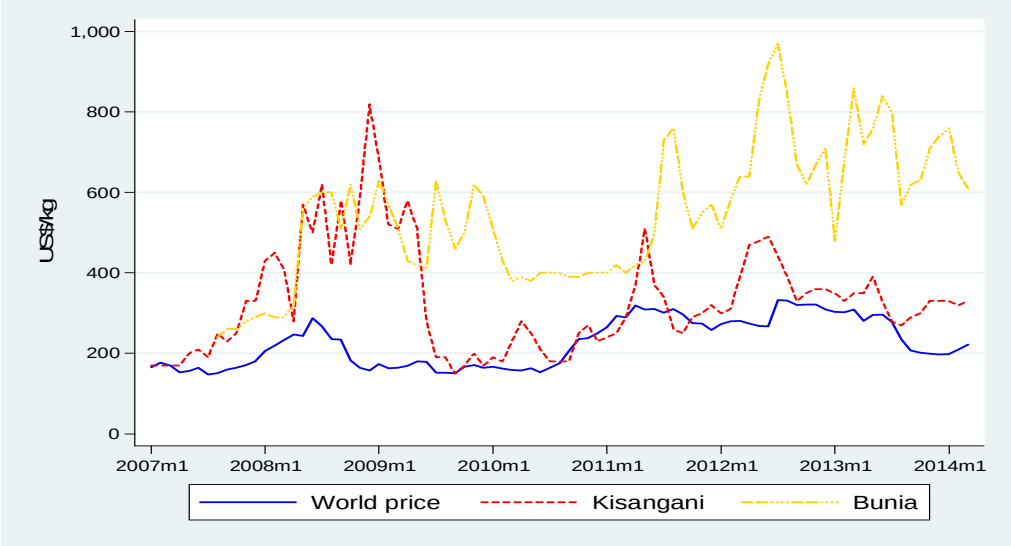
Despite the initial high price, rice prices picked up in 2011 due to the civil conflict that displaced an estimated 2 million people, hindering agricultural activities. In addition, rice prices in Bunia and Kisangani picked up again in 2012 due to the below-average rains across

the country – which negatively affected land preparation and planting activities – and shortages of basic inputs due to insecurity in the region. Figure 6-3 further indicates that rice prices in Kinshasa were relatively stable between January 2010 and June 2011, fluctuated for half a year, and returned to a more or less stable trend. These trends, however, followed closely the world rice prices, suggesting that there is a significant relation between these two markets.

Maize

Figure 6-4 shows the evolution of maize prices in Bunia and Kisangani as well as the world price. The figure indicates that the maize prices in Bunia and Kisangani increased dramatically in 2007 and 2008, following international prices. Price increase was much higher in Kisangani, where prices rose by 300 percent in 2009 compared to their 2007 levels. The increase in price is partly related to higher demand for rice for brewing, since maize is used as a substitute for rice in recipes.

Figure 6-4: Maize



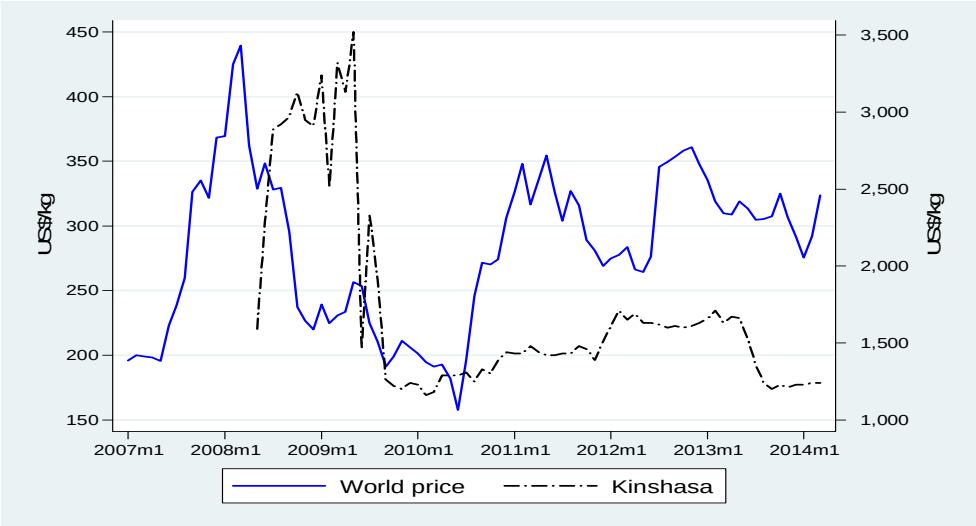
Source: Author's computation using data described in Table 6.1.

Figure 6-4 also shows another interesting trend in the maize prices in Bunia; that is, prices remain high and more volatile, whereas maize prices in the Kisangani market drastically dropped to the level of the world price in 2009 and continued to follow a similar pattern. A plausible explanation for the high volatility of the maize price in Bunia could be the conflict.

Wheat

Figure 6-5 plots the wheat prices in three towns in DRC: Bunia, Kinshasa, and Kisangani. The plot suggests that the bean markets follow practically the same pattern at a different speed; that is, prices began to increase in 2007 and peak in January 2009 and came down in July 2009 (a lower speed for Bunia) before picking up again in March 2010.

Figure 6-5: Wheat



Source: Author's computation using data described in Table 6.1.

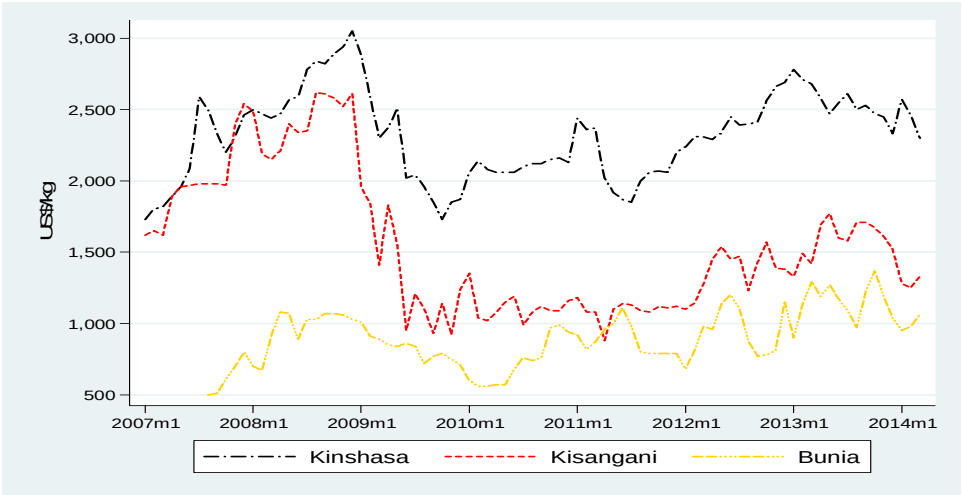
Beans

Figure 6-6 plots the bean prices in three towns in DRC: Bunia, Kinshasa and Kisangani. The plot suggests that bean markets follow practically the same pattern at a different speed; that is, prices began increasing in 2007 to peak in January 2009, came down in July 2009 (a lower speed for Bunia) before picking up again. Kinshasa records higher prices because it is a major

consuming town. Bunia and Kisangani, among others, are the main suppliers of beans in Kinshasa markets.[62] However, the large price differences between the two markets and Kinshasa is due to transportation costs and taxes. Beans from Bunia are transported by air, and it takes one day, whereas beans from Kisangani come within 3 weeks by river. The lower prices in Bunia are worth noting. In fact, Bunia also supplies beans in Kisangani.

Figure 6-6 further indicates that Kinshasa had two peak prices in January 2011 and January 2013. This seasonal price peak may be explained by the increase in demand for beans during the end of the year celebration, as beans are sometimes referred to as the "meat of the poor". Nonetheless, Kinshasa experienced a price surge between July 2012 and December 2013 when compared to November 2009 and February 2011. This sharp increase in the bean price in Kinshasa is due to the war in the Bunia region, particularly in Goma, which is another big supplier of Kinshasa. Nevertheless, the high spike in bean prices in the New Year and during wartime is amplified by rent seekers such as middlemen who usually take advantage of these situations as prices are not regulated.

Figure 6-6: Beans



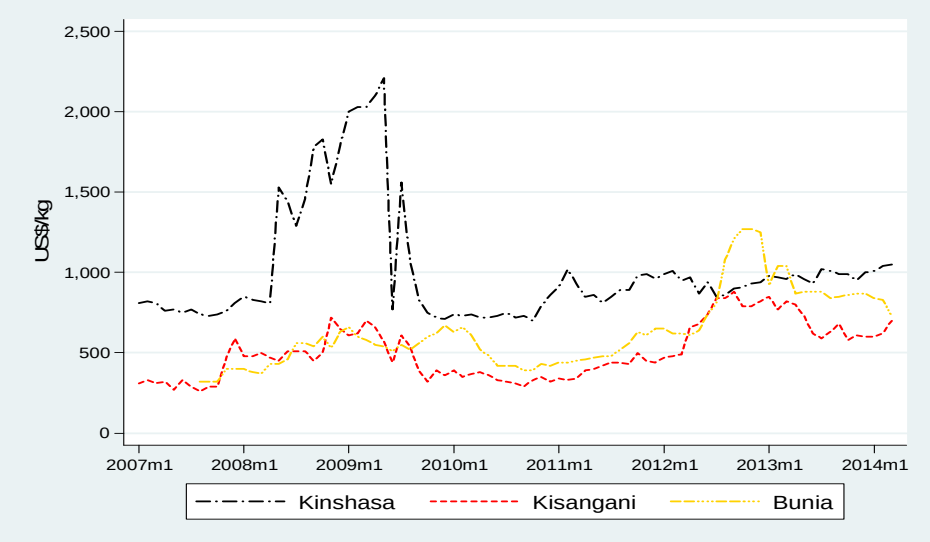
Source: Author's computation using data described in Table 6.1.

[62] Other domestic suppliers include Mbuji-Mayi, Seke-Banza, and international suppliers such as China and Tanzania.

Cassava

In the period between March 2008 and May 2009, cassava prices in Kinshasa rocketed by 173 percent and dropped sharply to the levels of March 2008, as Figure 6-7 illustrates. The rise in cassava price can be attributed to heavy rains, especially in Bandundu, which dramatically reduced the harvested production and transformation of cassava. The spike also coincides with the increase in the price of electricity that substantially increased production costs and consumer prices. Later, the price temporarily went up but came down in September 2009 and remained relatively stable. A sharp fall followed, but sales levelled off at about 800 in 2011, fluctuated slightly through the year, and are now increasing again. What is also worth noting about cassava prices is that they remained relatively low and stable in Bunia and Kisangani despite a spike in Kinshasa. A steady decline followed cassava prices in Kisangani (in 2009) and Bunia (in 2010), but prices in Bunia rose more and more steeply, throughout 2011, and reached a peak of 1,300 US$/Kg in October 2012. Especially alarming in this regard is the fact that, during June 2012 and April 2014, cassava prices in Bunia were higher than prices in Kinshasa.

Figure 6-7: Cassava

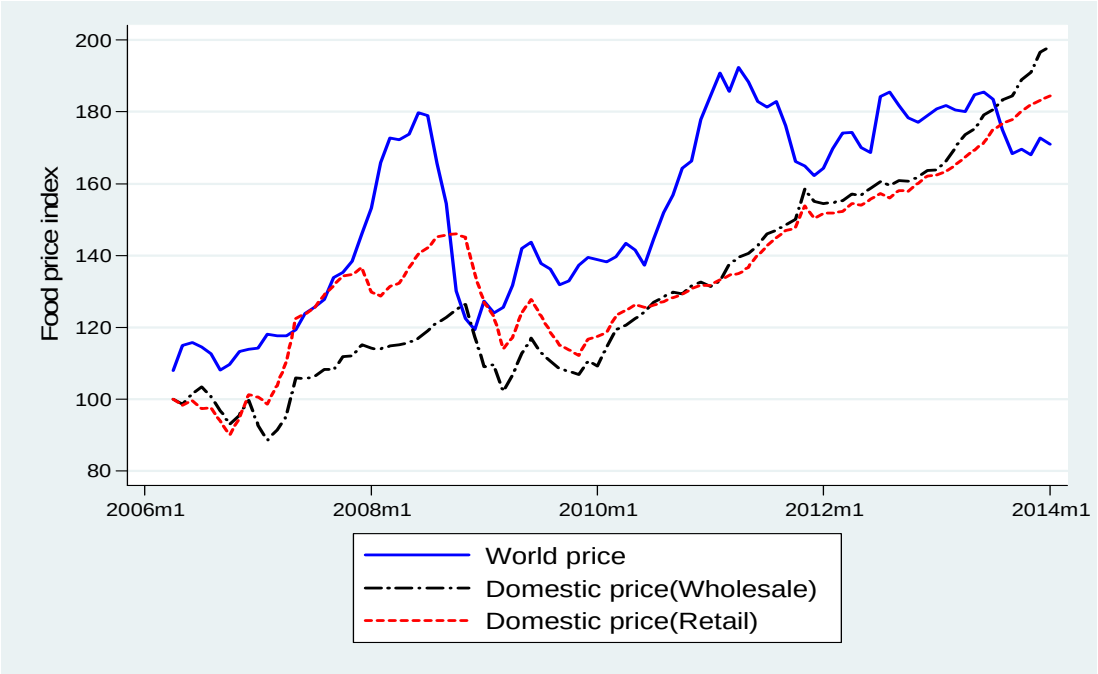


Source: Author's computation using data described in Table 6.1.

Food

The line graph in Figure 6-8 illustrates the trend in wholesale and retail food price in Kinshasa. Overall, both wholesale and retail food prices show an increasing trend over time and are found to move in a similar fashion. Food prices have almost doubled between 2006 and 2014. Between February 2006 and January 2010, food prices were highly volatile, following world food prices. Domestic prices fluctuated slightly at the beginning of 2006 and surged in June 2007, then continued to rise sharply until they hit a peak in January 2009. From 2010, food price in DRC rose sharply even when the international food price was stable or started to drop.

Figure 6-8: Monthly trends in food prices, 2007–11 (January 2007=100)



Source: Author's computation using data described in Table 6.1.

6.2.5. Summary of price trends

Tables 6-2 and 6-3 provide the descriptive statistics of the price data used in the analysis. Table 6-4 presents the results of the price correlation analysis for the case of world price transmission. The positive pairwise correlation between the world price and domestic rice

prices in Bunia, Kinshasa, and Kisangani indicate that all prices move in the same direction. The high correlation between world rice price and Kinshasa price is indicative of market integration. The correlation coefficients for maize are positive and significant, whereas the wheat price in Kinshasa does not correlate with the world wheat price. In addition, the correlation coefficient of wheat in Kinshasa is much lower than that of rice in the same city, which implies that the wheat market is not integrated in the world market. This lack of correlation was not expected, because wheat is an imported commodity.

Table 6-2: Descriptive statistics: World price

Commodity	N	Mean	Std. Dev	Coefficient of variation	Min	Max
Food	94	153	26	0.17	108	192
Maize	87	226	60	0.26	147	333
Rice	87	538	128	0.24	313	1015
Wheat	87	282	60	0.21	158	440

Source: Author's calculations.

Table 6-3: Descriptive statistics: Vertical and spatial market integration

City	Commodity	Location	N	Mean	Std. Dev	Coefficient of variation	Min	Max
Bunia	Rice	Retail	80	1110	152	0.14	870	1510
Bunia	Beans	Retail	80	901	196	0.22	500	1370
Bunia	Maize	Retail	80	544	167	0.31	240	970
Bunia	Cassava	Retail	80	632	230	0.36	320	1270
Kinshasa	Rice	Retail	87	1120	149	0.13	690	1340
Kinshasa	Beans	Retail	87	2316	308	0.13	1730	3050
Kinshasa	Wheat	Retail	71	1710	624	0.36	1160	3520
Kinshasa	Food	Retail	94	136	23	0.17	90	184
Kinshasa	Food	Wholesale	94	131	28	0.22	89	198
Kinshasa	Cassava	Retail	87	1010	361	0.36	700	2210
Kisangani	Rice	Retail	87	765	133	0.17	480	1200
Kisangani	Beans	Retail	87	1547	488	0.32	880	2620
Kisangani	Maize	Retail	87	332	133	0.40	150	820
Kisangani	Cassava	Retail	87	508	170	0.33	260	880

Source: Author's calculations.

Table 6-4: Pairwise correlation: World market integration

	Rice	Maize	Wheat
Bunia	0.3511*	0.4645*	
Kinshasa	0.7872*		0.0081
Kisangani	0.4877*	0.3800*	

Source: Author's calculations.
Note: * means significant at least at 10%.

Table 6-5 presents the results of a similar correlation analysis for maize and cassava across the three domestic markets. The cassava markets in Bunia and Kinshasa do not seem to be integrated, given the low and insignificant correlation. The coefficient of correlation for cassava is the highest between Bunia and Kisangani. A possible explanation for this might be because these two markets are close to each other. However, this does not hold true for the bean market, as the magnitude of the correlation coefficient for beans between Bunia and Kisangani is very low (23.46) when compared to that of cassava. The low correlation for beans is unexpected, since there is a lot of trade between these two cities, in addition to their close proximity. Nonetheless, the correlation coefficient for beans between Kinshasa and Kisangani or Kinshasa and Bunia is much higher than that between Bunia and Kisangani.

Table 6-5: Pairwise correlation: Domestic spatial integration

	Cassava			Beans		
	Bunia	Kinshasa	Kisangani	Bunia	Kinshasa	Kisangani
Bunia	1			1		
Kinshasa	0.1418	1		0.4397*	1	
Kisangani	0.7752*	0.4707*	1	0.2346*	0.5997*	1

Source: Author's calculations.
Note: * means significant at least at 10%.

With regard to the correlation between wholesale and retail food price, Table 6-6 shows that the magnitude of the correlation coefficient is very high and is estimated at 93.16 percent. The high correlation coefficient in wholesale and retail markets in Kinshasa was expected because

of the direct connection between wholesale and retail. These findings seem to suggest that wholesale and retail are highly integrated.

Table 6-6: Pairwise correlation: Vertical integration

	Wholesale	Retail
Wholesale	1	
Retail	0.9316*	1

Source: Author's calculations.
Note: * means significant at least at 10%.

6.2.6. Unit root tests

Prior to performing any time-series econometric analysis, it is necessary to investigate the stationarity properties of the variables. Tables 6-7 summarizes the unit root tests. They show that the series under analysis are non-stationary.

Table 6-7: Unit root tests

Commodity	Market	Augmented Dickey-Fuller			Phillips-Perron		DFGLS	
		With Trend	With intercept and trend	without intercept and without trend	With Trend	Without drift	With trend	Without trend
Rice	World	-2.57	-2.80	0.14	-2.29	-2.55	-1.04	-1.04
Rice	Bunia	-2.93	-3.69	1.19	-2.62	-3.40	-0.70	-0.70
Rice	Kinshasa	-2.79	-2.64	0.32	-3.09	-2.91	-0.94	-0.94
Rice	Kisangani	-3.54	-3.24	0.47	-3.45	-3.22	-0.32	-0.32
Maize	World	-2.17	-1.93	0.24	-1.74	-1.71	-1.14	-1.14
Maize	Bunia	-3.01	-2.70	0.67	-3.28	-2.86	-0.17	-0.17
Maize	Kisangani	-2.80	-2.86	0.19	-2.69	-2.75	-1.33	-1.33
Wheat	World	-2.32	-2.32	0.48	-2.23	-2.24	-1.38	-1.39
Wheat	Kinshasa	-1.69	-1.71	-1.05	-2.60	-1.82	-2.65*	-2.65*
Cassava	Kinshasa	-2.25	-2.16	0.65	-1.91	-1.89	-0.59	-0.59
Cassava	Kisangani	-1.75	-1.74	0.19	-2.49	-2.50	-2.60	-2.60
Cassava	Bunia	-1.79	-1.59	0.74	-2.13	-1.79	-1.04	-1.04
Beans	Kinshasa	-3.00	-2.84	0.48	-3.28	-3.17	-0.37	-0.37
Beans	Kisangani	-2.65	-2.76	0.35	-2.60	-2.74	-1.15	-1.15
Beans	Bunia	-1.46	-1.27	-0.33	-1.89	-1.65	-1.75	-1.75
Wholesale	Kinshasa	-0.84	-1.26	4.39	-0.66	-1.51	0.58	0.58
Retail	Kinshasa	-2.29	-3.64*	2.89*	-1.38	-4.63*	0.41	0.41

Source: Author's calculations.
Note: * means significant at least at 10%.

Similarly, Table 6-8 presents the results of the unit roots tests with structural breaks, based on Zivot and Andrews (1992) and Clemente et al. (1998). The figures indicate that the results from the tests fail to reject the null hypothesis that the series are not stationary in the presence of structural breaks.

