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Empirical and simulation essays on analyzing a country's export performance : the case of Ghana

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EMPIRICAL AND SIMULATION ESSAYS ON ANALYZING A COUNTRY'S EXPORT PERFORMANCE: THE CASE OF GHANA

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LIST OF ABBREVIATIONS

ACDI/VOCA: Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance
ACF: Autocorrelation Function
ADB: Agricultural Development Bank
ADF: Augmented Dickey-Fuller
AFD: *Agence Française de Développement*
AGOA: African Growth and Opportunity Act
AgSSIP: Agricultural Services Sub-Sector Investment Project
AIC: Akaike information Criterion
ARMA: Autoregressive-Moving-Average
BIC: Bayesian Information Criterion
BEC: Bayesian Estimation Criterion
BFGS: Broyden–Fletcher–Goldfarb–Shanno
BoG: Bank of Ghana
BoP: Balance of Payments
CAT: Criterion Autoregressive Transfer function
CSSVDCU: Cocoa Swollen Shoot Virus Disease Control Unit
CEPS: Customs, Excise and Preventive Service (Ghana Revenue Authority)
CMC: Cocoa Marketing Company
Cocobod: Ghana Cocoa Board
CPI: Consumer Price Index
DADU: District Agriculture Development Unit
DF: Degrees of Freedom
DGP: Data Generating Process
DOTS: Direction of Trade Statistics (IMF)
ECOWAS: Economic Community of West African States
EDIF: Export Development and Investment Fund
EPA: Economic Partnership Agreements
EPI: Export Price Index
ERP: Economic Recovery Program
ERS: Elliot, Rothenberg & Stock
Eurep/GlobalGAP: Euro-Retailer Produce Working Group/Global Good Agricultural Practices
FAO: Food and Agriculture Organization
FAS: Foreign Agricultural Service (USDA)
FASDEP: Food and Agriculture Sector Development Policy
FBO: Farmer Based Organizations
FDI: Foreign Direct Investment
Fed: Federal Reserve System
FPE: Final Prediction Error
FRI: Food Research Institute
GARCH: Generalized AutoRegressive Conditional Heteroskedasticity
GDP: Gross Domestic Product
GEPC/GEPA: Ghana Export Promotion Council/ Ghana Export Promotion Authority

GFZB: Ghana Free Zones Board
GHS: Ghana Cedi
GIZ/GTZ: *Deutsche Gesellschaft für Internationale Zusammenarbeit/ Gesellschaft für Technische Zusammenarbeit*
GLS: Generalized Least Squares
GoG: Government of Ghana
H-O: Heckscher–Ohlin
HQ: Hannan-Quinn
IFAD: International Fund for Agricultural Development
IFS: International Financial Statistics (IMF)
iid: independent and identically distributed
IMF: International Monetary Fund
JICA: Japan International Cooperation Agency
KAIC: Keating Akaike Information Criterion
KSBC: Keating Schwarz Bayesian Criterion
LBC: Licensed Buying Company
LM: Lagrange Multiplier
M&E: Monitoring and Evaluation
MA: Moving Average
MWALD: Modified Wald
MCA: Millennium Challenge Account
METASIP: Medium Term Agriculture Sector Investment Plan
METSS: Monitoring, Evaluation, and Technical Support Services
MGARCH: Multivariate Generalized AutoRegressive Conditional Heteroskedasticity
MGARCH-M: Multivariate Generalized AutoRegressive Conditional Heteroskedasticity in Mean
MIC: Modified Information Criterion
MiDA: Millennium Development Authority
MLE: Maximum-Likelihood Estimation
MoFA: Ministry of Food and Agriculture
MoTI: Ministry of Trade and Industry
MPC: Monetary Policy Committee
MSE: Mean squared error
NARP: National Agricultural Research Project
NEER: Nominal Effective Exchange Rate
NGO: Non-Governmental Organization
OECD: Organisation for Economic Co-operation and Development
OLS: Ordinary Least Squares
OPRI: Oil Palm Research Institute
OVCF: Outgrower and Value Chain Fund
PACF: Partial AutoCorrelation Function
PAMPEAG: Papaya and Mango Producers & Exporters Association of Ghana
PBC: Produce Buying Company
PIC: Post Information Criterion
PPI: Producer Price Index

REER: Real Effective Exchange Rate
RTIMP: Root and Tuber Improvement and Marketing Programme
RTIP: Root and Tuber Improvement Programme
SC/SBC: Schwarz (Bayesian) Criterion
SLR: Sim's Likelihood Ratio test
SPEG: Sea-Freight Pineapple Exporters of Ghana
SPU: Seed Production Unit
SWOT: Strengths Weaknesses Opportunities Threats
TOPP: Twifo Oil Palm Plantation Ltd
TWFCPI: Trade-Weighted Foreign Consumer Price Index
TWFGDP: Trade-Weighted Foreign Gross Domestic Product
TYDL: Toda, Yamamoto, Dolado and Lütkepohl
UCC: University of Cape Coast
USAID: United States Agency for International Development
USDA: United States Department of Agriculture
VAR: Vector Autoregressive
VARMA: Vector Autoregressive Moving Average
VECM: Vector Error Correction Model
VEPEAG: The Vegetable Producers and Exporters Association of Ghana
WPI: Wholesale Price Index

ABSTRACT

A large array of literature has revealed the complexity of export performance analysis. Using the case of Ghana, this dissertation, divided into three essays, seeks to provide the methodological guidance, empirical and simulation evidence necessary to analyze a country's export performance. The choice of Ghana was motivated by the country's growth experience, strong export and agricultural sectors and implemented reforms and programs since 1983.

In the first essay, we created a new trade-weighted Cedi index or real effective exchange rate (REER) that takes into account Ghana's most relevant patterns of trade and captures the evolution of Ghana's export price competitiveness overtime. Other factors of export performance have been identified collecting the perspectives of Ghana's agricultural export sector stakeholders and using grounded theory. This research showed that Ghana's export price competitiveness, as depicted by the REER, has improved since 1983 but has revealed many additional factors that played a role in the performance of Ghana's agricultural export sector.

Following export demand theory and the procedure of Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) (TYDL), the second essay estimates causal relationships between exports, the REER and foreign activity over the 1970-2009 period. Two additional models (VAR-GARCH-in-mean) were estimated to investigate the impact of exchange rate volatility on Ghana's exports. The results support the view that some of the implemented macroeconomic reforms have been the cause of Ghana's export performance. Additionally, we found that third-country exchange rate volatility has hampered Ghana's export growth.

The third essay tackles methodological shortcomings of the TYDL procedure. In a Monte Carlo experiment, we compared the Schwarz Bayesian criterion (SBC) and the likelihood ratio (LR) tests in terms of their lag order frequency distributions and the finite sample properties of the resulting modified Wald (MWALD) tests. We found that in general, the SBC selects the true lag length more often than the LR tests and that in large samples the choice of the lag selection method does not influence non-causality tests results. This research also revealed that in the presence of moving average terms or in the case of mixed unit-root processes, MWALD tests perform poorly.

1 INTRODUCTION

1.1 Overview of the Dissertation

The development experience of many developing countries in the fifties, sixties and seventies has led the International Monetary Fund (IMF) as well as other international organizations to intervene providing financial assistance and promoting stabilizing policies and pro-growth economic activities. Ghana, a small country in West Africa, greatly illustrates this circumstance. After years of economic and political unrest materialized *inter alia* by public debt, skyrocketing inflation rates, overvalued national currency (Ghana Cedi) and gross domestic product (GDP) contraction, the IMF launched the economic recovery program (ERP) in Ghana in 1983. The bedrock of this program was market-oriented policies aimed to encourage pro-growth activities such as exports. Thirty years after the inception of this program, Ghana is considered an economic success story in Africa. Two strong pillars of Ghana's economy are its agricultural sector and exports which have seemingly grown due to the implemented reforms and fostered the growth of the country. It is Ghana's experience that motivated this study.

A large body of literature has investigated the causes of a country's export performance, though there is currently little empirical evidence for Ghana. This question is generally assessed in an export demand framework where exports are mainly a function of prices and foreign income. Causal relationships are established carrying out causality tests as suggested by Granger (1969). More recently, the approach to causality testing developed by Toda and Yamamoto (1995); and Dolado and Lütkepohl (1996) (TYDL) has gained popularity. Nevertheless, the current

empirical literature falls short of several important methodological aspects. In fact, the existing trade theories call for complex analytical frameworks that involve a plethora of variables that need to be country as well as sector specific. Because of the lack of data, a thorough analysis of export performance is often difficult in the case of developing countries; in particular when studying the agricultural sector. In addition, the TYDL procedure may present some bottlenecks that had yet to be assessed in order to produce more accurate causality analysis findings.

In this context, this research seeks to analyze Ghana's export performance identifying possible associated factors and characterizing their impact. In particular, the effect on Ghana's exports of some of the macroeconomic reforms implemented since 1983 is evaluated while tackling the role of other factors. Building upon widely used methodological frameworks, new methods and theories are the subject of the three essays of this dissertation in order to provide the empirical and simulation evidence necessary to fully analyze a country's export performance.

The first essay (chapter 2) identifies potential drivers of Ghana's agricultural export performance starting with an analysis of export price competitiveness overtime. A new trade-weighted Cedi index or real effective exchange rate (REER) is proposed in order to depict the most relevant trading patterns of Ghana. This measure is inspired by the Federal Reserve's index (e.g., Loretan, 2005) and adapted to the case of Ghana. It allows directly appreciating the effect of both inflation control and exchange rate realignment on export price competitiveness. An extensive array of theoretical and empirical literature on export performance and competitiveness is reviewed in this essay. It reveals the numerous additional factors that can drive a

country's export performance. Many of those are non-price factors and they are generally disregarded in applied economics studies. A possible explanation for omission is the difficulty in measuring their effects (or metrics). In order to identify those factors we rely on grounded theory (Charmaz, 2006) and analyze the perceptions of Ghana's agricultural export sector stakeholders, collected in Ghana in 2011.

The second essay (chapter 3) builds upon the first as it uses the constructed REER and estimates its causal effect as well as that of foreign activity on Ghana's export performance. This analysis relies on export demand theory and follows the TYDL procedure which consists in estimating a lag-augmented vector autoregressive (VAR) model and carrying out modified Wald (MWALD) tests. The analysis is performed for both total and agricultural exports. Further, relying on decision theories and assuming risk aversion we estimate two additional models[1], found in the financial econometrics literature, to depict the dynamic relationships between export growth and exchange rate volatility. In particular, the effect of third-country exchange rate volatility on export growth is measured as suggested by Cushman (1986).

The third essay (chapter 4) rose from methodological concerns about the effects of lag order selection in the framework used in the third chapter. In a Monte Carlo experiment, we compare two lag selection methods that are commonly used in the empirical literature[2] analyzing their lag order frequency distributions and the finite sample properties of the MWALD tests resulting from the choice of a lag

[1] Multivariate generalized autoregressive conditional heteroskedasticity in mean (MGARCH-in-mean)

[2] Likelihood ratio tests (Sims, 1980) and Schwarz criterion (Schwarz, 1978)

selection method. In order to accommodate most situations encountered when modeling economic series, the analysis is carried out for twelve different processes. Of particular interest are processes that include moving average terms. Indeed, recent econometrics literature (e.g., Ng and Perron, 2001 and Qu and Perron, 2007) has shown that statistical tests might perform poorly in the presence of moving average terms.