Table 6-8: Unit root tests with structural break

Commodity	Market	Zivot-Andrews				Clemente, Montanes, Reyes with one structural break				Clemente, Montanes, Reyes with two structural breaks			
		Without trend		With trend		Additive outlier		Innovational outlier		Additive outlier		Innovational outlier	
		TTest	Break point	TTest	Break point	min t*	Break point	min t*	Break points	min t*	Break point	min t*	Break points
Rice	World	-4.57	2008m3	-5.32	2008m4	-3.236	2008m5	-2.61	2008m5;2009m1	-4.66	2007m12	-2.34	2008m5;2009m1
Rice	Bunia	-2.95	2009m8	-4.32	2008m5	-4.639	2008m1	-5.06	2008m1;2009m5	-3.58	2012m1	-4.71	2008m2;2009m5
Rice	Kinshasa	-4.72	2011m6	-3.40	2010m5	-3.854	2011m8	-4.23	2009m7;2011m8	-4.10	2011m4	-4.23	2009m7;2011m8
Rice	Kisangani	-4.10	2010m9	-3.14	2010m9	-3.846	2011m9	-5.49	2008m9;2011m7	-3.97	2011m4	-5.49	2008m9;2011m7
Maize	World	-3.42	2012m8	-2.52	2012m8	-2.924	2010m11	-2.98	2010m11;2013m10	-3.37	2010m5	-2.51	2008m12;2010m11
Maize	Bunia	-3.84	2008m8	-3.37	2008m8	-3.949	2011m8	-7.74	2008m2;2011m8	-3.98	2011m4	-3.95	2010m3;2011m8
Maize	Kisangani	-4.46	2008m2	-2.74	2008m2	-3.14	2009m7	-3.68	2009m7;2010m12	-3.96	2009m3	-3.68	2009m7;2010m12
Wheat	Kinshasa	-6.74	2009m11	-4.67	2009m11	-1.021	2009m3	-1.76	2009m7;2010m10	-7.63	2009m4	-1.81	2009m7;2010m12
Cassava	Kinshasa	-3.47	2010m10	-3.652	2010m10	-3.054	2012m2	-3.153	2010m7;2012m2	-3.804	2012m4	-3.153	2010m7;2012m2
Cassava	Kisangani	-4.04	2008m6	-2.335	2008m6	-4.613	2009m5	-2.073	2008m6;2009m5	-3.358	2009m4	-2.375	2008m6;2009m5
Cassava	Bunia	-3.88	2009m8	-2.583	2010m8	-3.033	2012m1	-3.541	2009m5;2012m1	-3.023	2012m2	-3.541	2009m5;2010m1
Beans	Kinshasa	-4.03	2009m2	-3.759	2010m3	-2.384	2012m11	-4.132	2009m9;2010m7	-3.896	2011m12	-4.132	2009m9;2010m7
Beans	Kisangani	-4.40	2009m2	-2.996	2010m5	-3.093	2009m8	-3.814	2009m3;2012m2	-3.107	2008m11	-3.758	2009m3;2010m7
Beans	Bunia	-3.35	2010m3	-2.325	2009m2	-3.348	2010m3	-2.325	2009m2	-4.161	2008m11	-6.528	2009m3;2012m2
Wholesale	Kinshasa	-3.06	2008m10	-2.909	2010m3	-2.086	2010m4	-2.704	2009m5;2011m5	-3.812	2007m8	-2.704	2009m5;2011m5
Retail	Kinshasa	-3.08	2008m2	-3.515	2009m2	-1.213	2009m12	-2.827	2008m8;2011m1	-5.959	2012m2	-2.77	2008m10;2011m1

Source: Author's calculations.

6.2.7. Integration with world markets

This subsection discusses the degree to which markets of rice, maize, and wheat in the DRC are integrated with world markets. To show whether markets are integrated, I conduct two cointegration tests. First, I run the Johansen cointegration test to assess whether there is a long-run relationship between each domestic price and the corresponding world price. To check the robustness of the results from the Johansen procedure, especially when it fails to reject the null hypothesis that there is no cointegration, I conduct a second cointegration test based on the Gregory-Hansen test for cointegration with regime shifts. The advantage of the

Gregory-Hansen test for cointegration – over the Johansen cointegration test – is that it accounts for structural breaks by testing the null hypothesis of no cointegration against the alternative of cointegration with a single shift at an unknown point in time. Where there is cointegration, I estimate an ECM to assess the extent and degree to which world price is transmitted to domestic price. As can be seen, I do not perform the Granger causality test in the context of integration with the world markets because DRC is a small country in the staple food crop markets and therefore has no influence on the world demand (Minot 2011). Table 6-9 summarizes the results of two tests of cointegration analysis.

Table 6-9: Cointegration tests for integration with world markets

Commodity	Market	Long-run relationship?		
		Johansen test	Ghansen test	
			ADF test	Breakpoint
Rice	Bunia	No	No	February 2008
Rice	Kinshasa	Yes	Yes	August 2008
Rice	Kisangani	Yes	No	August 2011
Maize	Bunia	Yes	No	March 2010
Maize	Kisangani	No	No	July 2007
Wheat	Kinshasa	No	Yes	March 2010

Source: Author's calculations.

The Johansen test shows that there is no statistically significant long-run relation in three out of the six markets. The three markets in DRC that showed a significant long-run relationship with the world market include two markets for rice (Kinshasa and Kisangani) and one market for maize (Bunia). Kinshasa is the capital city of DRC and imports a significant amount of rice. In contrast to the Johansen test, the Gregory-Hansen test for cointegration rejects the null hypothesis of the absence of cointegration in two markets out of six, implying that there is a long-run relationship with the structural break or regime shift in two of these markets. These markets are for rice and wheat in Kinshasa.

In the case of wheat price in Kinshasa, for instance, the findings suggest that the failure of rejection in the Johansen test is attributable to the absence of a structural break. The Gregory-Hansen test detects a break in the data in March 2010, which corresponds to the beginning of the world wheat price spike after 2007. This price spike was driven mainly by a weather-related supply shock such as drought and wildfires in Russia and Kazakhstan as well as heavy rain in Ukraine.

Interestingly, the Gregory-Hansen test contradicts the Johansen test in the rejection of the null hypothesis for rice in Kisangani and maize in Bunia. In these two markets, the Gregory-Hansen test fails to reject the null hypothesis of no cointegration because of the structural breaks in August 2011 for rice in Kisangani and March 2010 for maize in Bunia. Recall that the period of 2010 through 2012 corresponds to the resurgence of conflict in Eastern DRC, where about 2 million people were displaced by the end of 2011. Furthermore, the lack of a significant long-run relationship between local rice price in Kisangani and the international price may not be very surprising, because Kisangani is landlocked and not easily accessible from Kinshasa.

The results of the Gregory-Hansen test for cointegration confirm many other studies in the price transmission analysis and are compatible with food import figures in DRC. Indeed, wheat (grain and flour) import ranks first in the total DRC import and covers 100 percent of the wheat requirements. Kinshasa pole (including Bas-Congo) consumes over 80 percent of the wheat imported from Matadi port, while Eastern and Southern DRC depend solely on imported wheat from Uganda, Tanzania, and Zambia. Thus, this implies that the wheat price in Kinshasa is likely to be connected to the world price more closely than rice in Kisangani or maize in Bunia. In addition, Lecoutere et al. (2009) found that war and conflict in the North Kivu (Eastern DRC) reduced market opportunities by increasing transaction costs between producers and consumers. Overall, there is sufficient evidence to conclude that only the

Kinshasa markets of rice and wheat are integrated into the world markets. However, Table 6-10 shows that the speed of adjustment is very low.

Table 6-10: ECM

Commodity	Market	Speed of adjustment	Short-run adjustment	Long-run adjustment
Rice	Kinshasa	-0.05	0.22**	0.89**
Wheat	Kinshasa	-0.06***	-0.11	-1.76*

Source: Author's calculations.

6.2.8. Domestic spatial market integration

Now, I turn the analysis toward domestic spatial market integration between market pairs in DRC. Table 6-11 summarizes the results of cointegration tests and ECM. I find no evidence of a long-run relationship among cassava prices in the three markets pairs, thus implying that all three cassava markets are not integrated. The lack of integration of cassava markets in DRC is not surprising. Cassava is the main food crop in DRC and accounts for 39 percent of total agricultural production. Most of production is local and organized around big consumption centers. Regional cassava markets are independent and supply mainly Kinshasa and Lubumbashi. In the western region of DRC, for example, Kinshasa is likely to be integrated with Matadi and the Bandundu (le plateau de Bateke), which serves as a cassava feeder for Kinshasa. Thus, the distance is one factor explaining the non-integration between Kisangani and Kinshasa or Kinshasa and Bunia in terms of cassava.

Table 6-11: Cointegration tests for domestic integration and price transmission

Commodity	Market 1	Market 2	Long-run relationship?		
			Johansen test	Ghansen test	
				ADF test	Breakpoint
Cassava	Bunia	Kisangani	No	No	
Cassava	Bunia	Kinshasa	No	No	
Cassava	Kinshasa	Kisangani	No	No	
Beans	Kisangani	Bunia	No	Yes	August 2008
Beans	Kinshasa	Bunia	Yes	Yes	August 2008
Beans	Kisangani	Kinshasa	Yes	Yes	March 2009

Source: Author's calculations.

Despite the significant amount of trade in the Eastern market (Bunia, Kisangani, and Beni), the findings in Table 6-11 indicate that Kisangani and Bunia, which are only 580 km apart, are not integrated. Poor transportation infrastructure, high marketing costs, and production seasonality are among the reasons for a lack of integration of cassava markets in Bunia and Kisangani. For example, Kisangani is generally accessible from Bunia in 48 hours, but this can take two weeks during the rainy season. Thus, cassava in Bunia and Kisangani is produced locally or in feeder markets such as Komanda and Mambassa. Since cassava is in high demand in these regions, marketing costs are high due to rent seekers and lack of a strong pricing system.

On the other hand, the analysis of the bean spatial market integration finds that 2 market pairs out of 3 are integrated. The market pairs Kinshasa-Bunia with Kinshasa-Kisangani. This is expected, given that Kinshasa is the pole of consumption of beans due to the higher income and luxury image of beans in the country. Nevertheless, the lack of price transmission between Kisangani and Bunia was unexpected, given the amount of trade between these cities. The diagram in Figure 6-2 shows that direct bean trade takes place between Bunia and Kisangani. However, in addition to the factor discussed in the case of cassava, there is no price transmission between Bunia and Kisangani due to the lack of

information flow.[63] This indicates that physical trade is not the only determinant of market integration in DRC. Turning attention to the Gregory-Hansen test, the findings in Table 6-11 show the existence of a long-run relationship between the markets of beans in Bunia and Kisangani in the presence of a regime shift that occurred in August 2008. This structural break reflects a broader phenomenon of supply shock for many agricultural commodities during that period.

Given that these market pairs are integrated, I further conducted the Granger causality test of the causal relationship between each market pair. The results reported in Table 6-12 indicate a causal relationship between Kinshasa and Bunia, Kisangani and Kinshasa, and Kisangani and Bunia, and Table 6-13 shows that the speed of adjustment is low.

Table 6-12: Granger causality tests for domestic integration and price transmission

Null hypothesis (H0)	F-test	No. of lags	Decision
Bunia does not Granger cause Kisangani	0.19	2	Can not reject H0
Kisangani does not Granger cause Bunia	2.93***	2	Reject H0
Bunia does not Granger cause Kinshasa	0.95	2	Can not reject H0
Kinshasa does not Granger cause Bunia	18.26***	2	Reject H0
Kisangani does not Granger cause Kinshasa	13.29***	2	Reject H0
Kinshasa does not Granger cause Kisangani	0.90	2	Can not reject H0

Source: Author's calculations.

Table 6-13: ECM for domestic price transmission

			Error correction model		
Commodity	Market 1	Market 2	Speed of adjustment	Short-run adjustment	Long-run adjustment
Beans	Kisangani	Bunia	-0.11***	-0.05**	-0.94***
Beans	Kinshasa	Bunia	-0.31***	-0.41**	-1.29***
Beans	Kisangani	Kinshasa	-0.21***	0.7	-0.32***

Source: Author's calculations

6.2.9. Vertical integration

Now I turn my analysis to the transmission of price within the food supply chain in Kinshasa. The investigation makes use of the wholesale price and retail price because Kinshasa is a

[63] See Jensen (2007) for a discussion on information flow.

consumption city where the main trading activities are concentrated between wholesalers and retailers. Table 6-14 presents the results of the vertical food market integration in Kinshasa. The findings indicate that wholesale food and retail prices in Kinshasa have a long-run relationship. This is not surprising, since Kinshasa is a consumption city dominated by wholesale and retail markets.

Table 6-14: Cointegration tests for vertical price transmission

Commodity	Value chain		Long-run relationship?		
			Johansen test	Ghansen test	
				ADF test	Breakpoint
Food	Wholesale	Retail	Yes	Yes	June 2008

Source: Author's calculations

Most interestingly, the test for Granger causality reported in Table 6-15 shows that retail food prices Granger cause wholesale food price, but not vice versa. The direction of the causal relationship from the retail to the wholesale price indicates that retailers set the food price that wholesalers would have to follow. This might be due to the fact that the price adjusts the changes in demand conditions rather than supply. There are several possible explanations for this result. First, Kinshasa has more than 300 retail markets which are not organized. Only a few of them are constructed of stone materials, especially those within the competence of Kinshasa City Hall.[64] Wholesale and semi-wholesale markets are located within these major markets. Thus, most of retailer source food is from dispersed food entry points, as Kinshasa is surrounded by peri-urban farmers represented by the green belt in Figure 6-2. “Parking lot” also constitutes an important food entry point in Kinshasa, especially for rural production. The second reason is strong price speculation and the lack of price control. Food price is not regulated, especially at the retail and very retail levels. This leads to significant speculation as price depends on the quality of goods and inter-personal relations between buyers and

[64] These markets are Central market, Somba Zikida, Gambela, Matete, N’djili, and Masina (Liberté).

sellers.[65] For example, sellers also set higher prices to avoid being trapped by bargaining practices. Another reason is that wholesalers are not organized and exist in small numbers, as most of them are foreigners and specialize in imported goods.

Table 6-15: Granger causality tests for vertical price transmission

Null hypothesis (H0)	F-test	No of lags	Decision
Retail price does not Granger cause Wholesale price	7.22***	1	Reject H0
Wholesale does not Granger cause Retail price	0.41	1	Can not reject H0

Source: Author's calculations.

After the direction of the causal relationship from retail to wholesale food price is established, I proceed to the analysis of the speed and the asymmetry of transmission within the stage of supply chain. Table 6-16 summarizes the results obtained from the ECM on the speed and the extent to which price transmission occurs within the supply chain. It is apparent from this table that only the long-run adjustment is significant and greater than 1, meaning that there is imperfect transmission in the long run from retail to wholesale food price.

Table 6-16: ECM for vertical price transmission

Commodity	Value chain		Error correction model		
			Speed of ajustment	Short-run ajustment	Long-run adjustment
Food	Wholesale	Retail	-0.0022	0.01519	1.14745***

Source: Author's calculations.

6.3. Infrastructure development and transaction costs

The analysis in the previous subsection demonstrates that DRC food markets are weakly integrated with the world market and transmission of price information is very slow. Furthermore, DRC domestic markets are not well integrated among themselves, and inter-market price differences are very significant. Traditionally, it has been agreed that

[65] Sellers also set lower prices to attract buyers as there is no storage.

restrictive trade and exchange rate policies are responsible for the low integration into global markets (Sachs and Warner 1995a). For instance, Greb et al. (2012) found that trade openness improves integration into the world market. In addition to trade and exchange rate policies, high transportation and marketing costs, as well as other non-tariffs barriers, are among the most significant reasons for low market integration. Brenton et al. (2014) and Bonjean and Brunelin (2013), among others, recently confirmed the importance of these factors for Africa. High transaction costs, thus, increase consumer price and reduce producer price.

In this section, I conduct and analyze a set of experiments with these policies in order to promote competition in the DRC and increase market access for Congolese producers. The policies considered are a policy of opening markets, which I call trade liberalization; a policy of removing anticompetitive regulation, which reduces marketing margins; and a policy that reduces transportation margins. The main focus of this analysis is to assess the distributional impact of individual policies and to what extent they are complementary to diversification, which I discussed in the previous chapter. This study defines policies as being complementary when their impact on a given objective is higher when they are jointly implemented than when they are implemented separately. In the next subsection, I discuss in greater detail the design of the policy experiments. The subsections that follow discuss the macroeconomic, the sectoral, and the distributional effects of policy experiments.

6.3.1. Design of policy experiments

The study considers three policies to promote competition and increase DRC market integration. I use the same model and dataset as in Chapter 5 to conduct this range of experiments. Table 6-17 summarizes the policies simulated under the five scenarios.

Table 6-17: Design of policy experiments

Scenarios	Description
1	100 percent cut in import tariffs in the agro-food sector
2	10 percent reduction of marketing costs of agro-food products
3	10 percent reduction of transportation costs of agro-food products
4	Scenarios 1 and diversification
5	Scenarios 2 and diversification
6	Scenarios 3 and diversification

Source: Author's construction.

6.3.1.1. Trade liberalization simulation

Tariff reduction is intended to play a major role in the DRC's regional integration strategy, given that subsidies and price support measures were abolished in 2002. Based on the SAM data (see Table 2-7), which presents the key characteristics of the Congolese economy in 2005, the DRC's tariff structure provides less protection for agricultural and food products than for textiles and other manufactured products. However, trade and transportation costs are significant in agriculture and food sectors due to underdeveloped markets, infrastructure, and institutions. Given those features, especially the high transaction costs, it can be assumed that tariff pass-through is low and therefore one can expect agro-food trade liberalization to have only a small impact on the Congolese economy. In order to simulate the effects of trade liberalization on the DRC's economy and household welfare, the first experiment (Scenario 1) cuts tariffs in the agro-food sector by 100 percent. Even though it is unlikely that the DRC will move that drastically in this direction in trade negotiations, this experiment aims to benchmark the potential effect of a full tariff cut.

6.3.1.2. Trade margins and transportation margins simulation

In addition to the objective to assess the distributional impact of agro-food trade liberalization, this section also simulates the effects of reduced trade costs and transportation costs for agro-food products. Both simulations illustrate the effects of investment to improve local infrastructure. The objective of infrastructure development is to promote market integration and increase farmers' competitiveness by reducing transportation costs.

Currently, transportation costs are very high in the DRC due to the precarious conditions of road and railway infrastructure, most of which was destroyed in the conflict during the 1990s. For example, the DRC has 87,000 km of agricultural feeder roads, but less than 10 percent of these rural roads are accessible. In the scenarios, I simulate a 10 percent reduction in marketing costs and a 10 percent reduction in transportation costs of agro-food products.[66]

6.3.1.3. Synergetic effects of policies

This study also aims to assess the extent to which policy to promote competition and market integration in DRC are complementary with diversification into high-value agricultural and food products. The scenario of diversification in the previous chapter shows positive effects on growth and income.

6.3.2. Macroeconomic effects

Table 6-18 presents the simulation results for selected macroeconomic variables. It is evident in Scenario 1 that agro-food trade liberalization has almost no effect on the Congolese economy. These insignificant effects were expected, as the initial tariff rate, import penetration ratio, and export intensity of the agro-food sector are very low, whereas marketing costs and transportation costs are high (See Table 2-7). As can be seen, the exchange rate

[66] Reduced transportation costs for agricultural goods are posited by simultaneously reducing the domestic production, import, and export transportation cost coefficients parameters of equation (2-7).

depreciates by 1.87 percent, and both imports and exports increase by 0.68 and 0.63 percent, respectively. Investment decreases by 0.88 percent, which can be explained by an increase in the deficit because government income decreases with tariff cuts. Finally, agro-food trade liberalization yields positive effects on factor income. The effects are higher for urban informal labor, whose income increases by 1.05 percent compared to 0.96 percent for urban formal and 0.87 percent for rural workers. There are smaller increases in the return of capital, labor, and land.

Table 6-18: Simulation results – Changes in macroeconomic variables (percent)

	Scenario 1:	Scenario 2:	Scenario 3:	Scenario 4:	Scenario 5:	Scenario 6:
Gross domestic product	0.00	1.11	0.60	4.15	5.31	4.77
Absorption	0.00	1.10	0.59	4.08	5.22	4.69
Private consumption	0.16	1.21	0.62	4.91	6.00	5.37
Investment	-0.88	0.74	0.43	-0.29	1.38	1.04
Government consumption	-0.59	-0.07	0.58	0.60	1.14	1.79
Exports	0.68	2.95	0.60	2.46	4.76	2.40
Agriculture	4.53	33.00	40.48	118.47	151.69	160.76
Food	10.92	34.53	51.65	106.27	136.52	159.75
Imports	0.63	2.75	0.55	2.29	4.43	2.23
Agriculture	3.08	21.71	5.25	-2.43	17.84	2.49
Food	6.56	6.22	1.88	8.84	8.61	4.31
Exchange rate	1.87	0.74	-0.20	1.84	0.68	-0.27
Urban formal	0.96	1.61	0.51	5.21	5.91	4.79
Urban informal	1.05	0.23	1.54	6.66	5.81	7.24
Rural	0.87	0.68	1.22	4.11	3.94	4.54
Capital	0.56	2.02	0.88	3.24	4.85	3.64
Land	0.50	1.52	0.67	2.91	4.31	3.16

Source: Author's calculations.

Turning attention to reduced marketing margins for agro-food products (Scenario 2), the simulation results indicate that a 10 percent reduction in marketing costs of agro-food products increases GDP and private consumption by 1.11 and 1.21 percent, respectively. Under this scenario, total exports increase slightly more than imports (2.95 percent against 2.75 percent), and the exchange rate depreciates by 0.74 percent to ensure that the trade balance is in equilibrium. However, it is worth mentioning that reduced marketing margins for agro-food products lead to a significant rise in agricultural and food exports and imports. According to Table 6-18, agricultural and food exports increase by about 33 and 34 percent,

while imports of agricultural and food products increase by about 21.71 and 6.22 percent. Unlike agro-food trade liberalization, the reduction of marketing margins for agro-food products benefits urban informal workers less. Wage gains for urban formal workers are higher than for rural workers' areas and urban informal workers. In fact, the wages of urban formal workers increase by 1.61 percent, whereas the wages of rural and urban informal workers increase by 0.68 and 0.23 percent, respectively. Surprisingly, capital returns increase by 2.02 percent compared to 1.52 percent for land returns.

Scenario 3 simulates policies aimed to reduce transportation costs for agro-food products. According to Table 6-18, reduced transportation costs (Scenario 3) boost agro-food exports and slightly increase imports. This is because, on the one hand, they reduce import prices, and on the other, they increase export prices and hence exporters' gains. Agricultural and food exports increase by about 40.48 percent and food exports by about 51.65 percent. Conversely, agricultural imports increase by about 5.25 percent, while food imports increase by only 1.88 percent. The substantial increase in export performance relative to imports leads to the appreciation of the real exchange rate. GDP and total absorption rise marginally. In terms of factor income, it can be seen that the remuneration of all labor increases. The most significant rise in wages occurs for urban informal workers, mainly because of the expansion of the trade sector where their labor is used extensively. Nevertheless, I should mention that wage gains for rural workers are higher than for urban formal workers. This is because most rural workers are producers of agro-food products and benefit from increased producer prices. The wages of urban informal workers increase by 1.54 percent, whereas those of rural workers and urban formal workers change by 1.22 and 0.51 percent, respectively. Capital returns rise by 0.88 percent and land returns by 0.67 percent.