The contributions of this study can be argued in many ways. First, it provides additional scientific empirical evidence regarding the impact of market-oriented policies and programs in developing countries. It also points to new levers of export growth. As such, the generated knowledge can not only be useful to the Government of Ghana and development partners for future development efforts, but also to other developing countries especially in West Africa. Moreover, some of the methodological findings can be valuable to practitioners in the profession. Indeed, the methods used in this research have not been widely used in agricultural economics and the simulation results can guide practitioners when analyzing causality using the TYDL procedure.

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2 IDENTIFYING FACTORS OF EXPORT PERFORMANCE: AN APPLICATION TO GHANA AND ITS AGRICULTURAL EXPORT SECTOR

2.1 Introduction

The analysis of export performance is a complex task but highly important in light of the weight of trade in a country's economic growth. Countless proposed definitions, theoretical concepts and classifications of factors of export performance are available to researchers. But when analyzing a country's export performance, relevance should be the number one priority. Trying to fit pre-existing frameworks and/or using generic measures would poorly reflect a country's true experience.

As a result of colonization, Ghana has been traditionally specialized in the export of few primary commodities such as cocoa beans, gold and timber. However, after gaining its independence from Great Britain in 1957, exports started to decline. Inappropriate domestic policies and the unfavorable global context of the late sixties constrained Ghana to adopt the adjustment program financed by the International Monetary Fund in 1983. The key elements of the IMF's strategy were the realignment of relative prices and the restoration of monetary and fiscal discipline in order to encourage exports (Kapur, 1991). Figure 2-1 clearly shows that since the inception of the adjustment program in 1983, total export volumes have experienced exponential growth and little variability suggesting that the implemented macroeconomic policies have been effective at improving Ghana's export performance. Between 1983 and 2009, the average annual growth was 21%. Existing literature emphasizes the role of foreign income in the export performance of a country. Thus, the downturn of exports

in 2009 (figure 2-1) might be due to the Great recession that affected many of Ghana's trade partners.

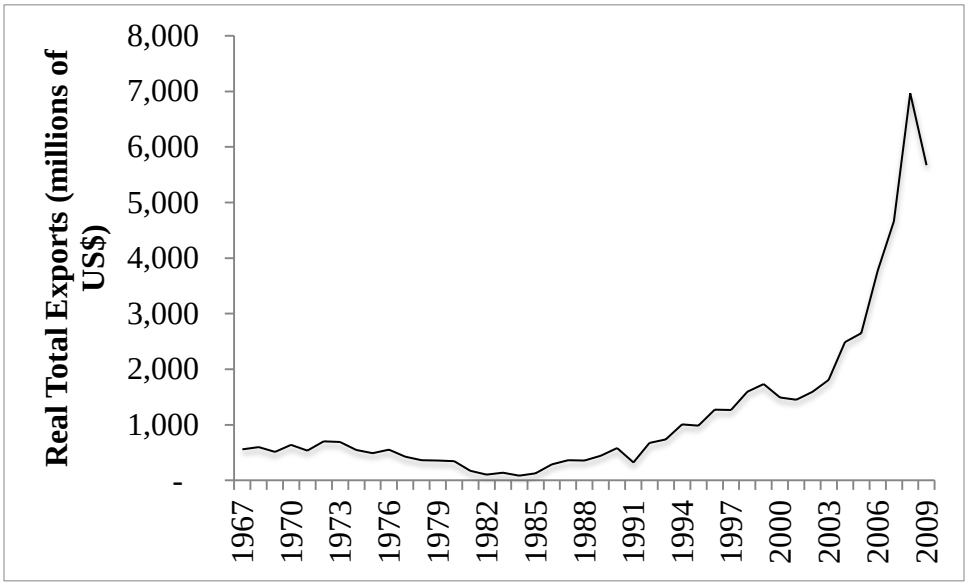

Figure 2-1: Annual Ghana's real total exports: 1967 — 2010.

The sectoral contribution of agriculture to exports is around 35.3% (FAO, 2011). The agricultural sector represents also 32.3% of Ghana's GDP (Ghana Statistical Service, 2010) and more than 50% of the labor force is employed in the agricultural sector (Ghana Statistical Service, 2011). During the episode of structural adjustments in Ghana (1983-1994), colossal amounts of money, technical and human resources have been channeled towards the export sector and in particular towards agricultural exports, agriculture having been identified as the main driver of growth (MoFA, 2010).

Scholars but also international organizations which are important contributors to Ghana's export development, have tried to understand the factors behind export performance. Both microeconomic and macroeconomic theories and their

applications in the empirical literature give a predominant role to prices in the understanding of a country's export performance. Clearly, a country's exports will expand as they become less expensive. A common measure of price competitiveness is the real effective exchange rate (REER). It is expressed as the trade-weighted average value of a domestic currency against those of a group of selected countries. In the trade-weighted scheme, the choice of countries and the design of weights are determinant for the measure of price competitiveness. Countries can be limited to major industrial nations or extended to the most representative trading partners. The usefulness of the REER compared to any bilateral exchange rates is now conventional wisdom (Ott, 1986). Surprisingly, if central banks generally give careful attention to the REER computation (e.g., Leahy, 1998) it is somewhat overlooked in empirical studies. In Ghana, the central bank reports the bilateral exchange rate of the Ghana Cedi against the U.S. dollar, the Euro and the British Pound respectively. The few studies (e.g., Sackey, 2001) having empirically measured the impact of relative price changes on Ghana's export performance often have used measures that do not reflect the current trading patterns of Ghana, which may have led to spurious results. Indeed, Ghana's trading patterns have evolved tremendously during the past two or three decades both in terms of partners and range of products.

Given the importance of agriculture in both the export sector and Ghana's economy in general, an analysis of the factors of agricultural export performance is highly needed. But this analysis shall not be based on common factors of export performance only; and this is for several reasons. First, the lack of data on agricultural trade flows between Ghana and its trading partners constrains us to use an aggregate

measure of export price competitiveness and as such may not reflect entirely agricultural export price competitiveness. Second, since 1983, while Ghana's price competitiveness was improving influenced by Ghana's currency (Ghana Cedi) and declining inflation, agricultural export volumes have been growing slowly with high variability (figure 2-2).

This clearly shows that other factors control Ghana's agricultural export performance. Theoretically, we know that traditional analytical frameworks of export performance are not as suitable for agricultural goods as for manufactured goods (Durand and Giorno, 1987). This is especially true for agricultural commodities and it is important to mention at this point that agents of Ghana's export development have made considerable efforts to move away from traditional exports (e.g., cocoa beans) promoting non-traditional exports (e.g., pineapple). Also, processed agricultural products (e.g., fruit salads) would fall in the category of manufactured products.

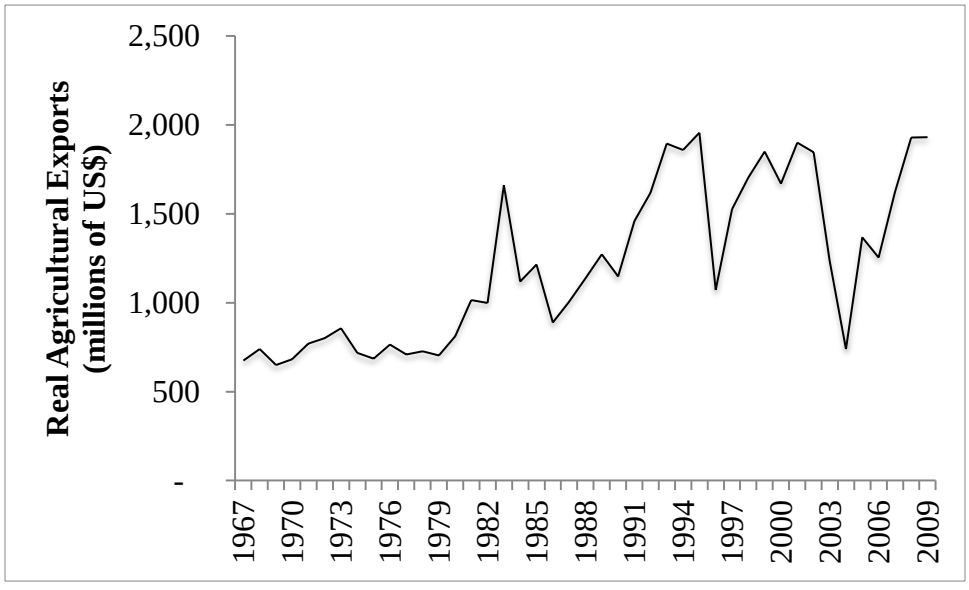

Figure 2-2: Annual Ghana's real agricultural exports: 1967 — 2009.

Third, new trade theories (e.g., Helpman and Krugman, 1985) have recently opened up new perspectives in export competitiveness and its measure. In particular, the study of non-price factors (e.g., quality)' impact on trade flows has gained importance in the empirical literature. A final point that we need to consider is that the agricultural export volumes tend to stagnate (figure 2-2), masking trends at the product-level. Some agricultural exports have grown (e.g., tomatoes) while others have declined (e.g., fishes and seafood). This suggests that an analysis that would identify the idiosyncrasies of each agricultural sector would help confer relevance to the analysis of export performance and avoid misleading generalizations.

The above-described background leads us to the general question that this research seeks to answer: What have been the most relevant factors in Ghana's agricultural sector export performance? This question is tackled using two approaches that although methodologically different, are based on a common principle: relevance. Ghana's price competitiveness is measured by a new Ghana Cedi trade-weighted index that we proposed here following the approach of the Federal Reserve (e.g., Loretan, 2005). We selected the *j* countries that had a share in Ghana's total trade of at least 0.5% in 2008. The weights change at each period (year or quarter) and are a linear combination of *j*'s bilateral import, export and third-market competitiveness weights. This weighting scheme allows, in a single number, to capture the competition that takes place both domestically and abroad. This measure of price competitiveness is analyzed reviewing Ghana's exchange rates and inflation experience since the independence (1957) and detailing the evolution of trade patterns in terms of partners and products. We made a point that agricultural export

performance might have been controlled by factors other than price factors. In an attempt to maximize the relevance of this research, we use grounded theory and qualitative methods to identify factors of export performance from the perspective of Ghana's agricultural export sector stakeholders. The combination of these two approaches allows us to provide a comprehensive picture of Ghana's agricultural export sector.

The methods that we have chosen for this research have not been widely used in the profession and our research will likely lead to some useful methodological findings. Moreover, from the qualitative analysis, new factors of export performance, specific to the agricultural sector, may emerge. We might also identify what has worked and what has not but also what is still needed to develop Ghana's agricultural export further. The information generated may be used by the Government and development partners in future development efforts. Finally, the new index of the foreign exchange value of the Ghana Cedi suggests important methodological aspects that could be used by Ghana's central bank and future related research to gauge the competitiveness of Ghana's goods in international trade.

The paper is structured as follows. We first provide an extensive review of the definitions and theoretical concepts of export performance and competitiveness. In the second section, we detail the methodological aspects of the index computation including the choice of the weighting scheme and the basket of currencies. In addition, we present the qualitative methods that have been used in this research, including data collection and analysis. The third section introduces a new measure of Ghana's price competitiveness. Its evolution overtime is analyzed by identifying the

correspondence between major breaking points and changes in exchange rates and monetary policies that have occurred in Ghana. We finish this section with a qualitative analysis of other possible determinants of Ghana's export performance including non-price factors. Section five discusses the eventual implications of these results.