Scenario 4 is a joint implementation of diversification and trade liberalization (Scenario 1), while Scenario 5 combines diversification and a reduction of marketing costs, and Scenario 6 combines diversification and a reduction of transportation costs. Scenarios 4, 5,

and 6 are motivated by the interest in assessing whether these three policies – trade liberalization, reduced trade margins, and reduced transportation margins – can be complementary to diversification. I would like to remind the reader that this study defines policies as being complementary when their impact on a given objective is higher when they are jointly implemented than when they are implemented separately. Table 6-18 shows that Scenario 4, which combines policies in Scenarios 1 and diversification, would yield effects on macroeconomic outcomes that are similar to the sum of the results in Scenarios 1 and diversification. From a policy perspective, this result indicates that diversification and trade liberalization are not complementary policies, according to our definition. This implies that policymakers can implement these policies at different times, as there is no substantial gain from carrying out both of them simultaneously. Scenario 5, which is a joint simulation of Scenario 1 and diversification, is similar to an arithmetic addition of individual scenarios, except for agricultural exports and investment and, to a lesser extent, wage returns. Thus, synergetic effects occur in exports. This implies that reducing trade margins generates competitive gains for agricultural exports and can therefore constitute a complementary policy for diversification. Similarly, reducing transportation margins produces synergetic effects in terms of exports, investment, and factor returns, especially for capital. Thus, a reduction of transportation costs is therefore a strong complement to diversification, if compared to a reduction of marketing margins or trade liberalization.

6.3.3. Sectoral effects

At a disaggregated level, trade liberalization in the agriculture and food sector (Scenario 1) causes a reduction of producer prices for these commodities. However, the composite price of agricultural commodities increases by 0.35 percent, whereas the composite price of food decreases by 0.85 percent (Table 6-19). The effects of trade liberalization are not transmitted to the domestic price of agricultural products because of the transaction costs and small

import intensity of the agricultural sector. The price changes are more pronounced for the import prices of agricultural goods than for the domestic demand prices of these goods, which in turn reduce the competitiveness of domestic products. The demand for domestically produced agricultural products therefore decreases in favor of imports. As a result, agricultural producer prices fall by 0.36 percent. The decrease in producer prices leads to a reduction, albeit very small, of agricultural value added.

Lowering marketing costs (Scenario 2) raises producer prices and reduces consumer prices. Table 6-19 shows that a 10 percent reduction in marketing margins for agro-food products leads to reduction by about 0.33 percent of agricultural composite price and 0.83 percent of food composite price. Similarly, agricultural producer price increases by about 1.68 percent compared to 3.74 percent of food producer price. This result is not surprising, because reduced marketing margins leads to efficiency gains that shift market share toward efficient producers, increase availability of products in the market, and therefore benefit consumers as the increase in the supply of agricultural products leads to a reduction of domestic demand prices and market prices. The increase in producer prices of the food and agricultural sectors leads to an increase in the value-added price of these industries, as indicated in Table 6-19. Note that the value-added price of the food sector increases much more than that of agriculture. In addition to improving the value added of the food sector and agriculture, reduced marketing margins also increase the value added of some services such as hotels and catering and transportation. These sectors are characterized by a high proportion of inputs from food and agricultural sectors. The 1.01 percent increase in value added in hotels and catering is caused mainly by the price change in inputs from the food sector and agriculture, whereas the 1.52 percent increase in valued added in transportation is due to the increase in demand, as lowered marketing margins increase the income of all types of labor. It is worth noting that reduced marketing costs also increase the demand for chemicals and other

manufacturing, whose value added increased respectively by 0.21 and 0.36 percent (Table 6-21).

Table 6-19: Simulation results – Scenarios 1, 2, and 3 – Changes in prices (percent)

Sectors	Scenario 1			Scenario 2				Scenario 3		
	PS	PD	PQ	PS	PD	PQ	PA	PS	PD	PQ
Agriculture	-0.02	0.35	0.35	1.68	0.06	-0.33	1.00	0.94	0.37	0.27
Forestry	0.48	1.07	1.12	1.90	0.56	0.43	0.51	0.61	0.82	0.85
Mining	1.60	1.65	1.83	0.96	0.67	0.39	-0.17	-0.03	0.10	0.08
Processed foods	-0.97	0.10	-0.85	3.74	-0.20	-0.83	1.47	1.47	0.14	-0.06
Textiles	0.68	0.70	1.27	1.44	1.39	0.25	0.57	0.57	0.58	0.73
Wood	1.02	1.11	1.22	1.76	1.46	1.24	0.02	0.21	0.30	0.30
Chemicals	1.07	1.26	1.53	1.76	1.11	0.86	-0.09	-0.09	0.14	0.04
Non-metals	0.94	1.24	1.51	2.17	1.16	0.87	-0.02	-0.02	0.29	0.15
Other manufacture	0.85	1.14	1.64	2.15	1.23	0.78	-0.03	-0.01	0.27	0.02
Utilities	0.92	0.92	0.92	1.57	1.57	1.57	0.34	0.44	0.44	0.44
Construction	0.74	0.74	0.77	1.47	1.47	1.45	0.70	0.70	0.70	0.68
Trade	2.61	2.61	2.61	-7.11	-7.11	-7.11	4.13	4.23	4.23	4.23
Hotels and catering	-0.40	-0.40	-0.17	-0.13	-0.13	-0.04	-0.02	-0.02	-0.02	-0.04
Transportation	1.19	1.19	1.25	8.02	8.02	7.31	-4.20	-4.39	-4.39	-3.99
Education and health	0.72	0.72	0.72	1.51	1.51	1.51	0.69	0.69	0.69	0.69
Financial intermediation	1.11	1.11	1.21	3.50	3.50	3.16	-1.05	-1.09	-1.09	-0.99
Other services	0.40	0.40	0.67	1.95	1.95	1.73	0.51	0.60	0.60	0.45
Personal and other community services	0.64	0.64	0.84	2.38	2.38	2.11	0.03	0.14	0.14	0.09
Private households with employed persons	1.01	1.01	1.01	1.24	1.24	1.24	0.74	0.74	0.74	0.74

Source: Author's calculations.
Note: PA stands for producer price; PS stands for domestic supply price without margins; PD stands for domestic demand price with margins; PQ stands for composite market price.

On the other hand, reduced transportation costs (Scenario 3) have similar effects of reducing market prices and raising producer prices as reduced marketing costs. Table 6-19 shows that a 10 percent reduction of transportation costs for food and agricultural products leads to a 0.06 percent reduction of food price and increases food producer price by 1.47 percent. Surprisingly, the agricultural composite price increases by 0.27 percent. This is mainly due to the decrease of import prices, because domestic demand prices only fall by 0.65 percent. The producer price of agricultural products rises by 1 percent. This is mainly due to the

improvement in the export price, since the domestic supply price of agricultural goods increases by only 0.94 percent.

Table 6-20: Simulation results – Scenarios 4, 5, and 6 – Changes in prices (percent)

Sectors	Scenario 4			Scenario 5			Scenario 6		
	PS	PD	PQ	PS	PD	PQ	PS	PD	PQ
Agriculture	-9.44	-5.47	-5.25	-7.51	-5.62	-5.75	-8.37	-5.37	-5.24
Forestry	1.65	4.62	4.66	3.18	4.12	3.97	1.84	4.42	4.44
Mining	2.98	7.63	5.29	2.34	6.63	3.80	1.33	6.07	3.52
Processed foods	-9.13	-1.66	-2.05	-4.34	-2.02	-2.10	-6.67	-1.62	-1.28
Textiles	2.44	4.19	4.47	3.27	4.94	3.43	2.37	4.11	3.96
Wood	2.53	3.91	3.90	3.33	4.30	3.95	1.73	3.11	3.00
Chemicals	3.63	5.08	4.46	4.39	4.95	3.78	2.45	3.95	2.94
Non-metals	2.94	5.06	4.51	4.26	5.01	3.85	1.99	4.12	3.14
Other manufacture	2.27	7.17	4.89	3.65	7.28	4.00	1.41	6.31	3.25
Utilities	2.31	2.31	2.32	3.01	3.01	3.01	1.86	1.86	1.86
Construction	2.97	2.97	2.98	3.75	3.75	3.72	2.97	2.97	2.93
Trade	11.48	11.48	11.48	1.33	1.33	1.33	13.29	13.29	13.29
Hotels and catering	-0.95	-0.95	-0.49	-0.71	-0.71	-0.40	-0.58	-0.58	-0.38
Transportation	5.63	5.63	5.42	12.78	12.78	11.77	-0.19	-0.19	-0.04
Education and health	2.31	2.31	2.31	3.17	3.17	3.17	2.33	2.33	2.33
Financial intermediation	3.29	3.29	3.31	5.81	5.81	5.38	1.02	1.02	1.06
Other services	2.99	2.99	3.09	4.64	4.64	4.22	3.24	3.24	2.90
Personal and other community services	2.41	2.41	2.59	4.27	4.27	3.95	1.94	1.94	1.85
Private households with employed persons	1.06	1.06	1.06	1.32	1.32	1.32	0.84	0.84	0.84

Source: Author's calculations.
Note: PA stands for producer price; PS stands for domestic supply price without margins; PD stands for domestic demand price with margins; PQ stands for composite market price.

With regard to value added, Table 6-21 shows that reduced transportation costs of agro-food products, simulated in Scenario 3, have a very small, albeit positive, effect on agricultural value added, which increases marginally by 0.01 percent as compared to the 0.17 percent increase in the value added of the food sector. This result indicates that agricultural productivity is very low and consequently it cannot react to the improved rural transportation infrastructure. Nonetheless, it is interesting to note that lower agro-food transportation costs benefit other economic sectors (except for mining, wood, and chemicals). Trade and financial intermediation capture most of these benefits, as their value added rises by 0.91 and 0.41

percent, respectively. The value added of hotel and catering and construction increase by 0.40 percent. Surprisingly, small changes occur in sectors for which agricultural products are used as intermediate inputs. As can be seen from Table 6-21, under Scenario 3, value added in the textiles sector rises by 0.23 percent.

Table 6-21: Simulation results – Changes in value added (percent)

Sectors	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6	
	QV	PV	QV	PV	QV	PV	QV	PV	QV	PV	QV	PV
Agriculture	-0.04	-0.18	0.04	1.87	0.00	1.17	10.97	10.80	11.07	13.13	11.03	12.29
Forestry	-0.25	0.59	0.28	1.37	0.05	1.11	0.65	1.47	1.20	2.32	0.95	2.06
Mining	0.32	2.06	-0.16	0.49	-0.32	-0.10	1.29	3.00	0.80	1.39	0.64	0.81
Processed foods	-0.26	-2.61	0.45	7.48	0.17	3.39	10.52	8.29	11.32	18.37	11.00	14.28
Textiles	-0.15	0.33	-0.01	1.02	0.23	1.93	0.16	0.61	0.30	1.38	0.55	2.35
Wood	1.27	1.55	-1.85	0.31	-0.45	0.63	2.35	2.64	-0.90	1.36	0.57	1.73
Chemicals	0.00	0.94	0.21	2.99	-0.08	0.02	0.40	1.33	0.62	3.54	0.31	0.40
Non-metals	-0.19	0.72	-0.03	0.93	0.16	1.19	0.45	1.35	0.63	1.61	0.82	1.89
Other manufacture	-0.31	0.65	0.36	1.54	0.21	1.09	0.26	1.19	0.95	2.14	0.79	1.70
Utilities	-0.14	0.92	-0.10	1.11	0.10	0.87	2.16	3.20	2.22	3.42	2.40	3.20
Construction	-0.81	-0.06	0.67	1.98	0.40	1.38	0.29	1.01	1.81	3.17	1.52	2.54
Trade	0.39	2.93	-2.18	-9.34	0.91	5.41	2.16	4.68	-0.47	-8.15	2.70	7.40
Hotels and catering	0.28	1.17	1.01	1.76	0.40	1.17	2.65	3.54	3.46	4.20	2.80	3.61
Transportation	0.04	1.20	1.52	9.83	-1.18	-5.57	0.46	2.08	1.59	11.11	-1.19	-5.00
Education and health	-0.54	0.53	0.32	1.36	0.25	1.04	0.40	1.44	1.29	2.34	1.20	2.01
Financial intermediation	-0.02	0.94	-0.66	1.40	0.41	0.66	1.62	2.56	0.97	3.07	2.07	2.31
Other services	-0.06	0.41	-0.03	1.13	0.06	1.25	2.77	3.22	2.80	4.00	2.89	4.13
Personal and other community services	-0.03	0.93	-0.78	0.98	0.44	0.92	0.27	1.21	-0.50	1.29	0.75	1.25
Private households with employed persons	-0.58	1.01	0.55	1.24	0.03	0.74	0.93	2.48	2.11	2.74	1.55	2.26

Source: Author's calculations

Note: QV stands for composite value-added quantity; PV stands for composite value-added price.

The joint implementation of diversification and trade liberalization (Scenario 4) leads to a reduction in prices in the domestic market (Table 6-20). The demand price and the composite market price of agricultural products decrease by 5.47 and 5.25 percent, respectively, compared to 1.66 and 2.05 percent in the food sector. The combined Scenario 5 leads to a 5.75 percent reduction of the agricultural composite price and a 2.10 percent reduction of the food composite price. This scenario also leads to an 11.07 percent increase in agricultural value

added and 11.32 percent in food value added. The synergic effects add only 0.01 percent to agricultural value added growth and 0.05 percent to value added growth in the food sector. Finally, under the combined Scenario 6, value added in agriculture improves by 11.03 percent and in the food sector by 11 percent. This scenario also increases the value added of other agriculture-related sectors. In contrast to the joint simulation of diversification and reduction of trade costs (Scenario 5), which produced marginal synergy effects in the value added of agricultural and food sectors, this scenario produces nil synergy effects.

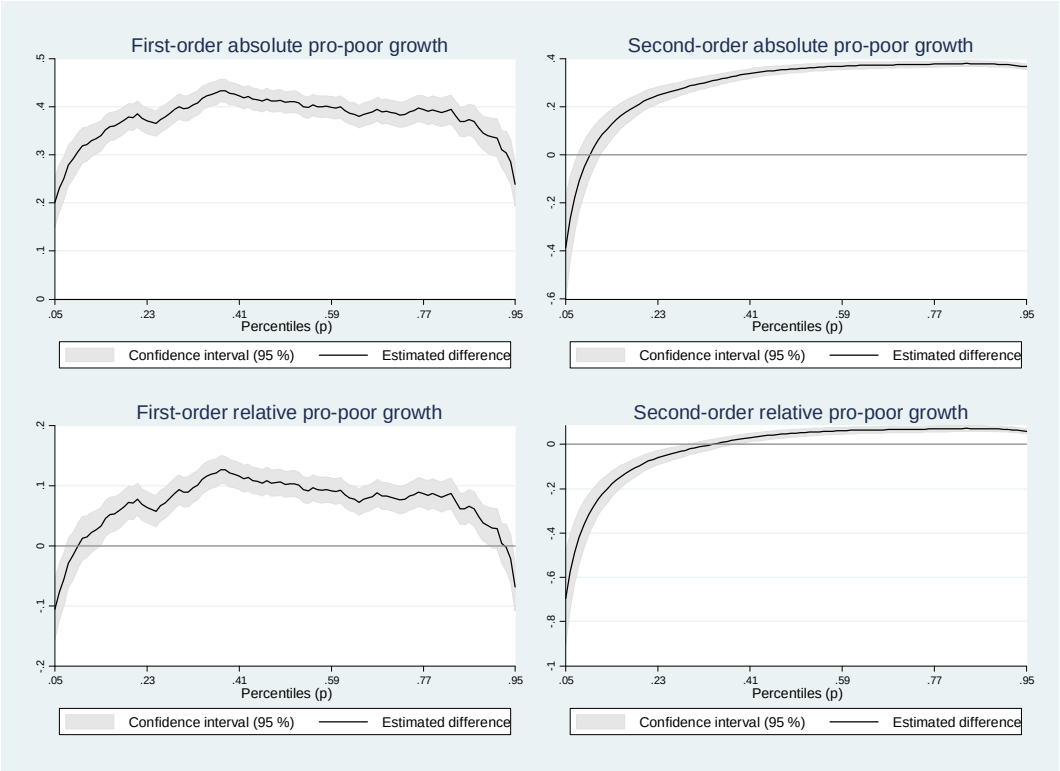
6.3.4. Distributional effects

Turning to the distributional effects, Figure 6-9 plots the pro-poor effects of agro-food tariff cut (Scenario 1) across the entire income distribution. The figure reveals that trade liberalization of agro-food products produce first-order absolute pro-poor effects for all households. The lower bound of the confidential interval is above the horizontal zero line, thus indicating that the first-order absolute pro-poor effects are statistically significant. It can also be seen in Figure 6-9 that tariff cut by itself is almost certainly first-order relatively pro-poor since the income in the 6^{th} lower percentile is lower than the average income growth. The highest gains appear to have accrued to households between the 30^{th} and 60^{th} percentile of income distribution. The impact of tariff cut on consumption contributed more to the welfare gains of these households than the impact on factor income. This is explained by the large share of agricultural and food products in the total consumption of these households, the price change of agricultural and food products, and the change in factor income due to tariff cut seen in the previous section.

Figure 6-10 shows the distributional effects of reduced marketing costs of agro-food products (Scenario 2). Despite the first-order absolute pro-poor effects, the graph shows that changes in poverty levels vary significantly among households below the 40^{th} percentile, and for the rest of households, the distribution of poverty changes is almost straight up. This is

because reduced marketing costs provide the most benefit to urban activities such as transportation, hotels and catering, construction, and processed food, increasing urban formal incomes by 1.61 percent. In addition, households at the upper tail of income distribution gain more than those in the lower part due to lower processed food prices, which decreased by 0.83 percent as compared to a 0.33 percent decrease of agricultural prices. Welfare gains for households at the lower tail of income distribution refer also to the impact of reduced trade costs in agriculture, mining, and wood, which mainly disfavored rural workers.

Figure 6-9: Pro-poor growth: Scenario 1

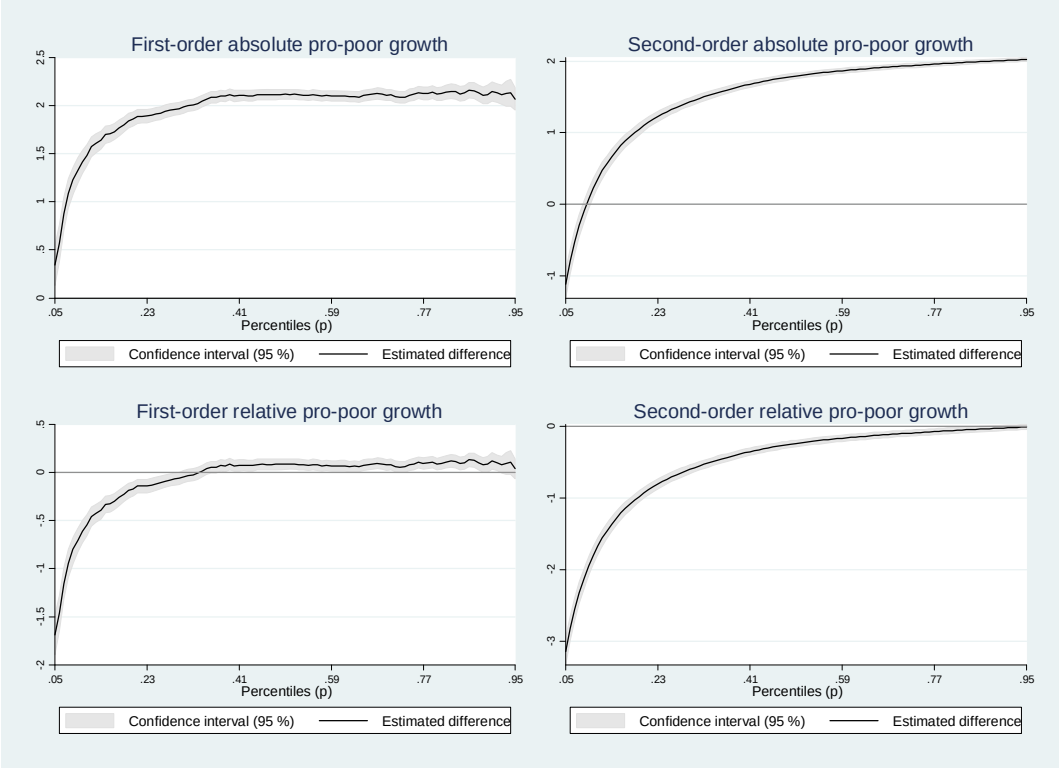


Source: Author's calculations.

Lowering transportation costs (Scenario 3), however, is not absolutely first-order pro-poor, because it does not benefit poor households as much as it does richer households. Figure 6-11 indicates that households in the 16th percentile suffer welfare losses, and welfare gains increase along the income distribution. A possible explanation is that poor households' share of marketed production is smaller compared to richer households, and therefore poor

households do not benefit from higher producer prices as much as richer households do. Poor households that are likely to be affected include those of subsistence and small-scale farmers, who tend to be disconnected from markets and therefore have few possibilities to substitute the consumption of home-produced commodities with marketed commodities. Since reducing agricultural transportation costs has less of a benefit for households that sell a small share of their production, the government should complement rural infrastructure development with policies to increase non-farm income through marketing support, skill upgrading, labor mobility, and promotion of non-farm activities.