2.2 Literature Review

In this section, we first review how the concept of export competitiveness has been defined in the literature and the different classifications of factors of competitiveness that are available to researchers. We then review the theoretical literature on trade, export performance and competitiveness from the seminal work of Adam Smith to the new trade theories.

2.2.1 Defining Export Competitiveness

The concept of competitiveness can be defined in several ways (Colyer and Kennedy, 2000) and can be difficult to measure (Buckley, Pass, & Prescott, 1988). The definition depends on the level of analysis (e.g., country), the product analyzed (degree of differentiation) and the objective of the analysis (e.g., export performance) (Abbott and Bredhal, 1992). In its broader sense, export competitiveness refers to "the ability of a country to produce and sell goods and services in foreign markets at prices and quality that ensures long-term viability and sustainability" (The World Bank). The United-States Department of Agriculture (USDA) defines export competitiveness as "the ability to deliver a product at the lowest cost" (Dohlman, Schnepf, & Bolling, 2001, p. 16) while the World Economic Forum regards it "as the set of institutions, policies, and factors that determine the level of productivity of a

country" (Schwab et al., 2009, p. 4). For Porter (1990) "we must abandon the whole notion of competitive nation" (Porter, 1990, p. 6). "The only meaningful concept of competitiveness at the national level is national productivity" (Porter, 1990, p.6) and to understand its determinants "we must focus not on the economy as a whole but on specific industries and industry segments" (Porter, 1990, p. 9).

The determinants or factors of competitiveness are numerous and a complete analysis of competitiveness would be a complex task (Lall and Wignaraja, 1998). There are both price and non-price competitiveness factors. According to the Organisation for Economic Co-operation and Development (OECD) "the concept of competitiveness encompasses many factors that impact on a country's macroeconomic performance" (Durand, Simon, & Webb, 1992, p. 5). These factors include "productivity and technological innovation, which in turn depends on investment in human and physical capital, and on the institutional and structural policy environment" (Durand et al., 1992, p. 5). Looking at the particular case of Mauritius, Lall and Wignaraja (1998) defined a simple framework that allows a complete analysis of a country's export competitiveness. The elements of export competitiveness are grouped into several categories which are the incentive structure, human resources, technology and standards, infrastructure, foreign investment, procedures and regulations, legal system, finance and export information/marketing. Colyer and Kennedy (2000) have also summarized the main factors of competitiveness namely, technology, input costs, production economies, production quality and enterprise differentiation, promotion and external factors. Among these external factors, macroeconomic variables such as exchange rates and consumer

incomes strongly influence a country's competitiveness (Colyer and Kennedy, 2000). Indeed, several authors (e.g., Krueger, 1992) agree that macroeconomic policies (e.g., inflation and exchange rates) are a determinant factor to export competitiveness (Colyer and Kennedy, 2000). In the case of agriculture and commodities in particular, competitiveness reflects factors such as:

> relative resource endowments and agro-climatic conditions, but also the impact of macroeconomic policies (affecting exchange rates, work incentives, investment, energy costs and availability, etc.), sector-specific policies (e.g., credit subsidies, import or export taxes on inputs or final products), infrastructure (for storage and transportation), and supporting institutions (e.g., credit, regulatory, news and information, etc.) that help markets to work effectively (Dohlman et al., 2001, p. 16).

Abott and Bredahl (1992) categorize the determinants of competitiveness for the agricultural sector. The categories are factor endowments and natural resources, technology, investments, human capital, managerial expertise, product characteristics, firm strategy and industry structure, input supply, marketing and distribution channels, infrastructure and externalities, regulatory environment and trade policy (Abott and Bredahl, 1992). Porter (1990) summarizes the *environmental* determinants of national advantage in the famous "diamond" (factors conditions, demand conditions, related and supporting industries and firm strategy, structure and rivalry). Finally, the World Economic Forum (Schwab et al., 2009) defines twelve pillars of competitiveness that are presented in table 2-1.

Table 2-1: The twelve pillars of competitiveness.
Source: Schwab et al. (2009).

Pillars	Role
BASIC REQUIREMENTS	
Institutions	
Infrastructure	Key for factor-driven economies
Macroeconomic stability	
Health and primary education	
EFFICIENCY ENHANCERS	
Higher education and training	
Goods market efficiency	
Labor market efficiency	Key for efficiency-driven economy
Financial market sophistication	
Technological readiness	
Market size	
INNOVATION AND SOPHISTICATION FACTORS	Key for innovation-driven economy
Business sophistication	
Innovation	

2.2.2 Theoretical Literature on Trade and Export Competitiveness

The exchange of goods across international borders has been practiced for centuries but it is only in 1776 that this practice and its advantages have been theorized with Adam Smith and his seminal book, *"the Wealth of the Nations"*. The theory, also known as the *Principle of absolute advantage* supports the specialization of countries in the production for which they have an absolute advantage, measured in terms of labor productivity. A country has an absolute advantage in the production of one good if it can produce that good using fewer resources (i.e., labor) than another country. It is on the base of absolute advantages that countries trade. Adam Smith's works constitute the bedrock of classical theory and have been expanded since by David Ricardo who observed, in 1817 (*On the Principles of Political Economy and Taxation),* that absolute advantages are not a sufficient condition to explain trade between countries. Using the well-known example of wine and cloth trade between

Portugal and England and assuming that there is only one factor of production (i.e., labor), Ricardo argued that countries trade on the basis of comparative rather than absolute advantages. This law stipulates that two countries would benefit from trade if they export according to the relative opportunity costs between two goods or services. Therefore, even though a country is not the most efficient producer of a particular good, it can still benefit from exporting that good.