Figure 6-10: Pro-poor growth: Scenario 2

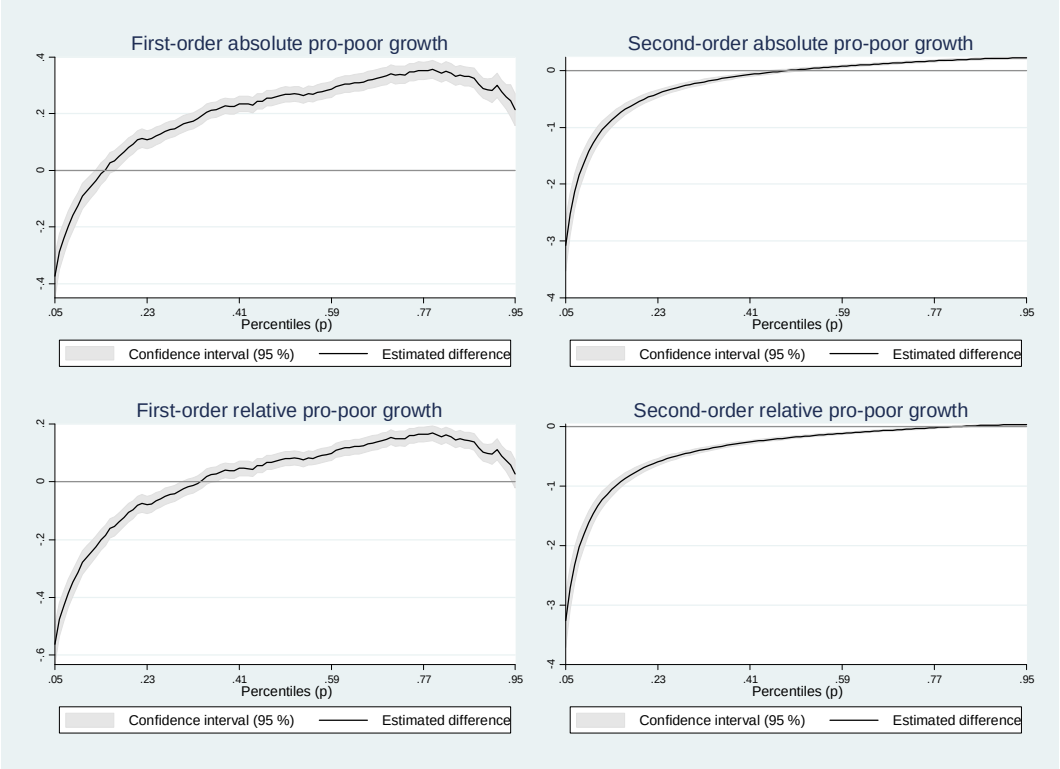


Source: Author's calculations.

Figures 6-12, 6-13, and 6-14 graph the distributional effects of the three joint simulations. Most importantly, these simulations indicate that welfare gains are higher than when the individual policies are implemented alone. Starting with Figure 6-12, which plots the combined distributional effects of diversification and agro-food trade liberalization, one can

see from panel (a) that welfare gains in this simulation are much larger than in the previous scenarios. First-order absolute pro-poor effects are strong along the entire income distribution. In relative terms, however, this scenario is almost not pro-poor, because households at the 7th percentile benefit less than the average income growth. Households between the 70th and 85th percentile of the income distribution capture the highest welfare gains.

Figure 6-11: Pro-poor growth: Scenario 3

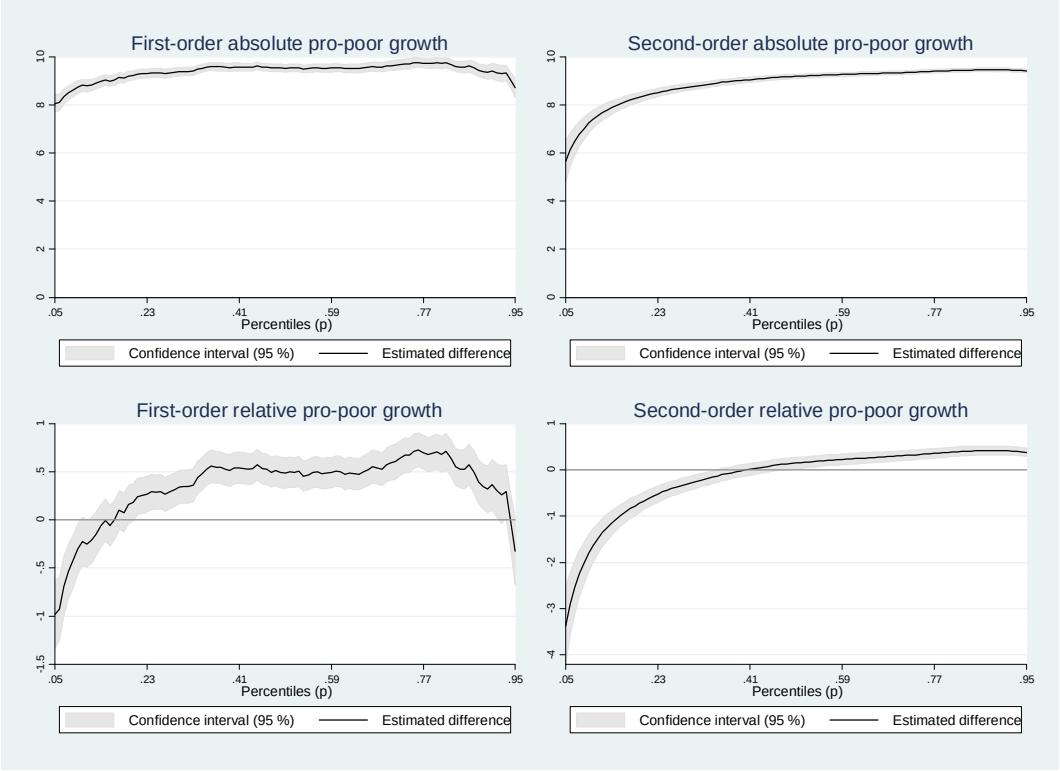


Source: Author's calculations.

Figure 6-13 plots the distributional impact of diversification combined with a reduction of trade costs in the agro-food sectors (Scenario 5). The graph shows that the combined scenario of diversification of agro-food products and agro-food trade liberalization is absolutely pro-poor as the distribution curve lies above the zero horizontal line. Households benefit from lower consumer prices of agricultural products and processed food – which decreased respectively by 5.25 and 2.05 percent – and higher factor income. Despite these higher

welfare gains for all households, it is important to note that this policy scenario is not relatively first-order pro-poor. Looking at the relative pro-poor growth, one can see that households at the 20th percentile of income distribution gain less in comparison to the average income growth. This is mainly due to the income effect of the scenario, in which rural income and land returns increased respectively by 4.11 and 2.91 percent as compared to 4.21 percent increase in urban formal income and 6.66 percent increase in urban informal income.

Figure 6-12: Pro-poor growth: Scenario 4

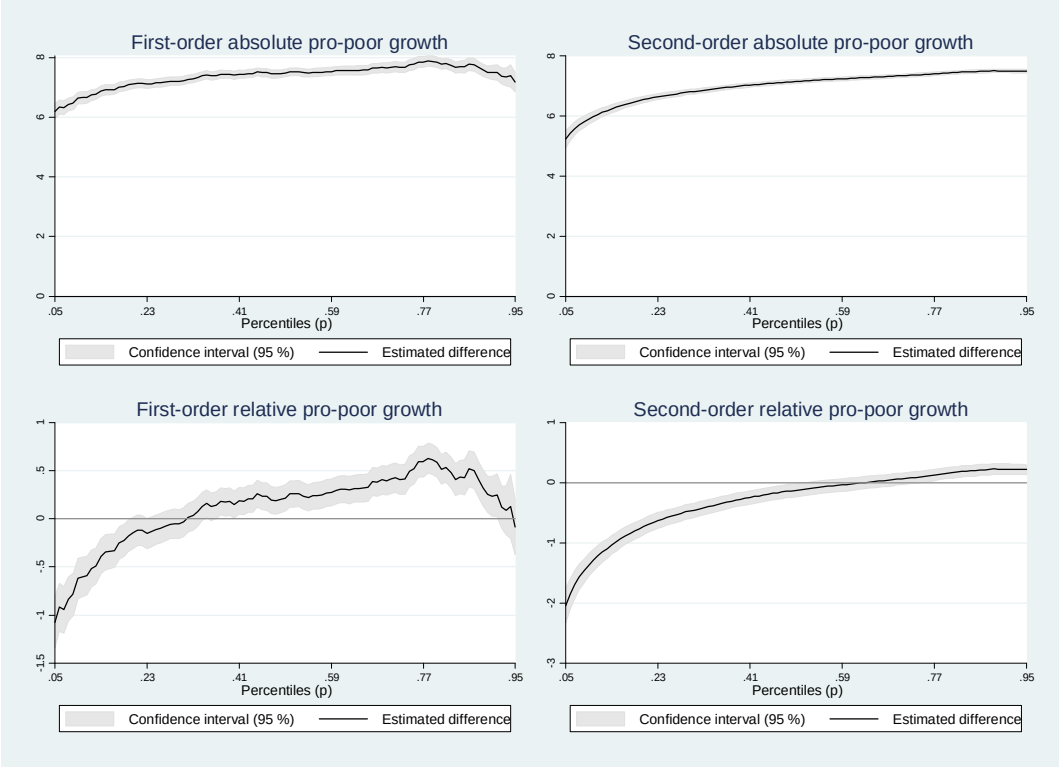


Source: Author's calculations.

Finally, Figure 6-14 displays the distributional effects of diversification and reduced transportation costs (Scenario 6). Once again, welfare gains are higher, as the graph indicates. Similar to Scenario 5, households gain from lower prices of agricultural products and processed food. Agricultural prices decreased by 5.54 percent while processed food prices decreased by 1.28 percent. Interestingly and unlike Scenario 5, the combination of diversification and reduced transportation costs (Scenario 6) produced first-order relative

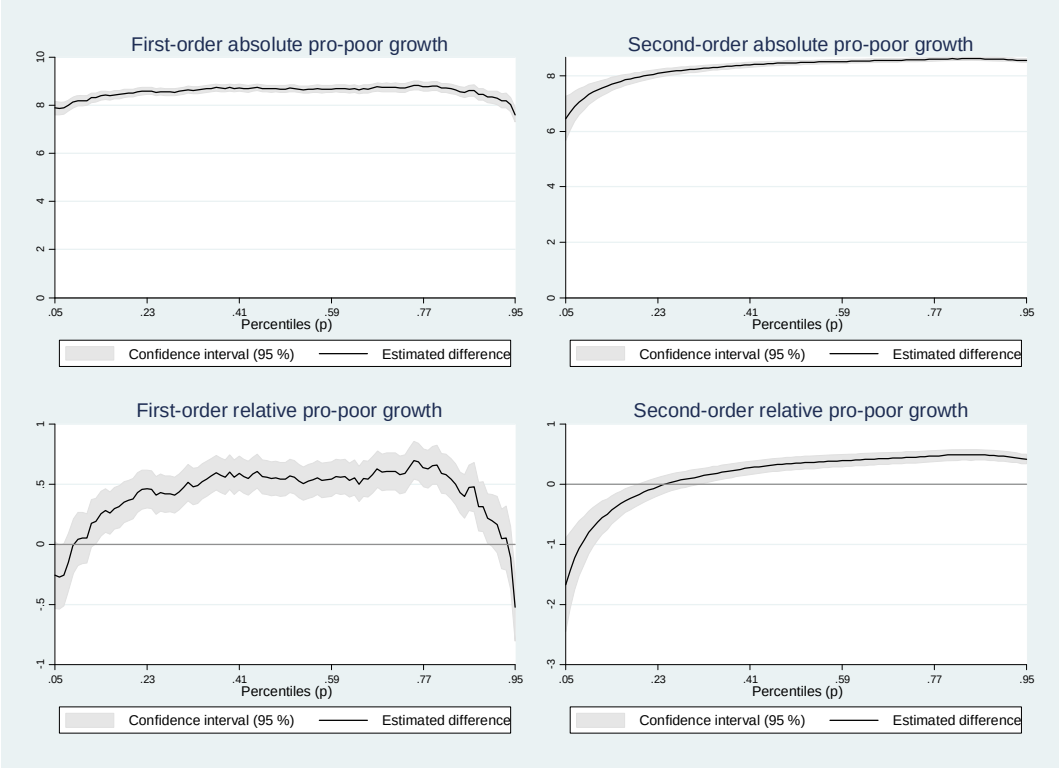
pro-poor effects. The graph shows that the upper bound of the welfare distribution is nearly above the zero horizontal line up to the 7th percentile of the income distribution and then increases significantly. Although the welfare effects vary along the income distribution in favor of richer households, it is worth noting the important contribution of urban informal income, rural income, and land return in generating first-order relative pro-poor growth. Under this scenario, urban informal income increased by 7.24 percent, while rural income and land return increased respectively by 4.54 and 3.16 percent.

Figure 6-13: Pro-poor growth: Scenario 5



Source: Author's calculations.

Figure 6-14: Pro-poor growth: Scenario 6



Source: Author's calculations.

6.4. Conclusions

The purpose of the current chapter was to determine the degree of market integration in DRC and evaluate the impact of investment and reforms to improve competition and market access of DRC firms. Based on the cointegration techniques and the error correction model, the analysis of market integration concerned with international and national rice, maize, and wheat markets in DRC, between cassava and beans domestic markets, and within food supply chain in Kinshasa. Since very little was found in terms of how market access affects production decision and welfare in the literature of price transmission, this study has also discussed the economy-wide and distributional impact of potential tariff cuts and lowering trade and transportation costs based on the results using a CGE-microsimulation model. Unlike many other studies on trade and poverty, this study went a step further by considering to what extent these policies can produce synergetic effects with diversification into

high-value agricultural and food products. This study defines policies as being complementary when their impact on a given objective is higher when they are jointly implemented than when they are implemented separately.

Returning to the question posed at the beginning of this chapter – namely, what is the degree of DRC market integration – the findings suggest that, in general, DRC markets are not well integrated. This study has shown that only two out of six markets are integrated into the world market. These markets are located in Kinshasa, the capital city of DRC, and were related to rice and wheat. This finding was excepted as these two commodities represent about 45 percent of DRC food imports. This suggests that price transmission occurs for high imported commodities only. Domestic markets are imperfectly integrated, and price transmission between integrated markets is very low. Regarding the question of the direction and to what extent price transmission occurs between stages of food supply chain in Kinshasa, the results of this study indicate that there was a transmission of price changes along the food supply chain, meaning that Kinshasa food market is vertically integrated. What is surprising is that there is only a one-way causal relationship from food retail to wholesale price in Kinshasa, implying that retailers set the food price that wholesalers would have to follow. A possible explanation for these results may be the existence of multiple food entry points, absence of large-scale wholesale, lack of information about retail markets, and the perishability of food products. The second major finding was the existence of high inter-market price difference and the significant effects of weather-related supply shock (drought) and armed conflicts on food price.

The investigation of policies to increase market access has shown that there are a number of potential complementarity and synergetic effects that can be key drivers of effectiveness of measures to increase productivity and competition. When simulating the three policies separately, the analysis found that agricultural trade liberalization has a small positive effect on welfare. The reason is that transaction costs are very high, whereas the initial tariff

rate, import penetration ratio, and exports intensity are very low. A reduction in transportation costs for agricultural products generates higher welfare gains than trade liberalization because lower transportation costs increase producers' gains and boost agricultural exports. In addition, reduced transportation costs in agriculture benefit other economic sectors, such as construction and trade, and therefore increase wages of low- and semi-skilled workers in urban areas. However, low productivity in agriculture prevents farmers from taking full advantage of opportunities offered by reduced transportation costs.

Policies directed towards reducing marketing costs for agricultural and food products may result in larger welfare gains than trade liberalization. Moreover, the boost in agricultural production resulting from lowered marketing margins reduces the DRC's dependence on imports, lowers consumer prices, increases consumption, and stimulates the growth of sectors such as processed food and textiles, which use agricultural products as intermediate inputs.

The study also sought to identify if additional effects may result from the interaction of policies and to understand the importance of sequencing and prioritizing reforms. This was done by running simulations of jointly implemented policies. The analysis points to a number of potential complementarities and synergetic effects that can be key drivers of effectiveness of measures to increase productivity and competition. The simulations also underscore the importance of sequencing reforms, as additional synergic effects may result from the interaction of policies. In particular, the results suggest that infrastructure development – aiming at reducing transportation costs – is a strong complement to diversification, as it produced synergetic effects in exports, investment, and capital return. Correspondingly, policies directed towards reducing marketing costs, such as cutting out the middle man, are likely to be complementary to diversification. However, the results at this stage suggest that agricultural trade liberalization may not be necessarily complementary to diversification, meaning that these two policies combined do not produce additional gains. In terms of policy

priorities, the results of the analysis suggest that infrastructure development should be given the highest priority, followed by reducing marketing costs for agro-food products.

Chapter 7. General conclusions and discussion

7.1. Introduction and overview of the study

Industrial policy is generally regarded as a set of well-coordinated measures targeted at specific industries – such as manufacture and/or agriculture and high productive service – in order to foster structural change in favor of a particular development path. Various industrial policies that have been implemented in the emerging economies and the rapid economic growth and structural transformation that resulted were intriguing factors to a point of inspiring the undertaking of this research. While the current growth path of natural resource countries in Africa has been jobless, the inequality has been increasing, and the policy direction is clear for diversifying away from natural resources, there has been little quantitative analysis of alternative growth strategies in Africa, and it is not clear to what extend these policies can be inclusive. This dissertation aimed at contributing to this growing area of research by providing empirical evidence regarding the role industrial policies in a resource-rich country like DRC.

This study accordingly set out to investigate the potential of industrial policies to boost productivity growth and enhance the process of productive transformation necessary for pro-poor growth. Specifically, this research had four goals. The first was to provide empirical evidence on welfare and distributional impacts of mining-led growth in DRC and investigate the potential of alternative growth strategies based on DRC economic structure and the patterns of the current era of globalization. Second, it identified policy options to promote growth and change in the industrial structure that are necessary for development. This study used a broad, but relevant for DRC, definition of industrial policy that includes the set of innovation and skill formation, trade, sectoral and competition policies employed by governments to induce structural change and industrialization. Finally, the study sought to identify special institutions that should be created to engineer the economic transformation.

This research employed an integrated approach that combined quantitative methods composed of computational methods and statistical analysis, including the input-output based model, computable general equilibrium and microsimulation model, linear regressions, and times series regression. The field of influence analysis, an input-output based model, was used to analyze the strength of the linkages between different industries and determine how the structure of the DRC's economy can guide the choice of development strategy. The CGE-microsimulation model was used to assess the economy-wide effects and pro-poorness of alternative mining and manufacture growth-led strategies as well as sectoral policies regarding such diversification into higher value-added agro-food products, skill upgrade, and trade and marketing efficiency of agro-food products. The model was further used to simulate the impact of tariff cuts and reduced trade and transportation costs. I used cointegration techniques to study the speed and the extent to which market are integrated in DRC.

I chose to organize the thesis into two empirical parts. The first part included two chapters that conducted a growth identification analysis to identify development paths for DRC to achieve a productive transformation that creates employment and improves the living standard. It showed that mining-based growth leads to an unproductive transformation due to the structural effects of the Dutch Disease. However, the findings on the linkages and alternative growth strategies suggested that DRC should create agricultural value chains and establish a competitive agro-food industry by increasing the value addition in and the processing capacity of agricultural products, and improving the efficiency of financial intermediation.

The second part included three chapters and positioned the dissertation in relation to the key policy lessons from emerging and fast-growing East-Asian economies, as reflected in the recent literature on structural transformation and economic development. In the end, it concluded that the policy directed to transform the productive structure and upskill of the labor is a key for productive transformation and that institution and institutional reforms to

improve marketing and transportation efficiency are crucial for agro-food development and inclusive growth. The findings suggest that the production of high-value agro-food products is complementary with marketing and transportation, but investment in domestic infrastructure development has high synergetic effects. The last major finding was that the use of capital-intensive technology in agriculture might lead to immiserizing growth due to the significant inequality in assets, especially land. The implication that emerged is that DRC should modernize agriculture with labor-using technologies and improve efficiency in the use of inputs.

In the following sections, I will elaborate further on these findings along the line of the contribution to the literature. Then, I discuss the limitations of this dissertation. After that, I identify the implications for policymakers to improve DRC's welfare through productive employment and well-coordinated industrial policies. Finally, I conclude the study with areas for future research.

7.2. Main findings

This subsection summarizes the main findings with regard to the research objectives and questions.

7.2.1. Chapter 2: Exploring the links between productive transformation, employment creation, and pro-poor growth.

This chapter provided an important opportunity to advance the understanding of how mining-based growth affects industrial transformation and income distribution. By using the latest available national accounts and household survey data, I constructed a SAM to extend our knowledge of DRC's economic structure. Then, I developed a CGE-microsimulation model based on SAM data to conduct simulation analysis.

1. What are the structural features of the DRC economy?

This study has revealed the coexistence of a rudimentary agriculture with a dynamic service sector. It also revealed high transaction costs, especially in forestry, processed foods, textiles, and other manufacturing. The consequence of the rudimentary characteristic of agricultural technology and high transaction costs is that 31 percent of agriculture production is home-consumed and does not enter the market. DRC mainly exports minerals with very limited value addition and imports manufactured goods. Almost the entire production of mining is exported, and it represents 69.1 percent of total exports. On the order hand, 64 percent of imports are composed of chemicals, other manufacturing, and processed foods.

Another major finding was that DRC's exports are increasingly more concentrated in a handful of products. In fact, the study found that 90 percent of DRC exports are concentrated in only five products and that the ten largest exported products accounted for 96 percent in the DRC export portfolio. DRC exports have been quite diversified in recent years, but the composition of exports has been relatively stable. The lack of diversification may be explained by the significant export performance of some nontraditional exports. However, these nontraditional exports are primary goods, and some of them have been exported before but in smaller proportions. Finally, with regard to the diversification of export markets, the study found that China has overtaken the United States and the European Union to become the main destination of DRC exports.

2. Why should DRC, a country with a strong comparative advantage in minerals, diversify away from mining?

The findings suggested that mining will remain the key driver of DRC exports for a very long time, but will not possibly be the source of economic growth. The most plausible reason is the existence of the Dutch Disease and the structural change that it generates. These structural effects will remain permanent, even in the long run, unless the government implements a

deliberative industrial policy. The results of the simulation has shown that, because of the mining boom, the real exchange rate appreciated so much so that it dampened exports and production of other tradable sectors, especially the import-intensive manufacturing sectors. The deindustrialization that resulted increases inequality, especially in the urban area, because mining is a very capital- and export-intensive sector with little employment elasticity and no linkage with the domestic economy. Furthermore, the structural effects of Dutch Disease tended to reduce investment incentive in high-skilled export-related sectors, which further leads to disinvestment in human capabilities.

Moreover, the findings highlighted the possible role of artisanal mining and demand for domestic agricultural and food products in improving the welfare of poor rural households. As a result of these spillover effects, poor rural households experimented with higher welfare gains compared to their counterparts in urban areas. Furthermore, the current findings clearly supported the relevance of mining rents to promote structural change and diversification. The results of mining growth simulation showed significant increase in public investment and government consumption. Despite the fact that this study has not simulated an alternative spending pattern financed by mineral rents, it is clear from the scenario of manufacturing-driven growth that DRC must foster structural transformation away from mining. In fact, the mimicking of Asia-style transformation indicated the generation of a productive transformation that produced pro-poor effects in DRC.

7.2.2. Chapter 3: Designing a development strategy based on the economic structure and market prospects.

The findings from this chapter add to a growing body of literature on growth identification. The methodological approach taken in this study is a field of influence approach-based SAM data constructed in chapter 2. The key strength of this chapter is that I applied the minimum

information decomposition of the Leontief inverse to design appropriate development policies based on the field of influence of changes.

3. What are the strengths of the linkages between different industries in DRC?

The investigation of the strength of the linkages between different sectors revealed that inter-industrial linkages are very low. I found that fourteen sectors out of nineteen have strong backward linkages against four sectors out of nineteen that exhibit forward linkages. Interestingly, agriculture, processed food, trade, and transportation were found to be key sectors of the DRC economy. The study further indicated that, although mining is a weak sector, it remains necessary for export expansion and economic growth. From a policy standpoint, this result suggested that the creation of backward and forward linkages is essential for mining to play a major role in DRC's industrialization.

4. How can industrial structure guide the choice of development strategy?

The findings highlighted the importance of creating agricultural value chains and establishing a competitive agro-food industry in DRC. The analysis suggested that increasing value addition in and processing capacity of agricultural products will generate the most important volume change in the economy, and improving the efficiency of financial intermediation will have an important additional scale effect, meaning that policies that promote its efficiency would have the highest potential to reinforce the impacts of agro-food development. The findings also pinpointed the role of investment in the transportation infrastructure and trade institutions in creating domestic and regional markets for competitive agro-food products.

7.2.3. Chapter 4: Examining policy options to promote the growth and change in the industrial structure necessary for development.

The present chapter provided additional evidence with respect to technical change and pro-poor growth. The empirical strategy proceeded as follows. I first used the CGE-Microsimulation model to generate the welfare effects of agricultural modernization strategies. Using these changes in welfare, I applied the pro-poor growth framework to assess which of the agricultural modernization strategies is pro-poor and the extent to which growth and redistribution contribute to welfare changes. Then, I selected a strategy that produced pro-poor welfare gains in the previous stage and used a least square regression to explain its characteristics. This study differed from previous studies in that it decomposed welfare effects in two components: the pure growth effect and the pure inequality effect.

5. What are the best or worse models for pro-poor agriculture modernization?

The findings indicated that labor-using technological change generates absolute and relative pro-poor effects, whereas capital-using technological change leads to immiserizing growth. The results of this research support the idea that poverty reduction led by large-scale investment in agriculture depends on the initial distribution of land. One major implication which follows from these results is that, given the high inequality in assets, the re-distribution of land matters as it affects how well the poor connect to the growth process. More importantly, the results suggest that labor-using technological change can be independently sufficient for reducing poverty via the income growth effects. However, the findings showed that agriculture alone cannot generate strong growth outside agriculture.

This study also highlighted how developing input supply networks generate pro-poor welfare gains. The findings suggested that reducing trade margins, for example by cutting the middlemen, should be implemented simultaneously with institutional reforms and policies that increase farmers' market power and improve marketing efficiency. On the other hand,

reducing chemicals' distribution costs increased access to the market for both producers and consumers, and it led to an increase in income for all labor types.

6. How do household characteristics affect pro-poor agricultural transformation?

This study also highlighted how securing tenure among smallholders and improving access to land for women are important for pro-poor agriculture modernization. I found that participation in off-farm activities is positively correlated with pro-poor welfare gains in rural areas, implying that participation in off-farm activities has positive spillover effects on pro-poor agricultural technological change in rural areas. The finding also suggested that every advance in post-primary education leads to higher pro-poor welfare gains. The results showed that welfare gains tend to be higher when women hold rights on land. Finally, the interaction between farm tools and credit is positive and significant. An implication of this is the possibility of establishing a specific credit for purchasing farm tools.

7.2.4. Chapter 5: Identifying economic policies and institutional reforms that should be created to engineer productive transformation.

This chapter built on policies that have been proven to be relevant for engineering productive transformation, such as diversification into higher value products and skill upgrade as well as those that are likely to strengthen the competitiveness of DRC agro-food products. There are two important areas in which this study makes an original contribution to economic policy development and management. First, this study has attempted to incorporate the concept of diversification into high-value-added products into a CGE model. The methods used for this analysis can be applied to other CGE models elsewhere in the world. Second, the study has made progress towards enhancing the understanding of the economy-wide and distributional effects of efficient marketing and transportation of agriculture and food products.

7. To what extent does diversification into higher value of agro-food products promote industrial development?

The investigation of diversification into higher-value agro-food products has shown that this policy has strong absolute pro-poor effects and is almost certainly first-order relatively pro-poor. Households below the 15th percentile benefited less than the average due to the impact of the policy in urban incomes and increase in demand of manufacturing products.

The relevance of skill upgrading is clearly supported by the current findings. The evidence showed that labor upskill has not only produced strong absolute and relative pro-poor effects, but also has the potential to lead to income convergence, where poor households' gains were higher than the richer ones.

8. What are the potential economy-wide and distributional impacts of economic policies and institutional reforms that achieve efficiency gains in agro-food marketing and transportation?

The analysis has revealed the underestimated contribution of agro-food marketing and transportation efficiency. The major finding was that marketing efficiency favors the middle class, and households at the 5^{th} percentile benefit less than the average population. The reason for this is that the improved marketing efficiency of agro-food products generates strong income growth that expanded the demand of food, other manufacturing products, and imports. Middle income groups benefited the most due to differences between domestic prices and import prices. This suggests that improving competition in the local agro-food chains is particularly effective in boosting food demand and imports.

With regard to transportation efficiency, the analysis found that efficiency growth in transportation of agro-food products generates strong pro-poor effects in absolute and relative terms and is likely to be particularly effective in leading to income convergence. The analysis indicated that the improved transportation efficiency has the potential not only to increase

income and employment, but also to provide positive price impacts for both agro-food producers and consumers and benefits to all households, particularly for low-income households.

7.2.5. Chapter 6: Assessing the degree of market integration and the role of sequencing reforms.

The current findings add to a growing body of literature on price transmission and market integration. This study has demonstrated, using DRC data, that structural break methods for cointegration are more suitable for price transmission analysis. Furthermore, the synergistic effects that I have identified between diversification and lowered trade and transportation costs have several practical applications, especially in terms of sequencing economic reforms.

9. What are the extent, pattern, and degree of food market integration in DRC?

The findings suggested that, in general, DRC markets are not well integrated. Evidence showed that the integration with the world market occurred for highly imported commodity goods such as rice and wheat for Kinshasa. Domestic markets are imperfectly integrated, and price transmission between integrated markets is very low. The second interesting finding is that there is a one-way causal relationship from food retail to wholesale price in Kinshasa, implying that the retailer set the food price that wholesalers would have to follow.

10. How do reforms which lower trade and transportation costs benefit the poor?

The analysis found that agricultural and food trade liberalization only has a small positive effect on welfare. The reason is that transaction costs are very high, whereas the initial tariff rate, import penetration ratio, and extent of exports are very low. A reduction in the transportation costs for agricultural products generates higher welfare gains than trade liberalization, because lower transportation costs increase producers' gains and boost

agricultural exports. In addition, reduced transportation costs in agriculture benefit other economic sectors, such as construction and trade and therefore increase wages of low- and semi-skilled workers in urban areas. However, low productivity in agriculture prevents farmers from taking full advantage opportunities offered by reduced transportation costs.

Policies directed toward reducing marketing costs for agricultural and food products result in larger welfare gains than trade liberalization and reduced transportation costs. Moreover, the boost in agricultural production resulting from lowered marketing margins reduces the DRC's dependence on imports, lowers consumer prices, increases consumption, and stimulates the growth of sectors such as processed food and textiles, which use agricultural products as intermediate inputs.

11. What are the synergetic effects between diversification into higher value agro-food products and reforms that increase the market access of DRC agro-food products?

The simulation also underscored the importance of sequencing reforms, as additional synergic effects may result from the interaction of policies. In particular, the results suggested that infrastructure development – aiming at reducing transportation costs – is a strong complement to diversification as it produced synergetic effects in exports, investment, and capital return. Correspondingly, policies directed towards reducing marketing costs – such as cutting the middle man – are likely to be complementary to diversification. However, the results at this stage suggested that agricultural trade liberalization may not be necessarily complementary to diversification, meaning that these two policies combined do not produce additional gains.

7.3. Limitations

The findings in this dissertation are subject to at least three limitations. The first limitation is common in the CGE models, given that its results depend on assumptions and functional forms. Second, the study is limited by the lack of information on the regional production

system and had relied on urban-rural disaggregation in the labor market.

Finally, the most important limitation lies in the fact that this study assumed diversification into higher-value products and reduced trade and transportation costs to be exogenous, and the model does not consider the resources needed to implement policies in those areas. The major reason for this is that estimating the costs associated with each policy and their financing sources would go beyond the scope of this dissertation. From the policy perspective, this analysis has thus not tended to compare the net benefit of these policies, but assessed the extent to which they led to productive transformation and pro-poor growth.

7.4. Policy recommendations

The analysis has concluded that DRC's economy is at the factor-driven stage at which industries concentrate in low value-added activities, labor is less productive and uneducated, and markets are not integrated. On the other hand, the findings have shown that DRC has tremendous potential to create agricultural value chains and establish a competitive agro-food industry for the regional market, meaning that DRC should start the transition to the second stage of an efficiency-driven economy. To build a competitive agro-food industry, the study has hypothesized that it is necessary for DRC to upgrade its production structure by raising the technology level and promote the competitiveness of domestic industries through efficient trade and transportation services.

A major implication that arises from the investigation is that the DRC government should increase investment in education and infrastructure development and upgrade agricultural value chains. In the long run, DRC should improve market and labor efficiency as well as financial intermediation. Keeping the limitations in mind and based on the facts and findings from this study, six sets of recommendations follow.

1. DRC should pursue institutional reforms that would increase its capacity to implement effective industrial policies and strategies and reduce the risk of failure.

The mismanagement of natural resource, the rent-seeking activities since the 1970s, and the extensive corruption and violence that occurred as a result sent DRC down the path of failure.[67] This is because rent-seeking activities moved resources away from growth-enhancing innovation. The experience of East Asia has demonstrated the positive use of rents such that the competition for rents led to learning firms that innovate to become more competitive in the global market. Past development policies have mostly failed in DRC because they were poorly implemented. Recent findings show that governance issues are important as they determine the nature of industrial policy and the instruments to be used. An implication of this is the possibility that industrial policy will be successful when:

- The DRC government takes concrete actions to improve its accountability. The current anti-corruption law was enacted in 2005 due to strong pressure from the international community. According to Transparency International, DRC's ranking of the corruption perception index dropped from 160 in 2012 with a score of 21 out of 100 to 154 in 2013 with a score of 22 out of 100, implying that DRC's recent measures to fight against corruption are working. Thus, the DRC government should pursue recent measures to enforce anti-corruption law and demonstrate their political will to effectively address the issue of corruption.
- DRC establishes institutions to avoid conflict. The development experience of Botswana shows that natural resource-rich states can prevent failure if they build institutions to avoid conflict and corruption. The findings from this study have shown high inequality in asset distribution, especially land. Therefore, the government should be proactive in the redistribution of productive assets by addressing land issues. The government may need

[67] State failure here refers to the inability of the state to provide to its people basic services such as health care, security, effective state institutions, human rights, education, and rule of law, among others.

to increase its cultivated land and secure land tenure for smallholders, especially for women. Given the current investment in land in DRC, land market reform can create the opportunity to move subsistence farming to market-oriented farming.

- DRC promotes policies that add local content in mining, manage artisanal mining, and create natural resource fund. The creation of a natural resource fund to finance industrial policy is particularly important, given that the findings have stressed the role of public investment from the natural resource boom. DRC should align public and private funding and institutions to facilitate the movement and reallocation of funds. This finding should also be used to provide short-run assistance to the poor and adjustment costs to those who suffer from reallocation and job loss.
- DRC increases the effectiveness of institutions to implement policies, especially in agriculture. In this regard, a necessary first step would be to establish an agricultural promotion agency to increase the government's capacity to implement effective agricultural policies and strategies. In fact, the government of DRC has developed more than 10 agriculture and rural development programs since 1966. Actually, there are five ministries in charge of agriculture, with 30 supporting agencies. However, all of the efforts undertaken have failed to increase agriculture's productivity and farmers' income. The findings have shown that the only way to increase agriculture production is by increasing land and labor, as productivity is very low and decreasing. Therefore, the immediate objectives of the Agency for Agricultural Promotion should be to catalyze the efforts of government services, the private sector, and the civil sector to enhance the rural extension service and accelerate the transfer to technology and the use of inputs, initiate agricultural mechanization, and strengthen marketing services.

2. **The DRC government should improve macroeconomic policy and exchange rate management.**

DRC government has succeeded to keep inflation in the single digits, specifically at 1 percent through the close of 2013, despite the increase of GDP growth at about 8 percent. Remember that inflation was at 49 percent in 2009 and 11 percent in 2011. DRC has also been able to stabilize other macroeconomic indicators such as the exchange rate, sound fiscal policies, sustainable current account on the balance of payments, and sustainable debt ratios. DRC policy makers should maintain sound macroeconomic fundamentals to mitigate the negative effects of exchange appreciation due to inflows. But more importantly, the government should engage in the following action:

- pursue policies to maintain competitive exchange rates and stimulate exports on non-mining products;
- improve domestic resource mobilization and reduce capital flight. The government should also consider savings and investment, especially in inputs;
- give tax incentives to domestic firms to innovate and to informal firms to legalize their activities.

3. **The DRC should modernize the agricultural production methods of small-scale farmers**

In the last five years, the Congolese government has invested US$56 million and imported nearly 3,000 tractors to increase productivity and boost agricultural production. However, the use of such technology is limited, because 69 percent of farmers are subsistence smallholders with less than two hectares of mostly fragmented land. For these farmers, it may be more effective, at least in the short run, to introduce improved hand tools and machines that can be used manually or powered by animals. Mountainous regions in the eastern part of the country should be given priority, particularly in view of the outdated equipment they use as a

consequence of war and displacement. The government may also need to establish supply chains to provide spare parts and back-up services to farmers and to train them in the use of the new equipment. It should also facilitate access to modern harvesting, on-farm storage, and post-harvesting equipment to enable farmers to add value to their products and reduce post-harvest losses.

In order to ensure the sustainability of these measures, they should be accompanied by:

- training for farmers in operating the equipment,
- promotion of local production of agricultural equipment, and
- tax credit and subsidy programs for poor small-scale farmers to encourage them to invest in domestically produced farm machinery.

4. Strengthen agricultural extension services, research, and education.

As land productivity in the DRC is low and has been decreasing since 2000, the government should help farmers strengthen their capacity to produce more output through rural extension services and the transfer of appropriate innovation. One way to achieve this would be to transform the more top-down extension service created in 1988 into one that employs a more bottom-up participatory approach. This could be achieved by giving more autonomy to provinces to allocate extension services so as to respond to local needs. For example, DRC policy makers should decentralize the *Service National de Vulgarisation* (SNV) in the hands of provincial governments. Efforts of decentralization have been made, but the government must accelerate the process and give autonomy to provinces. The ministry of agriculture, which will play the role of coordinator, may need to create exchange platforms to promote communication and collaboration among the SNV unit. As a coordinator, the ministry of agriculture would accelerate the transfer of innovation between regions. For example, the ministry may need to look at how to adapt the Farmer's Field School approach to other

regions by learning from the Western Kasai, where this approach has been successful since 2003. Another option would be to build the capacity of the Ministry of Agriculture and Rural Development field staff members, who number between 13,000 and 18,000 and mainly work in farm inspection and the collection of data, so that they can provide rural extension services.

In addition, research, extension, and education should be linked to promoting on-farm agricultural extension work and to developing technologies that respond to farmers' needs. The DRC has two agricultural and rural development education institutions – the High Institute of Agronomic Studies and the High Institute of Rural Development – as well as one agricultural research entity, the National Institute for Agricultural Studies and Research. These institutions, which fall under the Ministry of Higher Education and Scientific Research and have a field presence across almost the entire country, should join their efforts by promoting on-farm extension work for students, developing and adapting technologies to cater to the needs of farmers and provide farmers with training.

For the long-term sustainability of these actions, the government may need to strengthen coordination between ministries and their services as well as the links between agricultural education and research institutions, farmer associations, non-governmental organizations, churches, and private extension services and advisors. It should also provide support to farmers' organizations and strengthen the links between farmers, input suppliers, and credit providers; improve the organization capacity of farmers; and increase the operational linkage between farmers, input suppliers, and credit and marketing cooperatives. DRC's farmers have organized themselves into cooperatives and associations with the help of churches and NGOs. The government should encourage these initiatives and provide them with legal support and marketing information.

5. DRC should increase the physical and economic access of producers to higher-value markets by investing in infrastructure and market development.

One of the major findings of this dissertation is that infrastructure development is crucial to increase DRC competitiveness and has synergetic effects with diversification into higher value addition. However, DRC is a landlocked, fragile developing country – approximately four times the dimension of France – and is surrounded by nine neighboring countries. This situation poses many challenges but also creates opportunities for trade and development. The following is a set of recommendations for DRC to develop efficient multimode transport infrastructure and increase farmers' access to markets:

A) The government should build and maintain rural feeder roads and markets. The Congolese government has already embarked on an extensive road investment program, mainly focusing on the construction and rehabilitation of inter-urban roads. Those efforts should be encouraged, with increased attention paid to the quality and sustainability of these upgraded roads. DRC may consider creating incentives for the private sector to invest in infrastructure through private-public partnerships. Moreover, to improve market access and the mobility of small-scale farmers, investments should also be directed towards on-farm and village-level transport. The capacity of communities to maintain local roads and organize village-level transportation of agricultural products should be strengthened. Providing utility trailers, in addition to tractors, is important for transporting agricultural products to markets. The government should also design tax systems that protect agricultural and food products from excessive tolls charged for the use of urban access roads.

B) DRC could implement economic and institutional reforms to improve market access through transit transport and corridors. Given the limitation of funds, DRC should cooperate in the regional infrastructure. In this context, DRC may consider taking the following action:

- Strengthen regional cooperation on infrastructure projects. For example, DRC should show stronger commitment and leadership to the SADC transport corridor project.
- Foster bilateral cooperation to improve transit systems. It is important for DRC to maintain friendships and establish long-term relationships with Angola, Congo-Brazzaville, and Rwanda. RDC should harmonize and standardize trade-related documentation, especially with Angola, due to the language difference.
- Set rules and regulations as well as free trade agreements with Rwanda, Uganda, and Burundi for cross-border trade in the eastern part of DRC to reduce illegal trade and smuggling of agricultural and mineral commodities.

C) Considering its huge network of navigable rivers, DRC should consider the most effective approach to promote domestic rive transportation. DRC can incentivize the private sector to invest in domestic river transportation by reducing over taxation and military hassles along the Congo River and dredging and maintaining the river network. DRC may also encourage the cooperation between the shipbuilder Chanimetal and the private sector. However, and more importantly, a policy focus should be directed to informal welders "soudeurs" and mechanics to join the venture.

D) DRC should make use of the existing rail network. DRC inherited a fairly large rail network from colonialism. However, the lack of investment and maintenance has reduced operations. Since restoring the rail system requires tremendous investment, DRC may need to make the political decision to privatize the rail network.

E) DRC should create efficient food distribution and marketing channels, especially for smallholders.

- DRC should facilitate institutional arrangements, such as contract farming, group farming to create food value chain participant councils to organize food supply chain, and niche marketing. For example, DRC has approximately 64 embassies and consulates around the world. DRC may consider involving them in consumer niche marketing. DRC should

establish marketing systems to increase the proportion of marketed agricultural production for small-scale farmers. The DRC government should promote village-level storage and collective marketing to reduce high transaction costs for small scale farmers. DRC could promote commodity markets and support the establishment of cooperatives.

- DRC should promote private marketing to provide farmers with market information and research. For example, the government could encourage the use of ICT and cell phones in rural areas. This policy also has the potential to reduce the distribution costs of fertilizer.

6. DRC should improve the quality of education and invest in skill and technological upgrade.

Education in DRC is among the most sectors affected by the 32-year crisis faced by the country. From the 1960s until the early 2000s, the national budget for education declined from 25 percent to 5 percent, creating a decrease of 96 percent in spending per pupil per year in primary and secondary schools (from US$109 in 1980 to US$4 in 2002). In 2010, DRC policy makers decided to make primary education free in public schools and increased the share of the public budget spent on education to 15.02 percent by 2013. Despite this renewed commitment to education as one of the priority sectors, the DRC government should show greater political will in the design and implementation of education programs. On the basis of the findings in the empirical analysis, this study put forward the following three recommendations to improve the contribution of education to productive transformation and inclusive development in DRC:

A. The government should remove the cost barrier for the poor to access free primary education. In fact, the cost remains a barrier to primary education, because parents must still bear high school expenses such as transportation, school uniforms, and most importantly the primary graduation test fees, “Test national de fin d'études primaires”. DRC policy makers may consider eliminating or phasing out primary graduation test fees

in poor and remote regions. The government could also involve the local community in education reform and school infrastructure maintenance, which can possibly reduce other indirect costs. DRC should increase the provision of schools and enhance private-public partnerships in education and training.