A more realistic view of trade theory takes into account other factors of production. One of the most impacting international trade theories is the Heckscher-Ohlin (H-O) synthesis and its extensions. The essence of this synthesis is a differential in factor endowments in both intensity and abundance. Assuming two factors of production (labor and capital), countries that are capital-abundant should specialize in the production of capital-intensive goods while countries that are labor-abundant should produce and export labor-intensive goods.

A close theoretical approach to the H-O model follows a macroeconomic perspective. Growth is either attributed to differences in factors of production (quantities of human and physical capital) or to differences in efficiency of production. In the Solow model these two components refer to differences in capital accumulation and differences in production function. The productivity of a country (total factor productivity) becomes the principal measure of a country's competitiveness. Moreover, certain fundamentals of macroeconomics (e.g., inflation, exchange rates, trade balances and foreign capital flows) are often considered as determinants of a country's competitiveness and macroeconomic models such as the Mundell-Fleming model allow explaining the effect of those determinants on trade

volumes. In particular, the Mundell-Fleming model predicts that in the case of a small-opened economy such as Ghana, assuming perfect capital mobility and changing price levels, an appreciation of the real exchange rate would cause a fall in exports. Although, the assumption of perfect capital mobility is generally too restrictive, this model shows that monetary policies can impact a country's exports under floating exchange rates.

The so-called Leontief Paradox (1954) questions the validity of the H-O model and constitutes the starting point to a large array of alternative theories. Notable explanations to the failure of the H-O model cast doubt on two main assumptions which are identical and homothetic consumer preferences and identical technology across countries. Vanek (1959) assessed the proposition that natural resources endowment is an important factor of production that might explain trade volumes and directions. This proposition will later become an extension to the H-O synthesis (*Heckscher-Ohlin-Vanek theorem)*. In Vanek's theory, natural resources can only be considered as a factor of production for a restraint number of products that he calls "resource products" (e.g., raw materials and foodstuffs). In particular, the work of Vanek shows that U.S. patterns of trade (i.e., export of capital-intensive goods vs. labor-intensive goods) cannot be explained by the abundance of capital and labor only, as suggested by the H-O theory. If the U.S., capital-abundant country, exports labor-intensive products and import capital-intensive products when the H-O theory would predict the contrary, it might be because of the complementarity between capital and natural resource factors. In the U.S., capital is abundant but natural resources are relatively scarce which explains why the U.S. tends to import products

that highly require both capital and natural resources (e.g., agricultural goods). Linder (1961; 1967) has also challenged the H-O theories showing their inapplicability to developing countries and the central role of product quality in trade. Also, conventional trade theories cannot explain developing countries trade simply because they assume a full utilization (Linder 1967) of resources such as full employment (an argument later advanced by Stiglitz). Developing countries trade also suffers from a lack of adaptive capacity to new market and technical opportunities. Linder (1961) further shows the relationship between product quality and the average income of a country both at the demand and supply levels. A country with high (low) average income tends to produce quality products because of a high (low) domestic demand for these products and will develop a comparative advantage in the production of high (low) quality products. Because of the correlation between product quality and income at both supply and demand levels, countries with similar average income will tend to trade together (*Linder's hypothesis*). Markusen (1986) developed a theory that takes into account this assertion and predicts that trade between North and South is based on factor endowments (inter-industry trade) while trade between East and West (understanding North America and Western Europe) is of an intra-industry type. We somewhat encounter this linkage between income distribution and trade patterns in the product-life cycle theory of Vernon (1966). According to this theory, trade patterns depend on a country's class (e.g., developing) and the stage of product development (new product, maturing product or standardized product). Vernon's theory mostly applies to high income products and products for which labor and capital are highly substitutable. Vernon's theory sheds light on the role of innovation,

scale, ignorance and uncertainty in trade (Vernon, 1966). In short, a particular country can locally produce and sell, export and import a same product depending on the stage of the cycle. In the early stages of the cycle, production is concentrated in the country of origin. The cost of input is less relevant than the need for communication and input flexibility. We identify here the importance of market information. The high product differentiation characterizing this stage tends to decrease as the product matures. The phase of maturation corresponds to a growth in exports to countries with similar income (other advanced economies) where demand for the product is growing. Eventually, it becomes cheaper to produce in these new markets. During the last phase of the cycle, the product is highly standardized, market knowledge is, consequently, less a problem and production can be relocated to developing countries where costs are lower and the demand for standardized products is high (on the basis of price). The country of original production will start to import. Other theories recognize the strong role of public policies in trade. In particular, Travis (1964) criticizes the free trade assumption of the H-O theorem and discusses how protection structures trade. Protection (tariffs, quotas and subsidies) allocates resources in sectors that may not reflect a country's factor endowments. It affects production patterns but also consumption, trade and factor prices (Travis, 1964). In the same spirit, Barkema, Drabenstott and Tweeten (1990) argue that government policies cancel out the effects of comparative advantages on trading patterns. Finally, some authors have acknowledged the role of labor skills (human capital) in international trade. There is empirical evidence of higher wages in the export sector (Kravis, 1956) that can be linked to higher skills in this sector than in the import-competing sector

(Waehrer, 1968). Distinguishing human capital from physical capital, the former seems to have a stronger influence on comparative advantages and trade (e.g., Baldwin, 1971). Findlay and Kierzkowski (1983) conciliate this literature with the H-O theory classifying labor into two categories (skilled and unskilled labor) and goods according to their proportion of skilled/unskilled labor.