B. DRC policy makers should revise and optimize the curriculum to increase its quality and relevance to address current and future socio-economic issues. Efforts should focus on how to:

- increase morality, patriotism, and teamwork;
- improve the acquisition of basic mathematics-related skills, which in turn will foster thinking and problem-solving skills;
- acquire communication, leadership, and entrepreneurship skills;
- introduce food-related education and establish a food science and technology program[68] as one of the future offerings.

C. DRC could develop agro-industry capacity and technological capabilities. DRC may consider performing the following actions:

- accelerate technology transfer in the field of food processing, food packing, and post-harvesting;
- target scholarships for agro-industry technology and food logistics;
- target subsidies for food science institutions (schools, universities, etc.);
- and encourage the acquisition of competency skills through in-firm training.

7.5. Possible extensions

This research has presented many questions in need of further investigation. As the CGE analysis was limited by the lack of information on the regional and product levels, future research is needed to account for the existing variation in regional and provincial production

[68] Which is different from culinary and dietician programs.

structure and land use. Further research could disaggregate the SAM into regions and provide detailed disaggregation for factors of production, especially land and capital. It would be particularly interesting to study how repatriation and possible re-investment of dividends affect industrial development. Another possible study could be the impact of regional domestic transaction costs on industrial development and market access for the poor. A natural progression of this work could be to analyze the potential effects of regional cooperation in improving access to high-value markets.

Further research on industrial development finance would be worthwhile, given that DRC is an aid-dependent country, and the findings of this dissertation have shown the significant role of investment and financial intermediation in reallocating resources to higher productive sectors. What is now needed is a rigorous economic analysis involving the estimation of costs associated with each industrial policy and its financing sources. It is suggested that the association of ODA, natural resource funds, FDI, and domestic private investment be investigated in future studies to assess the optimal combination of these financing sources on industrial development.

The issue of diversifying into higher-value products is an intriguing one which could be usefully explored in further research. In this dissertation, I have incorporated diversification as an additional input to TFP. A number of possible future studies using the same simulation setup could incorporate the indicators based on the concepts of economic complexity and product space (Hausmann and Hidalgo 2011).

REFERENCES

Abdulai A (2000) Spatial price transmission and asymmetry in the Ghanaian maize market. J Dev Econ 63 (2):327-349

ACET (2014) 2004 African Transformation Report: Growth with Depth. The African Center for Economic Transformation, Accra, Ghana

Acosta A (2012) Measuring spatial transmission of white maize prices between South Africa and Mozambique: An asymmetric error correction model approach. The African Journal of Agricultural and Resource Economics 7 (1):1-13

Acquah HD-G, Micah JA, Owusu R (2012) Price transmission in domestic agricultural markets: Evidence from selected cassava markets in Ghana. Journal of Sustainable Development in Africa 14 (5):218-228

AfDB (2007) African Development Report 2007. AfDB,

AfDB (2011) Middle of the Pyramid: Dynamics of the Middle Class in Africa. AfDB Market Brief April 20, 2011. African Development Bank, Tunis

AfDB, OECD, UNDP, UNECA (2013) African Economic Outlook 2013: structural transformation and natural resources in Africa. OECD Publishing. doi:http://dx.doi.org/10.1787/aeo-2013-en

African Union, ECA, AfDB (2012) Land Policy in Africa: Central Africa Regional Assessment. AUC-ECA-AfDB Consortium, Addis Ababa

Agosin MR (2007) Export Diversification and Growth in Emerging Economies. Working Paper No. 233. University of Chile, Department of Economics,

Alexander C, Wyeth J (1994) Cointegration and market integration: An application to the Indonesian rice market. The Journal of Development Studies 30 (2):303-334. doi:10.1080/00220389408422317

Alston JM, Foster KA, Gree RD (1994) Estimating Elasticities with the Linear Approximate

Almost Ideal Demand System: Some Monte Carlo Results. The Review of Economics and Statistics 76 (2):351-356. doi:10.2307/2109891

Alvarez-Cuadrado F, Poschke M (2011) Structural Change Out of Agriculture: Labor Push versus Labor Pull. American Economic Journal: Macroeconomics 3 (3):127-158. doi:doi: 10.1257/mac.3.3.127

Amartya S (1981) Poverty and Famines: An Essay on Entitlement and Deprivation. Clarendon Press, Oxford

Amin Guitierrez de Pineres S, Ferrantino M (1997) Export diversification trends: Some comparisons for Latin America. The International Executive 39 (4):465-477. doi:10.1002/tie.5060390403

Amin Guitierrez de Pineres S, Ferrantino MJ (2000) Export Dynamics and Economic Growth in Latin America. Ashgate Publishing Ltd., Burlington, Vermont

Anderson K, Strutt A (2014) Emerging economies, productivity growth and trade with resource-rich economies by 2030. Aust J Agr Resour Ec 58 (4):590-606. doi:10.1111/1467-8489.12039

Annabi N, Cissé F, Cockburn J, Decaluwé B (2008) Trade Liberalisation, Growth and Poverty in Senegal: a Dynamic Microsimulation CGE Model Analysis. Économie et Prévision 186 (5):117-131

Araar A, Duclos J-Y, Audetz M, Makdissi P (2009) Testing For Pro-Poorness Of Growth,With An Application To Mexico. Review of Income and Wealth 55 (4):853-881

Arndt C, Robinson S, Tarp F (2000) Marketing Margins and Agricultural Technology in Mozambique. The Journal of Development Studies 37 (1):121-137

Atuesta L, Hewings GJD (2012) Economic Welfare Analysis of the Legalization of Drugs: A CGE Microsimulation Model for Colombia. Econ Syst Res 25 (2):190-211. doi:10.1080/09535314.2012.728130

Badiane O, Shively GE (1998) Spatial integration, transport costs, and the response of local

prices to policy changes in Ghana. J Dev Econ 56 (2):411-431. doi:http://dx.doi.org/10.1016/S0304-3878(98)00072-8

Balassa B (1965) Trade Liberalization and Revealed Comparative Advantage. The Manchester School of Economic and Social Studies 33:99-123

Balassa B (1986) Comparative Advantage in Manufactured Goods: A Reappraisal. The Review of Economics and Statistics 68 (2):315-319

Baldwin RE (2008) Managing the noodle bowl: the fragility of east asian regionalism. The singapore economic review 53 (3):449-478. doi:doi:10.1142/S0217590808003063

Baltzer K (2013) International to domestic price transmission in fourteen developing countries during the 2007-08 food crisis. WIDER Working Paper No. 2013/031. World Institute for Development Economic Research (UNU-WIDER), Helsinki

Banque Centrale du Congo (2007-2013) Bulletin mensuel d'informations statistiques. Banque Centrale du Congo, Kinshasa

Banque Centrale du Congo (Various years) Rapport Annuel Banque Centrale du Congo/, Kinshasa

Baquedano FG, Liefert WM (2014) Market integration and price transmission in consumer markets of developing countries. Food Policy 44 (0):103-114

Barrett CB, Li JR (2002) Distinguishing between Equilibrium and Integration in Spatial Price Analysis. Am J Agr Econ 84 (2):292-307. doi:10.2307/1244953

Baulch B (1997) Transfer Costs, Spatial Arbitrage, and Testing for Food Market Integration. Am J Agr Econ 79 (2):477-487. doi:10.2307/1244145

BEAU (1986) Consommation des produits vivriers à Kinshasa. Kinshasa

Becketti S (2013) Introduction to Time Series Using Stata. Stata Press, College Station, TX

Bela B (1997) "Revealed" Comparative Advantage Revisited: An Analysis of Relative Export Shares of the Industrial Countries, 1953-1971. The Manchester School of Economic & Social Studies 45 (4):327-344

Benjamin NC, Mbaye AA (2012) The Informal Sector, Productivity, and Enforcement in West Africa: A Firm-level Analysis. Review of Development Economics 16 (4):664-680

Bibi S, Cockburn J, Tiberti L, Fofana I (2010) Impacts of the Global Crisis and Policy Responses on Child Well-being: A Macro-Micro Simulation Framework. Innocenti Working Papers No 2010-06. UNICEF Innocenti Research Centre, Florence and UNICEF Regional Office for West and Central Africa, Dakar,

Bleaney M, Greenaway D (2001) The impact of terms of trade and real exchange rate volatility on investment and growth in sub-Saharan Africa. J Dev Econ 65 (2):491-500

Boccanfuso D, Coulibaly M, Timilsina GR, Savard L (2011) Economic and Distributional Impacts of Biofuels in Mali. Cahiers de recherche No. 11-08. Departement d'Economique de la Faculte d'administration à l'Universite de Sherbrooke,

Boccanfuso D, Coulibaly M, Timilsina GR, Savard L (2013a) Macroeconomic and Distributional Impacts of Jatropha-based Biodiesel in Mali. Policy Research Working Paper 6500. The World Bank, Washington, D.C.

Boccanfuso D, Kaboré ST (2004) Croissance, inégalité et pauvreté dans les années quatre-vingt-dix au Burkina Faso et au Sénégal. Revue d'économie du développement 2 (12):9-35

Boccanfuso D, Savard L, Estache A (2013b) The Distributional Impact of Developed Countries' Climate Change Policies on Senegal: A Macro-Micro CGE Application. Sustainability 5 (6):2727-2750

Bonjean CA, Brunelin S (2013) Le commerce agricole en Afrique de l'Ouest et du Centre: les frontières sont-elles abolies? Revue d'économie du développement 27 (1):5-31

Bourguignon F, Ferreira FHG (2005) Decomposing Changes in the Distribution of Household Incomes: Methodological Aspects. In: Bourguignon F, H. G. Ferreira, Lustig N (eds) The Microeconomics of Income Distribution Dynamics in East Asia and Latin America. Oxford University Press, New York,

Bourguignon F, Morrisson C (1998) Inequality and development: the role of dualism. J Dev Econ 5:233-257

Brenton P, Portugal-Perez A, Régolo J (2014) Food Prices, Road Infrastructure, and Market Integration in Central and Eastern Africa. Policy Research Working Paper No. 7003. World Bank Washington, DC

Brümmer B, Zorya S (2005) Wheat / flour price transmission and agricultural policies in Ukraine: a Markov-switching vector error correction approach. Paper presented at the Paper prepared for presentation at the XIth Congress of the European Association of Agricultural Economists, Copenhagen, Denmark, August 23-27, 2005,

Burfisher ME (2011) Introduction to Computable General Equilibrium Models. Cambridge university press,

Cameron AC, Trivedi PK (2010) Microeconometrics Using Stata, Revised Edition. Stata Press, College Station, Texas

Capone R, Bilali HE, Debs P, Cardone G, Driouech N (2014) Food Economic Accessibility and Affordability in the Mediterranean Region: an Exploratory Assessment at Micro and Macro Levels. Journal of Food Security 2 (1):1-12

Chang H-J (2010) Hamlet without the Prince of Denmark: How development has disappeared from today's 'development' discourse. In: Khan SR, Christiansen J (eds) Towards new developmentalism: Markets as means rather than master Routledge, Abingdon,

Chausse J-P, Kembola T, Ngonde R (2012) L'agriculture : pierre angulaire de l'économie de la RDC. In: Herderschee J, Samba DM, Tshibangu MT (eds) Résilience d'un Géant Africain : Accélérer la Croissance et Promouvoir l'Emploi en République Démocratique du Congo, vol II : Etudes sectorielles. MÉDIASPAUL, Kinshasa, pp 1-97

Chen S, Ravallion M (2004) Welfare Impacts of China's Accession to the World Trade Organization. The World Bank Economic Review 18 (1):29-57.

doi:10.1093/wber/lhh031

Chenery H (1979) Structural Change and Development Policy. Oxford University Press, New York

Cleaver HM, Jr. (1972) The Contradictions of the Green Revolution. The American Economic Review 62 (1/2):177-186. doi:10.2307/1821541

Clemente J, Montañés A, Reyes M (1998) Testing for a unit root in variables with a double change in the mean. Econ Lett 59 (2):175-182

Cogneau D, Robilliard A-S (2001) Croissance, distribution et pauvreté: un modèle de micro simulation en équilibre général applique à Madagascar. Working Papers DT/2001/19. DIAL (Développement, Institutions & Analyses de Long terme),

Cogneau D, Robilliard A-S (eds) (2008) Simulating Targeted policies with Macro Impacts: Poverty Alleviation Policies in Madagascar. The impact of macroeconomic policies on poverty and income distribution: Macro-micro evaluation techniques and tools. Palgrave Macmillan and the World Bank, Houndmills

Collier P (2007) The Bottom Billion. Oxford University Press, Oxford

Collier P, Soludo CC, Pattillo C (2008) Economic Policy Options for a Prosperous Nigeria. Palgrave Macmillan, New York

Cramer C (1999) Can Africa Industrialize by Processing Primary Commodities? The Case of Mozambican Cashew Nuts. World Development 27 (7):1247-1266

Cramon-Taubadel SV (1998) Estimating asymmetric price transmission with the error correction representation: An application to the German pork market. Eur Rev Agric Econ 25 (1):1-18. doi:10.1093/erae/25.1.1

Crespi G, Fernández-Arias E, Stein E (2014) Rethinking Productive Development: Sound Policies and Institutions for Economic Transformation. Development in the Americas (DIA) Inter-American Development Bank, Washington, D.C

Cudjoe G, Breisinger C, Diao X (2008) Local Impacts of a Global Crisis: Food Price

Transmission and Poverty Impacts in Ghana. IFPRI Discussion Paper No. 00842. International Food Policy Research Institute, Washington, DC

Cuffaro N (1997) Population growth and agriculture in poor countries: A review of theoretical issues and empirical evidence. World Development 25 (7):1151-1163. doi:http://dx.doi.org/10.1016/S0305-750X(97)00025-9

Das RJ (1998) The Green Revolution, agrarian productivity and labor. International Journal of Urban and Regional Research 22 (1):122-135. doi:10.1111/1468-2427.00127

Dawkins C, Srinivasan TN, Whalley J (2001) Chapter 58 - Calibration. In: James JH, Edward L (eds) Handbook of Econometrics, vol Volume 5. Elsevier, pp 3653-3703

de Janvry A, Sadoulet E (1996) Growth, inequality and poverty in Latin America: a causal analysis, 1970–94. Working Paper no. 784. Department of Agricultural and Resource Economics, University of California at Berkeley, California

de Janvry A, Sadoulet E (2010) Agricultural Growth and Poverty Reduction: Additional Evidence. The World Bank Research Observer 25 (1):1-20. doi:10.1093/wbro/lkp015

de Janvry A, Sadoulet E, Zhu N (2005) The Role of Non-Farm Incomes in Reducing Rural Poverty and Inequality in China. CUDARE Working Paper Series 1001. University of California at Berkeley, Department of Agricultural and Resource Economics and Policy, Berkeley, CA

Deaton A (1999) Conmmodity Prices and Growth in Africa. Journal of Economic Perspectives 13 (3):23-40

Deaton A, Muellbauer J (1980) An Almost Ideal Demand System. American Economic Review 70 (3):312-326

Defourny J, Thorbecke E (1984) Structural Path Analysis and Multiplier Decomposition within a Social Accounting Framework. Economic Journal 94: 111-136

Delgado CL (1986) A Variance Components Approach to Food Grain Market Integration in Northern Nigeria. Am J Agr Econ 68 (4):970-979. doi:10.2307/1242143

Dervis K, de Melo J, Robinson S (1982) General equilibrium models for development policy. Cambridge University Press, New York

DFID (2006) Technology and its Contribution to pro-poor Agricultural Development. DFID Working Papers No. 4. University of Greenwich, London, England

Di Maio M (2009) Industrial Policies in Developing Countries: History and Perspectives. In: Mario Cimoli GD, and Joseph E. Stiglitz (ed) Industrial Policy
and Development: The Political Economy of Capabilities Accumulation. Oxford
University Press, Oxford, pp 107–143

Di Maio M (2014) Industrial policy. In: Currie-Alder B, Kanbur R, Malone DM, Medhora RP (eds) International Development: Ideas, Experience and Prospects. Oxford University Press, Oxford,

Diao X (2012) Strategies and priorities for African agriculture : economywide perspectives from country studies. International Food Policy Research Institute, Washington, D.C.

Diao X, McMillan M (2014) Towards Understanding Economic Growth in Africa: A Reinterpretation of the Lewis Model. IFPRI Discussion Paper No. 01380. IFPRI, Washington, DC

Dickey DA, Fuller WA (1979) Distribution of the Estimators for Autoregressive Time Series With a Unit Root. J Am Stat Assoc 74 (366):427-431. doi:10.2307/2286348

Dimaranan BV (ed) (2006) Global Trade, Assistance, and Production: The GTAP 6 Data Base. Center for Global Trade Analysis, Purdue University

Dorward A, Shenggen Fan, Kydd J, Lofgren H, Morrison J, Poulton C, Rao N, Smith L, Tchale H, Thorat S, Urey I, Wobst P (2004) Institutions and Policies for Pro-poor Agricultural Growth. Dev Policy Rev 22 (6):611-622

DRC (2005) Enquête 1-2-3. Kinshasa

DRC (2011) Document de la Politique et des Stratégies Industrielles de la République Démocratique du Congo. Kinshasa

Duclos J-Y (2009) What is “Pro-Poor”? Soc Choice Welf 32 (1):37-58. doi:10.1007/s00355-008-0308-x

Durojaiye BO, Aihonsu JOY (1988) Market integration and seasonal prices of staple foodstuffs: A case study of Ogun State, Nigeria. Food Policy 13 (4):375-382

Duruflé G., Fabre R., J.M Y (1988) Les effets sociaux et économiques des projets de développement rural. Série Méthodologie. Ministère de la Coopération, la Documentation Française, Paris

Eicher CK (1995) Zimbabwe's maize-based Green Revolution: Preconditions for replication. World Development 23 (5):805-818. doi:http://dx.doi.org/10.1016/0305-750X(95)93983-R

Elliott G, Rothenberg TJ, Stock JH (1996) Efficient Tests for an Autoregressive Unit Root. Econometrica 64 (4):813-836. doi:10.2307/2171846

Elliott K (2008) Biofuels and the Food Price Crisis: A Survey of the Issues. Working Paper No. 151. The Center for Global Development, Washington, DC

Engle RF, Granger CWJ (1987) Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica 55 (2):251-276. doi:10.2307/1913236

ESCAP (2011) Sustaining Recovery and Dynamism for Inclusive Development: Connectivity in the Region and Productive capacity in Least Developed Countries. Economic and Social Survey of Asia and the Pacific United Nations Economic and Social Commission for Asia and the Pacific, Bangkok

Essama-Nssah B, Go DS, Kearney M, Korman V, Robinson S, Thierfelder K (2007) Economy-wide and Distributional Impacts of an Oil Price Shock on the South African Economy. Policy Research Working Paper 4354. The World Bank and Institute of Development Studies (IDS), Sussex University,

Fackler PL, Goodwin BK (2001) Chapter 17 Spatial price analysis. In: Bruce LG, Gordon CR (eds) Handbook of Agricultural Economics, vol Volume 1, Part B. Elsevier, pp

971-1024. doi:http://dx.doi.org/10.1016/S1574-0072(01)10025-3

Fagernas S (2004) Analysing the Distributional Impacts of Stabilisation Policy with a CGE Model: Illustrations and Critique for Zimbabwe. ODI Strategic Policy Impact and Research Unit Papers, No. 4.

FAOSTAT database (2014) FAO. http://faostat.fao.org/default.aspx. Accessed 14/01/2014

FAO/WHO/UNU (2004) Human energy requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. FAO Food and Nutrition Technical Report Series, No. 1.