All these alternative approaches to the standard trade theory (H-O) were synthesized into the so-called new trade theory with Helpman and Krugman (1985) being a major contribution. This theory acknowledges the fact that trade may occur between similar countries and not only between countries with different factor endowments. One of the strong explanations behind this observation is the existence of economies of scale and encouraged specialization. Krugman explains why countries with apparently similar factor endowments would trade. In fact, countries can specialize building comparative advantages on "almost accidental advantages" that with time and the power of increasing returns to scale become large comparative advantages (Krugman, 2008). Another important component of this theory is that it supports the assumption of monopolistic competition where firms sell differentiated products that are imperfect substitutes. This is a strong assumption that acknowledges the role of variety in consumer preferences (Helpman and Krugman, 1985). Helpman and Krugman (1985) show that in the presence of economies of scale and differentiated products, trade volumes strongly depend on the relative size of a country (GDP). They conclude that "in a constant-returns world the volume of trade would depend entirely on differences between countries; if all countries had identical relative factor endowments, technology, and tastes, there would not be trade at all" (p.

262). If increasing returns exist and countries are completely specialized, trade will depend on income differences only. They however do not deny the role of factor endowments, stating that in case of incomplete specialization, the more different factor endowments the countries have (but also the more similar are their incomes), the more they will trade. Helpman and Krugman (1995) further expand their theoretical framework to explain inter-industry, intra-industry and intra-firm (vertical integration) trade. Finally, Graham and Krugman (1995) underline the positive relationship between foreign direct investment (FDI) and trade. As integration, FDI encourages trade (Graham and Krugman, 1995) but they are also substantial intangible benefits such as knowledge and technological spillovers induced by FDI. An important difference of new trade theory compared to more traditional theories is that it includes a framework to analyze at the firm-level to explain intra-industry trade. Ekholm, Forslid, & Markusen (2003) have developed export-platform FDI theory to explain why some countries invest and develop plants in other countries (generally low-cost) to export to a third market. This type of FDI is based on cost-consideration and/or the desire to gain access to a large integrated market such as Europe.

More recent trade theoretical works ("New" new trade theory) deepen the analysis at the intra-industry level and assume, based on empirical research using firm-level data, heterogeneity of firms in terms of productivity (Melitz, 2003). Empirically, it is observed that firms in the export sector are more productive than in the non-export sector and that resource allocation occurs between firms within a same industry. Melitz (2003)'s model shows how exposure to trade induces an endogenous

selection of firms. The most productive firms will export while the least productive will exit the export market (Melitz, 2003). This process leads to an intra-industry resource reallocation towards the most productive firms and, as a consequence, an increase in the aggregate level of production (and export volumes). Melitz (2003) further predicts that the decision of engaging into export activities depends highly on export market entry costs (fixed). Only the most productive firms can bear the large fixed costs linked to export activities but, because of the uncertainty relative to their initial level of productivity, firms face the same probability of entering an industry. Once they enter, if their productivity level generates negative profits, they will immediately exit the market. According to Melitz (2003) public policies have a preponderant role in the inter-firm reallocation process.

Considering the numerous monetary, exchange rate and trade liberalization reforms implemented since 1983 in Ghana, theories on the effect of macroeconomic factors on a country's trade appear to be the most useful for this research. In addition, theories that consider the role of factors such as product quality (e.g., Linder, 1961) or skills (e.g., Waehrer, 1968) in trade can also be useful for the analysis of Ghana's export performance at the micro-level.

2.3 Methods and Data

As correctly stated by Durand et al. (1992); "the measurement of international competitiveness is a matter of choices and compromises with available data" (p.6). The methods selected for this research reflect this statement.

2.3.1 The Real Effective Exchange Rate: A Measure of Export Price Competitiveness

In order to measure the export price competitiveness of Ghana, we need to compare the price of Ghana's goods with the price of the goods of Ghana's trading partners. To be able to capture Ghana's competitiveness relative to all its trading partners in one single number, the use of a multilateral trade-weighted index is preferred. Also, changes in the exchange rate between two currencies influence the price of the exported goods as perceived by the importer. For all the above, the multilateral trade-weighted index of the foreign exchange value of the Ghana Cedi or effective exchange rate appears to be a good indicator to appraise Ghana's export price competitiveness. The nominal effective exchange rate is "a measure of the value of a currency against a weighted average of several foreign currencies" (The World Bank, 2013). The OECD, Eurostat, Federal Reserve (Fed) and International Monetary Fund (IMF) are examples of central banks or international institutions that follow this definition to measure a country's export competitiveness. However, the approach used to compute the index differs from one institution to another and there are three main levels at which the pertinence of an index can be appreciated. First, the selected currencies in the trade-weighted basket shall account for most of a country's external trade (White, 1997). Second, the weights shall capture the changes in a country's trade patterns (time-varying weights) and all types of competitions. After carefully reviewing the literature on effective exchange rate calculations, we found that the Fed's approach would produce the most informative index if applied to Ghana.

2.3.1.1 Choice of the Index Formula

The nominal effective exchange rate (NEER) is calculated as follows:

$$I_t = I_{t-1} * \prod_{j=1}^{N(t)} \left(\frac{e_{j,t}}{e_{j,t-1}}\right)^{w_{j,t}}. \quad (1)$$