Feenstra RC, Hanson GH (1999) The Impact of Outsourcing and High-Technology Capital on Wages: Estimates For the United States, 1979–1990. The Quarterly Journal of Economics 114 (3):907-940. doi:10.1162/003355399556179

Felipe J, Kumar U, Abdon A (2010) How Rich Countries Became Rich and Why Poor Countries Remain Poor It's the Economic Structure . . . Duh! Working Paper No. 644. The Levy Economics Institute,

Felipe J, Kumar U, Abdon A, Bacate M (2012) Product complexity and economic development. Structural Change and Economic Dynamics 23 (1):36-68. doi:http://dx.doi.org/10.1016/j.strueco.2011.08.003

Felipe J, Kumar U, Usui N, Abdon A (2013) Why has China succeeded? And why it will continue to do so. Cambridge Journal of Economics 37:791–818

Ferraz JC, Kupfer D, Marques FS (2014) Industrial policy as an effective development tool: Lessons from Brazil. In: Salazar-Xirinachs JM, Nübler I, Kozul-Wright R (eds) Transforming economies: Making industrial policy work for growth, jobs and development. International Labour Office, Geneva,

Foster J, Greer J, Thorbecke E (1984) A Class of Decomposable Poverty Measures. Econometrica 52 (3):761-766. doi:10.2307/1913475

Frankel JA (2010) The Natural Resource Curse: A Survey. Working paper No. 15836. National Bureau of Economic Research,

Freebairn D (1995) Did the Green Revolution concentrate incomes? A quantitative study of research reports. World Development 23:265-279

Gabriele A (2010) The Role of the State in China's Industrial Development: A Reassessment. Comp Econ Stud 52 (3):325-350

Gardner BL (1975) The Farm-Retail Price Spread in a Competitive Food Industry. Am J Agr Econ 57 (3):399-409. doi:10.2307/1238402

Gelb A, Mengistae T, Ramachandran V, Shah MK (2009) "To Formalize or Not to Formalize? Comparisons of Microenterprise Data from Southern and East Africa.". Working Paper 175. Center for Global Development, Washington, DC

Ghosh AR, Ostry J (1994) Export Instability and the External Balance in Developing Countries. IMF Staff Papers 41:214–235

Gibbon P (2001) Upgrading Primary Production: A Global Commodity Chain Approach. World Development 29 (2):345-363. doi:http://dx.doi.org/10.1016/S0305-750X(00)00093-0

Glaeser B (1987) The Green Revolution revisited. Allen & Unwin, London

Global Information and Early Warning System (2014) Food Price Data and Analysis Tool. FAO Rome

Goldman A, Smith J (1995) Agricultural transformations in India and Northern Nigeria: Exploring the nature of Green Revolutions. World Development 23 (2):243-263. doi:http://dx.doi.org/10.1016/0305-750X(94)00115-F

Goletti F, Ahmed R, Farid N (1995) Structural determinants of market integration: The case of rice markets in Bangladesh. The Developing Economies 33 (2):196-198. doi:10.1111/j.1746-1049.1995.tb00713.x

Goodwin BK, Piggott NE (2001) Spatial Market Integration in the Presence of Threshold Effects. Am J Agr Econ 83 (2):302-317. doi:10.1111/0002-9092.00157

Goodwin BK, Schroeder TC (1991) Cointegration tests and spatial price linkages in regional

cattle markets. Am J Agr Econ 73 (2):452-464

Granger CWJ (1969) Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica 37 (3):424-438. doi:10.2307/1912791

Greb F, Jamora N, Mengel C, Cramon-Taubadel Sv, Würriehausen N (2012) Price transmission from international to domestic markets. Courant Research Centre: Poverty, Equity and Growth - Discussion Paper No. 125. University of Göttingen, Germany,

Greenwald BC, Stiglitz JE (2013) Learning and Industrial Policy: Implications for Africa. In: Stiglitz JE, Lin JY, Patel E (eds) The Industrial Policy Revolution II: Africa in the 21st Century. vol International Economic Association. Palgrave Macmillan, Houndmills, UK and New York, pp 25-49

Gregory AW, Hansen BE (1996) Residual-based tests for cointegration in models with regime shifts. J Econometrics 70 (1):99-126. doi:http://dx.doi.org/10.1016/0304-4076(69)41685-7

Gregory AW, Nason JM, Watt DG (1996) Testing for structural breaks in cointegrated relationships. J Econometrics 71 (1–2):321-341. doi:http://dx.doi.org/10.1016/0304-4076(96)84508-8

Griffin K (1979) The political economy of agrarian change: An essay on the Green Revolution. Second Edition edn. Macmillan Press, London

Gylfason T, Herbertsson TT, Zoega G (1999) A MIXED BLESSING. Macroeconomic Dynamics 3 (02):204-225. doi:doi:null

Hamilton JD (1994) Time series analysis. Princeton University Press, New Jersey

Hammouda HB, Stephen NK, Angelica EN, Mustapha Sadni J (2009) Growth, productivity and diversification in Africa. Journal of Productivity Analysis 33:125–146. doi:10.1007/s11123-009-0155-5

Harris J, Todaro M (1970) Migration, Unemployment and Development: A Two-Sector

Analysis. The American Economic Review 60:126–142

Harrold P, Jayawickrama M, Bhattasali D (1996) Practical Lessons for Africa from East Asia in Industrial and Trade Policies. World Bank discussion papers. The World Bank, Washington, D.C

Hausmann R, Hidalgo CA (eds) (2011) The atlas of economic complexity: Mapping paths to prosperity. MIT Press, Cambridge

The Atlas of economic complexity mapping paths to prosperity (2014) MIT Press. http://atlas.media.mit.edu/book/. Accessed 2014

Hausmann R, Hwang J, Rodrik D (2006) What you export matters. Centre for Economic Policy Research Discussion Paper Series (U K), vol No 5444:1-, January 2006.

Hausmann R, Hwang J, Rodrik D (2007) What you export matters. Journal of Economic Growth 12, No. 1:1-25

Hausmann R, Klinger B (2006) Structural Transformation and Patterns of Comparative Advantage in the Product Space. Working Paper No. 128. Center for International Development, Harvard University,

Hausmann R, Rodrik D (2003) Economic development as self-discovery. J Dev Econ 72, No. 2:603-633

Hayami Y, Ruttan VW (1970) Factor Prices and Technical Change in Agricultural Development: The United States and Japan, 1880-1960. Journal of Political Economy 78 (5):1115-1141. doi:10.2307/1830883

Hayami Y, Ruttan VW (1985) Agricultural development: An international perspective. revised and expanded edn. The Johns Hopkins University Press, Baltimore

Hazell P (2009) The Asian Green Revolution. IFPRI Discussion Paper 00911. IFPRI, Wanshignton, DC

Hazell P, Ramasamy C (1991) The green revolution reconsidered: The impact of high-yielding rice varieties in South India. Johns Hopkins University Press, Baltimore

and London

Headey D, Fan S (2008) Anatomy of a crisis: the causes and consequences of surging food prices. Agr Econ 39:375-391. doi:10.1111/j.1574-0862.2008.00345.x

Heckman JJ (1979) Sample Selection Bias as a Specification Error. Econometrica 47 (1):153-161

Herderschee J, Kaiser K-A, Mukoko DS (2012) Resilience of an African Giant: Boosting Growth and Development in the Democratic Republic of Congo. Directions in Development. The World Bank, Washington DC

Herzer D, Nowak-Lehmann FD (2006) What Does Export Diversification Do for Growth? An Econometric Analysis. Applied Economics (38):1825–1838

Hesse H (2008) Export Diversification and Economic Growth. Commission on Growth and Development Working Paper No. 21. The World Bank, Washington, D.C

Hewings GJD, Fonseca M, Guilhoto J, Sonis M (1989) Key Sectors and Structural Change in the Brazilian Economy: A Comparison of Alternative Approaches and their Policy Implications. Journal of Policy Modeling 11 (1):67-90. doi:http://dx.doi.org/10.1016/0161-8938(89)90025-2

Hewings GJD, Sonis M (2009) Coefficient Change and Innovation Spread in Input-Output Models. Working Papers in Input-Output Economics 09-003. The International Input-Output Association,

Hewings GJD, Sonis M, Jensen RC (1988) Fields of Influence of Technological Change in Input-Output Models. Papers in Regional Science 64 (1):25-36. doi:10.1111/j.1435-5597.1988.tb01112.x

Hirschman AO (1958) The Strategy of Economic Development. Yale University Press, New Haven

Hobday M (2013) Learning from Asia's Success: Beyond Simplistic 'Lesson-Making'. In: Szirmai A, Naudé W, Alcorta L (eds) Pathways to Industrialization in the Twenty-First

Century: New Challenges and Emerging Paradigms. WIDER Studies in Development Economics. Oxford University Press, Oxford,

Hogan W, Sturzenegger F (eds) (2010) The Natural Resources Trap: Private Investment without Public Commitment. The MIT Press, Cambridge-London

Hortiwise, FlowerWatch BV (2012) A Study on the Kenyan-Dutch Horticultural Supply Chain. The Dutch Ministry of Economic Affairs, Agriculture & Innovation The Hague

Huggins C (2010) Land, power and identity: Roots of violent conflict in Eastern DRC. International Alert, United Kingdom doi:http://www.international-alert.org/sites/default/files/DRC_LandPowerIdentity_EN_2010.pdf

Hugon P (1985) Le miroir sans tain. Dépendance alimentaire et urbanisation en Afrique: un essai d'analyse mésodynamique en termes de filières. In: Altersial, CERED, M.S.A (eds) Nourrir les villes: En Afrique sub-saharienne. L'Harmattan, Paris, pp 9-46

Hummels D (2007) Transportation Costs and International Trade in the Second Era of Globalization. Journal of Economic Perspectives 21 (3):131-154. doi:doi: 10.1257/jep.21.3.131

Hummels D, Ishii J, Yi K-M (2001) The nature and growth of vertical specialization in world trade. J Int Econ 54 (1):75-96. doi:http://dx.doi.org/10.1016/S0022-1996(00)00093-3

Ianchovichina E, Loening J, Wood C (2012) How Vulnerable are Arab Countries to Global Food Price Shocks? Policy Research Working Paper No. 6018. The World Bank, Washington, DC

IDE-JETRO, World Trade Organization (2011) Trade patterns and global value chains in East Asia: From trade in goods to trade in tasks. World Trade Organization, Geneva

Ifejirika CA, Arene CJ, Mkpado M (2013) Price Transmission and Integration of Rural and Urban Rice Markets in Nigeria. Journal of Agriculture and Sustainability 3 (1):66-85

Imbs J, Mumta H, Ravn M, Rey H (2003) Non-Linearities and Real Exchange Rate Dynamics.

Journal of the European Economic Association 1 (2-3):639-649

Imbs J, Wacziarg R (2003) Stages of Diversification. American Economic Review 93 (1):63-86. doi:doi: 10.1257/000282803321455160

IMF (2014) Primary Commodity Prices Database. Washington, DC

INS (2008) Les Travaux de Comptabilité Nationale en République Démocratique du Congo. Institut National de la Statistique, Kinshasa

Irz X, Lin L, Thirtle C, Wiggins S (2001) Agricultural Productivity Growth and Poverty Alleviation. Development Policy Review 19 (4):449-466. doi:10.1111/1467-7679.00144

Isham J, Woolcock M, Pritchett L, Busby G (2005) The Varieties of Resource Experience: Natural Resource Export Structures and the Political Economy of Economic Growth. The World Bank Economic Review 19 (2):141–174

Ismet M, Barkley AP, Llewelyn RV (1998) Government intervention and market integration in Indonesian rice markets. Agr Econ 19 (3):283-295

Jensen R (2007) The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector. The Quarterly Journal of Economics 122 (3):879-924. doi:10.1162/qjec.122.3.879

Johansen S (1988) Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control 12 (2–3):231-254. doi:http://dx.doi.org/10.1016/0165-1889(88)90041-3

Johansen S, Juselius K (1990) MAXIMUM LIKELIHOOD ESTIMATION AND INFERENCE ON COINTEGRATION — WITH APPLICATIONS TO THE DEMAND FOR MONEY. Oxford B Econ Stat 52 (2):169-210. doi:10.1111/j.1468-0084.1990.mp52002003.x

Johansen S, Mosconi R, Nielsen B (2000) Cointegration analysis in the presence of structural breaks in the deterministic trend. Econometrics Journal 3 (2):216-249.

doi:10.1111/1368-423X.00047

Jones WO (1972) Marketing Staple Food Crops in Tropical Africa. Cornell University Press, London

Kakwani N (2000) On measuring growth and inequality components of poverty with application to Thailand. Journal of Quantitative Economics 16 (1):67–80

Kakwani N, Khandker S, Son HH (2003) Poverty Equivalent Growth Rate: With Applications to Korea and Thailand. Technical report. Economic Commission for Africa,

Kakwani N, Pernia EM (2000) What is Pro-poor Growth? Asian Development Review 18 (1):1-16

Kamiantako M (1993) The Impact of Stabilization and Structural Adjustment Policies (SSAPs) in Zaire : Analysis within a Social Accounting Matrix Framework. Visiting Research Fellow Series n°221. Institute of Developing Economies, Tokyo

Kaplinsky R, Morris M (2008) Do the Asian Drivers Undermine Export-oriented Industrialization in SSA? World Development 36 (2):254-273. doi:http://dx.doi.org/10.1016/j.worlddev.2007.06.007

Kuiper WE, Lutz C, van Tilburg A (2003) Vertical price leadership on local maize markets in Benin. J Dev Econ 71 (2):417-433. doi:http://dx.doi.org/10.1016/S0304-3878(03)00035-X

Lambert PJ, Aronson JR (1993) Inequality Decomposition Analysis and the Gini Coefficient Revisited. The Economic Journal 103 (420):1221-1227. doi:10.2307/2234247

Lambert PJ, Decoster A (2005) The Gini Coefficient Reveals More. Discussions Paper Series (DPS) 05.08. Center for Economic Studies

Lecoutere E, Vlassenroot K, Raeymaekers T (2009) Conflicts, International changes and food insecurity in eastern D. R. Congo. Afrika focus 22 (2):41-63

Lederman D, Maloney WF (eds) (2007) Natural Resources : Neither Curse nor Destiny. The World Bank, Washington, DC

Lele U (1972) Food Marketing in India: Private Performance and Public Policy Cornell University Press, Ithaca, N.Y.

Lin JY, Treichel V (2012) Learning from China's Rise to Escape the Middle-Income Trap: A New Structural Economics Approach to Latin America. Policy Research Working Paper No. 6165. The World Bank, Development Economics Vice Presediency, Washington, DC

Lloyd TA, McCorriston S, Morgan CW, Rayner AJ (2006) Food scares, market power and price transmission: the UK BSE crisis. Eur Rev Agric Econ 33 (2):119-147

Lo D, Wu M (2014) The State and industrial policy in Chinese economic development. In: Salazar-Xirinachs JM, Nübler I, Kozul-Wright R (eds) Transforming economies: Making industrial policy work for growth, jobs and development. International Labour Office, Geneva,

Loayza NV, Raddatz C (2010) The composition of growth matters for poverty alleviation. J Dev Econ 93 (1):137-151

Löfgren H, Harris R, Robinson S (2002) A Standard Computable General Equilibrium (CGE) Model in GAMS Micro Computers in Policy Research No. 5. International Food Policy research Institute, Washington DC

Long C (2011) Land Rights in the Democratic Republic of Congo: a new model of rights for forest-dependent communities? . In: Helliker K, Murisa T (eds) Land Struggles and Civil Society in Southern Africa. Africa World Press, New Jersey,

Los B, Timmer MP, Vries GJd (2013) Globalization or Regionalization? A New Approach to Measure International Fragmentation of Value Chains. GGDC RESEARCH MEMORANDUM No. 138. Groningen growth and development centre, University of groningen,

Magnac T (1991a) Segmented or Competitive Labor Markets. Econometrica 59 (1):165-187. doi:10.2307/2938245

Magnac T (1991b) Segmented or Competitive Labor Markets? Econometrica 59:165–187

Manyika J, Sinclair J, Dobbs R, Strube G, Rassey L, Mischke J, Remes J, Roxburgh C, George K, O'Halloran D, Ramaswamy S (2012) Manufacturing the future: The next era of global growth and innovation. The McKinsey Global Institute,

Matsuyama K (1992) Agricultural Productivity, Comparative Advantage, and Economic Growth. Journal of Economic Theory 58:317–334

McMillan M, Headey D (2014) Introduction – Understanding Structural Transformation in Africa. World Development 63 (0):1-10. doi:http://dx.doi.org/10.1016/j.worlddev.2014.02.007

McMillan M, Rodrik D, Verduzco-Gallo Í (2014) Globalization, Structural Change, and Productivity Growth, with an Update on Africa. World Development 63 (0):11-32. doi:http://dx.doi.org/10.1016/j.worlddev.2013.10.012

McMillan MS, Harttgen K (2014) What is driving the 'African Growth Miracle'? National Bureau of Economic Research Working Paper Series No. 20077. doi:10.3386/w20077

McMillan MS, Rodrik D (2011) Globalization, Structural Change and Productivity Growth. National Bureau of Economic Research Working Paper Series No. 17143. doi:10.3386/w17143

Mengel C, Cramon-Taubadel Sv (2014) Distance and border effects on price transmission: A meta-analysis. Global Food Discussion Papers No. 37. University of Göttingen, Germany

Meyer J (2004) Measuring market integration in the presence of transaction costs—a threshold vector error correction approach. Agr Econ 31 (2–3):327-334. doi:http://dx.doi.org/10.1016/j.agecon.2004.09.017

Meyer J, von Cramon-Taubadel S (2004) Asymmetric Price Transmission: A Survey. J Agr Econ 55 (3):581-611. doi:10.1111/j.1477-9552.2004.tb00116.x

Minot N (2011) Transmission of World Food Price Changes to Markets in Sub-Saharan Africa.

IFPRI Discussion Paper No. 01059. International Food Policy Research Institute, Washington, DC

Minten B, Kyle S (2000) Retail margins, price transmission and price asymmetry in urban food markets: the case of Kinshasa (Zaire). J Afr Econ 9 (1):1-23. doi:10.1093/jae/9.1.1

Mishra S, Lundstrom S, Anand R (2011) Service Export Sophistication and Economic Growth. Policy research working paper No. 5606. The World Bank, Washington, DC

Mookherjee D, Shorrocks A (1982) A Decomposition Analysis of the Trend in UK Income Inequality. The Economic Journal 92 (368):886-902. doi:10.2307/2232673

Morris M, Kelly V, Kopicki RJ, Byerlee D (2007) Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines. The World Bank, Washington, DC

Moustier P, Leplaideur A (1999) Cadre d'analyse des acteurs du commerce vivrier africain. Urbanisation, alimentation et filières vivrières. CIRAD, Montpellier

Mumvwela CM (2004) Le développement local au Kwango-Kwilu (RD Congo). Publications Universitaires Europeennes / Sér. 29 ; 18 Peter Lang Publishing, Bern

Mutambatsere E, Mabaya ET, Christy RD (2007) Integration and Equilibrium in the Maize Markets in Southern Africa. Paper presented at the Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Portland, OR, July 29 – August 1, 2007,

Naudé W, Rossouw R (2008) Export Diversification and Specialization in South Africa: Extent and Impact. WIDER Research Paper No. 2008/93. UNU-WIDER, Helskinki

Naudé W, Rossouw R (2011) Export diversification and economic performance: evidence from Brazil, China, India and South Africa. Econ Change Restruct 44 (1-2):99-134

Ngai R, Pissarides C (2007) Structural Change in a Multi-Sector Model of Growth. American Economic Review 97 (1):429–443

Nhate V, Massingarela C, Salvucci V (2013) The political economy of food price policy:

Country case study of Mozambique. WIDER Working Paper No. 2013/037. UNU-WIDER, World Institute for Development Economic Research (UNU-WIDER)

Nübler I (2014) A theory of capabilities for productive transformation: Learning to catch up. In: Salazar-Xirinachs JM, Nübler I, Kozul-Wright R (eds) Transforming economies: Making industrial policy work for growth, jobs and development. International Labour Office, Geneva,

Nweke FI, Lutete D, Dixon AGO, Ugwu BO, Ajobo O, Kalombo N, Bukaka B (2000) Cassava production and processing in the Democratic Republic of Congo. . Collaborative Study in Africa Working Paper No. 22. International Institute of Tropical Agriculture, Ibadan

OECD (2012) Agricultural Policies for Poverty Reduction. OECD Publishing. doi:http://dx.doi.org/10.1787/9789264112902-en

OECD (2013) Perspectives on Global Development 2013: Industrial Policies in a Changing World. OECD Publishing, Paris

Otchia C (2013) How could Industrial Structure Guide the Choice of Development Strategy? A Field of Influence Analysis for the Democratic Republic of Congo. The International Journal of Economic Policy Studies 8 89-112

Owens T, Wood A (1997) Export-oriented industrialization through primary processing? World Development 25 (9):1453-1470. doi:http://dx.doi.org/10.1016/S0305-750X(97)00042-9

Page J (2012) Can Africa Industrialise? J Afr Econ 21 (suppl 2):86-124. doi:10.1093/jae/ejr045

Palaskas TB, Harriss‐white B (1993) Testing market integration: New approaches with case material from the West Bengal food economy. The Journal of Development Studies 30 (1):1-57. doi:10.1080/00220389308422304

Park A, Jin H, Rozelle S, Huang J (2002) Market Emergence and Transition: Arbitrage,

Transaction Costs, and Autarky in China's Grain Markets. Am J Agr Econ 84 (1):67-82. doi:10.1111/1467-8276.00243

Perron P (2006) Dealing with structural breaks. In: Patterson K, Mills TC (eds) Palgrave Handbook of Econometrics vol 1: Econometric Theory. Palgrave Macmillan, United Kingdom, pp 278–352

Phillips PCB, Perron P (1988) Testing for a unit root in time series regression. Biometrika 75 (2):335-346. doi:10.1093/biomet/75.2.335

Porter M, Sachs J, McArthur J (2002) Executive summary: Competitiveness and stages of economic development. In: Porter M, Sachs J, P. K. Cornelius, McArthur JW, Schwab K (eds) The global competitiveness report 2001–2002. Oxford University Press, New York, pp pp. 16–25

Porter ME (1990) The competitive advantage of nations. Macmillan, New York

Porto GG (2006) Using survey data to assess the distributional effects of trade policy. J Int Econ 70 (1):140-160. doi:http://dx.doi.org/10.1016/j.jinteco.2005.09.003

Pyatt G, Round JI (1985) Social Accounting Matrices : A Basis for Planning. The World Bank, Washington D.C.

Rapsomanikis G, Hallam D, Conforti P (2006) Market Integration and Price Transmission in Selected Food and Cash Crop Markets of Developing Countries: Review and Applications In: Sarris A, Hallam D (eds) Agricultural Commodity Markets And Trade: New Approaches to Analyzing Market Structure And Instability. Edward Elgar Publishing, United Kingdom,

Rapsomanikis G, Mugera H (2011) Price Transmission and Volatility Spillovers in Food Markets of Developing Countries. In: Piot-Lepetit I, M'Barek R (eds) Methods to Analyse Agricultural Commodity Price Volatility. Springer New York, pp 165-179. doi:10.1007/978-1-4419-7634-5_10

Rashid S, Minot N (2010) Are Staple Food Markets in Africa Efficient? Spatial Price

Analyses and Beyond. Paper presented at the Paper presented at the COMESA policy seminar "Food price variability: Causes, consequences, and Policy Options", 25-26 January 2010, Maputo, Mozambique,

Ravallion M (1986) Testing Market Integration. Am J Agr Econ 68 (1):102-109. doi:10.2307/1241654

Ravallion M (1997) Can high inequality developing countries escape absolute poverty? Econ Lett 56 51–57

Ravallion M, Chen S (2003a) Measuring pro-poor growth. Economics Letters (Netherlands) 78, No. 1:[93]-99

Ravallion M, Chen S (2003b) Measuring pro-poor growth. 78 (1):93–99

Ravallion M, Lokshin M (2008) Winners and Losers from Trade Reform in Morocco. In: Bourguignon F, Bussolo M, Pereira da Silva L (eds) The impact of macroeconomic policies on poverty and income distribution : macro-micro evaluation techniques and tools. World Bank and Palgrave, Washington, DC, pp 27-60

Richardson JD (1978) Some empirical evidence on commodity arbitrage and the law of one price. J Int Econ 8 (2):341-351. doi:http://dx.doi.org/10.1016/0022-1996(78)90027-2

Robinson S, El-Said M (2000) GAMS Code for Estimating a Social Accounting Matrix (SAM) using Cross Entropy (CE) Methods. IFPRI Discussion Paper 64. IFPRI, Washington D.C.

Sachs JD, Warner A (1995a) Economic Reform and the Process of Global Integration. Brookings Pap Eco Ac 1995 (1):1-118. doi:10.2307/2534573

Sachs JD, Warner AM (1995b) Natural Resource Abundance and Economic Growth. Working Paper No. 5398. National Bureau of Economic Research,

Sachs JD, Warner AM (2001) The curse of natural resources. Eur Econ Rev 45 (4-6):827-838

Salazar-Xirinachs JM, Nübler I, Kozul-Wright R (eds) (2014) Transforming economies: Making industrial policy work for growth, jobs and development. International Labour

Office, Geneva

Sanjuán AI, Dawson PJ (2003) Price transmission, BSE and structural breaks in the UK meat sector. Eur Rev Agric Econ 30 (2):155-172. doi:10.1093/erae/30.2.155

Santos S (2006) Constructing a Database for Economic Modelling from the System of National Accounts: a Social Accounting Matrix for Portugal. Ecomod 2006 Conference Paper Ecomod, Hong Kong, China

Savard L (2003) Poverty and income distribution in a CGE-household micro-simulation model: Top/dowm/bottom-up approach. Cahiers de recherche 0343. CIRPEE,

Sephton PS (2003) Spatial Market Arbitrage and Threshold Cointegration. Am J Agr Econ 85 (4):1041-1046. doi:10.1111/1467-8276.00506

Sexton RJ, Kling CL, Carman HF (1991) Market Integration, Efficiency of Arbitrage, and Imperfect Competition: Methodology and Application to U.S. Celery. Am J Agr Econ 73 (3):568-580. doi:10.2307/1242810

Smale M (1995) "Maize is life": Malawi's delayed Green Revolution. World Development 23 (5):819-831. doi:http://dx.doi.org/10.1016/0305-750X(95)00013-3

Sonis M, Guilhoto J, Hewings GJD, Martins EB (1995) Linkages, Key Sectors, and Structural Change: Some New Perspectives. The Developing Economies XXXIII (3):233-270

Sonis M, Hewings GJD (1989) Errors and sensitivity in inputoutput analysis: new approach. In: R. Miller, Polenske K, Rose A (eds) Frontiers in input-output analysis. Oxford University Press, New York,

Sonis M, Hewings J (1992) Coefficient Change in Input–Output Models: Theory and Applications. Economic Systems Research 4 (2):143-158. doi:10.1080/09535319200000013

Sonis M, Hewings J, Guo J (2000) A New Image of Classical Key Sector Analysis: Minimum Information Decomposition of the Leontief Inverse Economic Systems Research 123:401-423

Spiller PT, Wood RO (1988) The estimation of transactions costs in arbitrage models. J Econometrics 39:309-326

Steel WF, Snodgrass D (2008) World Bank Region Analysis on the Informal Economy. In: Raising Productivity and Reducing Risk of Household Enterprises. Annex 1, "Diagnostic Methodology Framework.". World Bank, Washington, DC,

Stephens EC, Mabaya E, Cramon-Taubadel Sv, Barrett CB (2012) Spatial Price Adjustment with and without Trade*. Oxford B Econ Stat 74 (3):453-469. doi:10.1111/j.1468-0084.2011.00651.x

Syrquin M (1989) Patterns of Structural Change. In: H. Chenery, Srinavasan TN (eds) Handbook of Economic Development. Elsevier Science Publishers, Amsterdam,

The World Bank (2013) Enterprise Surveys. The World Bank, Washigton, DC

World Development Indicators (2014).

The World Bank Group (2011) Growth and productivity in agriculture and agribusiness : evaluative lessons from World Bank Group experience. Washington, DC

Thirtle C, Lin L, Piesse J (2003) The Impact of Research-Led Agricultural Productivity Growth on Poverty Reduction in Africa, Asia and Latin America. World Development 31 (12):1959–1976

Thirtle C, Townsend R, van Zyl J (1998) Testing the induced innovation hypothesis: an error correction model of South African agriculture. Agr Econ 19 (1–2):145-157. doi:http://dx.doi.org/10.1016/S0169-5150(98)00030-9

Timmer CP (1987) Corn Marketing. In: Timmer CP (ed) The Corn Economy of Indonesia Cornell University Press, Ithaca, pp 201-234

Timmer CP (1996) Liberalized Agricultural Markets in Low-Income Economies: Discussion. Am J Agr Econ 78 (3):830-832. doi:10.2307/1243314

Timmer P (1997) How well do the poor connect to the growth process? Mimeo, University of California, San Diego

Trenkler C, Wolf N (2005) Economic integration across borders: The Polish interwar economy 1921 borde. European Review of Economic History 9:199-231

UNCTAD (2013a) Least Developed Countries Report 2013: Growth with employment for inclusive and sustainable development. United Nations Publications, New York and Geneva

UNCTAD (2013b) World Investment Report 2013: Global Value Chains: Investment and Trade for Development. UNCTAD, Switzerland

UNCTAD (2014) UNCTADSTATS. Yearly. UNCTAD, Switzerland

UNECA (1984) An Aggregate Social Accounting Matrix (SAM) for Zaire, 1980: A Preliminary Report. E/ECA/PSD.3/16. UNECA, Addis Ababa

UNECA (2013) Making the Most of Africa's Commodities: Industrializing for Growth, Jobs and Economic Transformation. Economic Report on Africa. Economic Commission for Africa, Addis Ababa

UNIDO (2013) Sustaining Employment Growth: The Role of Manufacturing and Structural Change. Industrial Development Report 2013. UNIDO, Vienna

United Nations (1993) System of National Accounts. United Nations, New York

Commodity Trade Statistics Database (COMTRADE) (2014) http://comtrade.un.org/db/default.aspx.

Varela G, Aldaz-Carroll E, Iacovone L (2012) Determinants of Market Integration and Price Transmission in Indonesia. Policy Research Working Paper No. 6098. The World Bank - East Asia and Pacific Region,

Vavra P, Goodwin BK (2005) Analysis of Price Transmission Along the Food Chain. OECD Food, Agriculture and Fisheries Working Papers No. 3. OECD Publishing. doi:10.1787/752335872456

Versailles B (2012) Market Integration and Border Effects in Eastern Africa. Centre for the Study of African Economies Working Paper 2012-01. University of Oxford Oxford

Vlassenroot K, Huggins C (2005) Land, migration and conflict in eastern DRC. In: Huggins C, Clover J (eds) From the Ground Up: Land Rights, Conflict and Peace in Sub-Saharan Africa. Institute for Security Studies, Pretoria, pp 115–194

Vlassenroot K, Raeymaekers T (eds) (2004) Conflict and social transformation in Eastern DR Congo. Academia Press, Ghent

Weldegebriel HT (2004) Imperfect Price Transmission: Is Market Power Really to Blame? J Agr Econ 55 (1):101-114. doi:10.1111/j.1477-9552.2004.tb00082.x

Wilshaw R (ed) (2013) Exploring the Links between International Business and Poverty Reduction: Bouquets and Beans from Kenya. Oxfam and International Procurement & Logistics Ltd,

World Bank (2000) World Development Report: Attacking Poverty. Oxford University Press, New York

World Bank (2007) Agriculture for Development: World Development Report 2008. World Bank, Washington, DC

Zivot E, Andrews D (1992) Further Evidence of Great Crash, the Oil Price Shock and Unit Root Hypothesis. Journal of Business and Economic Statistics 10 (3):251-270

Zoltan JA, Desai S, Hessels J (2008) Entrepreneurship, economic development and institutions. Small Bus Econ 31 (3):219-234. doi:10.1007/s11187-008-9135-9

APPENDIX

Appendix 1: List of equations

Indices			
a	Activities	c	Commodities
f	Factors (labor and capital)	h	Households
Exogenous parameters (Greek characters)			
α^{ac}	Domestic goods aggregation function shift parameter	δ^{ac}	Domestic goods aggregation function share parameter
α^{p}	Production function efficiency parameter	δ^{p}	Production function share parameter
α^{q}	Import function shift parameter	δ^{q}	Import function share parameter
α^{t}	Export function shift parameter	δ^{t}	Export function share parameter
β^{h}	Household marginal budget share for home products	ρ^{ac}	Domestic goods aggregation function exponent
β^{m}	Household marginal budget share for marketed goods	ρ^{p}	Production function substitution elasticity
γ^{h}	Subsistence consumption for home commodity	ρ^{q}	Import function substitution elasticity
γ^{m}	Subsistence consumption for marketed commodity	ρ^{t}	Export function substitution elasticity
θ_{ac}	Yield of output *c* per unit of activity *a*		
Exogenous parameters (Latin characters)			
ca	Intermediate input coefficients	$qgov$	Base government consumption quantity
cd	Domestic transaction cost coefficients	$qinv$	Base investment demand quantity
ce	Export transaction cost coefficients	sh	Marginal propensity to save
ci	Capital price index weights	$shif_{hf}$	Factor income distribution shares
cm	Import transaction cost coefficients	ta	Activity tax rate
cpi	Consumer price index	te	Export tax
cw	Consumer price index weights	tf	Factor direct tax rate
fpr	Productivity of factor in activity	th	Personal direct tax rate
ga	Government consumption adjustment factor	tm	Import tariff rate
gh	Per capita transfer from government	tq	Sales tax rate
$inta$	Quantity of aggregate intermediate input per activity unit	wh	Net transfer from rest of world
iva	Quantity of value added per activity unit		
Endogenous variables			
FS	Fiscal surplus (deficit)	QH	Household consumption quantity
PA	Activity output price	QI	Investment demand quantity
PD	Domestic supply price with margin	QK	New capital stock quantity
PE	Export price	QM	Import quantity
PM	Import price	QN	Aggregate intermediate input quantity
PN	Aggregate intermediate input price	QQ	Composite supply quantity
PQ	Composite supply price	QT	Transaction cost demand quantity
PS	Domestic supply price without margin	QV	Composite value-added quantity
PV	Composite value-added price	WF	Economy-wide factor return
QA	Activity output quantity	YF	Total factor income
QD	Domestic supply quantity	YG	Total government revenues
QE	Export quantity	YH	Total household income
QF	Factor demand quantity	X	Exchange rate
QG	Government consumption quantity		
Exogenous variables			
DPI	Domestic producer price index	IA	Investment demand adjustment factor
$FSAV$	Foreign savings	QFS	Total factor supply
$GADJ$	Government consumption adjustment factor	WD	Sector distortion in factor return

Production and price

$$QINT_{ca} = ca_{ca} \cdot PN_a \quad (1)$$

$$PN_a = \sum_c PQ_c \cdot ca_{ca} \quad (2)$$

$$QV_a = \alpha_a^p \cdot \sum_f \left(\delta_{fa}^p \cdot fpr_{fa} \cdot QF_{fa}^{-\rho_a^p}\right)^{-1/\rho_a^p} \quad (3)$$

$$WF_f \cdot WD_{fa} = PV_a \cdot QV_a \cdot \sum_f \left(\delta_{fa}^p \cdot fpr_{fa} \cdot QF_{fa}^{-\rho_a^p}\right)^{-1} \cdot \delta_{fa}^p \cdot fpr_{fa}{}^{-\rho_a^p} \cdot QF_{fa}^{-\rho_a^p-1} \quad 4$$

$$QV_a = iva \cdot QA_a \quad 5$$

$$QN_{ca} = inta \cdot QA_a \quad 6$$

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PV_a \cdot QV_a + PN_a \cdot QN_a \quad 7$$

$$QXAC_{ac} = \theta_{ac} \cdot QA_a \quad 8$$

$$PA_a = \sum_c PXAC_{ac} \cdot \theta_{ac} \quad 9$$

$$QXAC_{ac} + \sum_h QHA_{ach} = \theta_{ac} \cdot QA_a \quad 10$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_a \delta_{ac}^{ac} \cdot QXAC_{ac}{}^{-\rho_c^{ac}}\right)^{-\frac{1}{\rho_c^{ac}-1}} \quad 11$$

$$\frac{PXAC_{a\,c}}{PX_c} = PX_c * QX_c \left(\sum_a \delta_{ac}^{ac} \cdot QXAC_{ac}{}^{-\rho_c^{ac}}\right)^{-1} * \delta_{a\,c}^{ac} * QXAC_{a\,c}^{-\rho_c^{ac}-1} \quad 12$$

$$QX_c = \alpha_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t}\right)^{1/\rho_c^t} \quad 13$$

$$PE_c = pwe_c \cdot (1 - te_c) \cdot X - \sum_c PQ_c \cdot ce_{cc} \quad 14$$

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PS_c} \cdot \frac{(1 - \delta_c^t)}{\delta_c^t}\right)^{1/(\rho_c^t-1)} \quad 15$$

$$PX_c \cdot QX_c = PS_c \cdot QD_c + PE_c \cdot QE_c \quad 16$$

$$PD_c = PS_c + \sum_c PQ_c \cdot cd_{cc} \quad 17$$

$$PM_c = pwm_c \cdot (1 + tm_c) \cdot X + \sum_c PQ_c \cdot cm_{cc} \quad 18$$

$$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + \left(1 - \delta_c^q\right) \cdot QD_c^{-\rho_c^q}\right)^{-1/\rho_c^t} \quad 19$$

$$\frac{QM_c}{QD_c} = \left(\frac{PD_c}{PM_c} \cdot \frac{\left(1 - \delta_c^q\right)}{\delta_c^q}\right)^{1/(1+\rho_c^q)} \quad 20$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PD_c \cdot QD_c + PM_c \cdot QM_c \quad 21$$

$$QT_c = \sum_c (cd_{cc} \cdot QD_c + cm_{cc} \cdot QM_c + ce_{cc} \cdot QE_c) \quad 22$$

$$CPI = \sum_c cw_c \cdot PQ_c \quad 23$$

Incomes and domestic demand

$$YF_f = \sum_c WF_f \cdot WD_{fa} \cdot QF_{fa} \quad (24)$$

$$YH_h = \sum_f shif_{hf} \cdot (1 - tf_f) \cdot (1 - rf_f) \cdot YF_f + gh_h \cdot cpi + wh_h \cdot X \quad (25)$$

$$QH_{c\,h} = \gamma^{m}_{c\ \ h} + \frac{\beta^{m}_{c\,h} * \left(EH_h - \sum_c PQ_c * \gamma^{m}_{c\,h} - \sum_a \sum_c PXAC_{a\,c} * \gamma^{h}_{a\,c\ \ h}\right)}{PQ_c} \quad (26)$$

$$QHA_{a\,c\,h} = \gamma^{h}_{a\,c\,h} + \frac{\beta^{h}_{a\,c\,h} * \left(EH_h - \sum_c PQ_c * \gamma^{m}_{c\,h} - \sum_a \sum_c PXAC_{a\,c} * \gamma^{h}_{a\,c\ \ h}\right)}{PXAC_{a\,h}} \quad (27)$$

$$QI_c = IA \cdot qinv_c \quad (28)$$

$$QG_c = GA \cdot qgov_c \quad (29)$$

$$YG = \sum_h th_h \cdot YH_h + \sum_f tf_f \cdot YF_f + \sum_c (ta_a \cdot QA_a \cdot PA_a) + \sum_c (tm_c \cdot pwm_c \cdot QM_c \cdot X + te_c \cdot PE_c \cdot QE_c + tq_c \cdot PQ_c \cdot QQ_c) + gh_h + gh_{row} \cdot X \quad (30)$$

Equilibrium conditions

$$\sum_a QF_{fa} = QFS_f \quad (31)$$

$$QQ_{ct} = \sum_a QINT_{ca} + \sum_h QH_{ch} + QG_c + QI_c + QT_c \quad (32)$$

$$\sum_c pwm_c \cdot QM_c = \sum_c pwe_c \cdot QE_c + \sum_h wh_h + FSAV \quad (33)$$

$$YG = \sum_c PQ_f \cdot QG_c + gh \cdot cpi + FS \quad (34)$$

$$\sum_h sh_h \cdot (1 - th_h) \cdot YH_h + FS + FSAV \cdot X = \sum_c PQ_c \cdot QI_c \quad (35)$$

$$DPI = \sum_c dw_c \cdot PS_c \quad (36)$$

Appendix 2: Tools for agricultural modernization

Pre-harvesting			Operations		Tools	
					Traditional	**Modern**
			Land clearing	Chopping and destumping	Cutlass and machete	
Obtain physical space for cultivation			Land development		Hoe, spade, basket, and wheelbarrow	Tractor & blades (cutting blade, piling blade, etc)
Improve soil quality	By forms of soil		Land preparation	Tillage	Hoe	Plow
				Harrowing	Hoe	Harrow
				Hilling, ridging, mound making	Hoe	Tractor/animal attachment ridger
	By adding/removing various components	Nutrient	Soil amendment		Hand broadcasting and cutlass	Motor knapsack sprayers
		Water	Irrigation		Water can	Irrigation pump
		Pest	Remove pest by chemicals		Hand sprayer	Motor knapsack sprayers
		Weed	Weeding		Hoe and cutlass	Weeder
Plant seed, seed stick		Seed and seed stick	Sowing		Hand broadcasting and cutlass	Seed planter and Cultivators
Harvesting and Post-harvesting						
Harvesting			Harvesting		Sickles, scythe, cutlass, and lifter (cassava)	Reaper and tractor
Value-addition ***with*** physical transformation of materials	Separate edible parts from others		Threshing and, winnowing		Thumping by draft animals	Tractor and threshing machine
			Dehulling		Mortar, pestle	Huller
			Peeling		Kitchen knives, water	Peeling machine
			Extraction (oil)			Oil pressing machine
	Preservation and storage		Drying and storage		Mats and racks	Artificial drier
	Attract demand from consumers		Milling, grating, grinding, and pounding		Traditional grater, mortar, and pestle	Grater and milling machine
			Various (soaking, boiling, roasting, pressing, steaming, frying fermentation)		Sacks, fuel woods, iron	
					pan, earthen pots, water, fryer, stones or tied wooden frames (pressing)	Hydraulic jack press (pressing)
Value-addition without physical transformation of materials	Attract demand from		Sorting, grading, packing, assembling		Hand sorting, grading	Sorter and grader
	Change of locations		Transportation		Head loading, pushcart and wheelbarrow	Draft animals and truck

Appendix 3: Labor market model

	Rural	Urban	Urban	Urban
Age	0.0224***	-0.0149***	-0.0170***	-0.0224***
	(0.00568)	(0.00571)	(0.00582)	(0.00568)
Age square	-0.000376***	0.000278***	0.000313***	0.000376***
	(6.01e-05)	(6.08e-05)	(6.18e-05)	(6.01e-05)
Male	0.524***	-0.497***	-0.536***	-0.524***
	(0.0461)	(0.0443)	(0.0463)	(0.0461)
Education (year)	-0.137***	0.119***	0.139***	0.137***
	(0.00385)	(0.00370)	(0.00392)	(0.00385)
Married	0.238***	-0.240***	-0.238***	-0.238***
	(0.0372)	(0.0360)	(0.0372)	(0.0372)
Household size	-0.0194***	0.0193***	0.0196***	0.0194***
	(0.00485)	(0.00473)	(0.00485)	(0.00485)
Other income	-5.58e-06***	1.25e-05***	9.54e-06***	5.58e-06***
	(1.43e-06)	(1.38e-06)	(1.45e-06)	(1.43e-06)
Constant	0.383***	-0.406***	-0.499***	-0.383***
	(0.126)	(0.125)	(0.128)	(0.126)
	Employed	Informal	Formal	Unemployed
Age	-0.0727***	0.00538	0.0563***	-0.0727***
	(0.00707)	(0.00598)	(0.00888)	(0.00707)
Age square	0.000908***	-8.16e-05	-0.000420***	0.000908***
	(7.14e-05)	(6.37e-05)	(9.29e-05)	(7.14e-05)
Male	-0.437***	-0.361***	0.135*	-0.437***
	(0.0576)	(0.0444)	(0.0706)	(0.0576)
Education (year)	0.0535***	0.0329***	0.178***	0.0535***
	(0.00507)	(0.00364)	(0.00512)	(0.00507)
Married	-0.203***	-0.135***	-0.0844*	-0.203***
	(0.0497)	(0.0369)	(0.0512)	(0.0497)
Household size	0.00425	0.0142***	0.00577	0.00425
	(0.00680)	(0.00491)	(0.00622)	(0.00680)
Other income	3.40e-06***	-1.45e-06**	6.13e-07	3.40e-06***
	(5.98e-07)	(6.94e-07)	(7.34e-07)	(5.98e-07)
Constant	-0.0868	-0.620***	-4.401***	-0.0868
	(0.161)	(0.130)	(0.205)	(0.161)
athrho	-1.814***	2.489***	2.683	1.814***
	(0.294)	(0.102)	(25.35)	(0.294)
Observations	10,418	10,418	10,418	10,419

Appendix 4: Sensitivity analysis for diversification (Chapter 5)

	Elasticities of productivity with respect to diversification		
	diver = -2.048	*diver* = -2.121	*diver* = -1.113
Gross domestic product	4.14	3.99	7.74
Absorption	4.07	3.93	7.61
Private consumption	4.74	4.57	8.85
Investment	0.56	0.54	1.05
Government consumption	1.17	1.12	2.35
Exports	1.78	1.71	3.35
Imports	1.66	1.60	3.12
Exchange rate	1.66	1.60	3.06
Urban formal	4.27	4.17	6.89
Urban informal	5.63	5.51	8.78
Rural	2.88	2.80	4.94
Capital	2.70	2.61	4.79
Land	3.24	3.14	5.62