The nominal Ghana Cedi exchange rate index I_t is a geometrically weighted average of bilateral exchange rates where $e_{j,t}$ ($e_{j,t-1}$) is the bilateral exchange rate of the Ghana Cedi in terms of foreign currency *j* at time *t* (*t-1*), *N(t)* is the number of foreign currencies (main trading partners of Ghana) at time *t* and $w_{j,t}$ is the weight of currency *j* at time *t*. I_{t-1} is the value of the index at *t-1*. The base year (1960) was set at 100. The decision of using a geometric mean instead of an arithmetic mean pertains to the practitioner. However, note that the geometric average would be preferred if the numbers are not independent. The value of all the selected currencies is given relative to the Ghana Cedi and as such the exchange rates entering the index are not independent. The weights are based on international trade data. One of the advantages of the Fed's approach is that it captures all types of competition (Leahy, 1998; Loretan, 2005). Indeed, the weights are actually made of three types of weights. Import weights, $\mu_{Gh,j,t}$, take into account the competition between domestic goods (produced in Ghana) and imported products (*M*); export weights, $\varepsilon_{Gh,j,t}$, capture the competition between Ghana's exports (*X*) and goods produced in country *j* and finally, third competition weights, $\tau_{Gh,j,t}$,. measure the competition between Ghana's exports and country *j*'s exports in a third-market country *k*. The different weights are computed as follows:

$$\mu_{Gh,j,t} = M_{Gh,j,t} / \sum_{j=1}^{N(t)} M_{Gh,j,t}. \quad (2)$$

$$\varepsilon_{Gh,j,t} = X_{Gh,j,t} / \sum_{j=1}^{N(t)} X_{Gh,j,t}. \quad (3)$$

$$\tau_{Gh,j,t} = \sum_{k \neq j, k \neq Gh}^{N(t)} \varepsilon_{Gh,k,t} * \mu_{k,j,t}. \quad (4)$$

The weights used in the trade-weighted index (equation 1) are a linear combination of the import, export and third competition weights:

$$w_{j,t} = (\tfrac{1}{2})\mu_{Gh,j,t} + (\tfrac{1}{2})((\tfrac{1}{2})\varepsilon_{Gh,j,t} + (\tfrac{1}{2})\tau_{Gh,j,t}). \quad (5)$$

As Ghana and its trading partners have had different inflation experience, the real effective exchange rate (REER) appears to be a better indicator of competitiveness:

$$REER_t = \frac{NEER_t * CPI_{Gh,t}}{TWFCPI_t}, \quad (6)$$

where $CPI_{Gh,t}$ is the domestic price and $TWFCPI_t$ the trade-weighted foreign consumer price index (CPI). Depending on the purpose of the study, different prices can be used. The CPI and GDP deflator tend to capture the price of non-tradable goods while export price indices (EPI), wholesale price indices (WPI) and producer price indices (PPI) are better measure of tradable goods (Chinn, 2005). But, as noticed by Chinn (2005), the choice of the price deflator is more a matter of data availability. In general, more price deflators are available at low frequencies (i.e., annual). When studying developing countries such as Ghana, the choice is even more limited which explains why we decided to choose the CPI.

The trade-weighted foreign CPI ($TWFCPI_t$) is an arithmetic average of the price deflator of Ghana's main trading partners and weights are the same as previously defined.

$$TWFCPI_t = \sum_{j=1}^{N(t)} w_{j,t} * CPI_{j,t}. \quad (7)$$

2.3.1.2 Choice of the Currencies

Following the Fed's approach, Ghana's REER is constructed for a group of countries that had a share in Ghana's exports or imports of at least 0.5% in 2008. Based on this criterion, we selected fifteen representative countries. Although not optimal, we use a fixed basket of countries to avoid cumbersome computations. On the other hand, eventual geopolitical changes (e.g., reunification of Germany and introduction of the Euro) have been rigorously taken into account. In particular, members of the European Union enter the index individually instead of assimilating the Euro zone to a single country. Tables 2-2 and 2-3 show the countries that have been selected along with their value and share in Ghana's total imports and exports respectively. In 2008, these countries represented 54% and 72% of Ghana's total exports and imports respectively. These percentages are actually low and suggest that Ghana imports from and, to a greater extent, exports to a large basket of countries, a small fraction of its total trade. Diversifying the number of partners can turn to be an advantage. More specifically, in 2008, the Netherlands represented 13% of Ghana's exports while China, the first import market, represented 16%. Note that the importance of these selected countries in Ghana's trade has decreased overtime. Indeed, in 1960, the selected fifteen economies represented more than 80% of both Ghana's imports and exports.

2.3.1.3 REER: Data Sources

The REER is first computed annually from 1964 to 2010. Annual Ghana's total nominal exports in millions of US$ are from the Global Insight website and the

original source is the IMF, Direction of Trade Statistics (IMF/DOTS). For the NEER, bilateral exchange rates between the Ghana Cedi (GHS) and main trading partners currencies were established via the US$ for which nominal exchange rates are available for all countries. Annual bilateral exchange rates between the US$ and the GHS as well as other currencies are from the Global Insight website (IMF/International Financial Statistics (IFS)). CPI (total) series for Ghana and all trading partners except China were obtained from the online World Bank database. Only the overall retail price index was available for China and it was retrieved from the Global Insight website. The study also uses quarterly data from 1984 (Q1) to 2010 (Q4). We chose to cover this precise period because we are mainly interested in Ghana's most recent export experience. Also, as the quantitative analysis is complemented by focus groups and personal interviews, we needed to study a period recent enough such that participants would be able to remember and talk easily about Ghana's export sector.

Table 2-2: Ghana's imports from selected partners (2008 value and share).

Partner name	**Imports value 2008 (millions of US$)**	**Share imports 2008 (%)**	**Share imports 1960 (%)**
China	1906.86	15.62	0.83
Nigeria	1793.74	14.69	0.36
United-States	669.57	5.48	5.72
India	614.59	5.03	0.80
France	532.72	4.36	2.02
United-Kingdom	532.69	4.36	36.76
Cote d'Ivoire	500.12	4.10	0.72
Netherlands	429.98	3.52	9.47
South Africa	426.95	3.50	0.97
Italy	335.26	2.75	1.96

(Table 2-2 continued)

Partner name	Imports value 2008 (millions of US$)	Share imports 2008 (%)	Share imports 1960 (%)
Belgium	315.55	2.58	1.38
Germany	310.80	2.55	10.77
Malaysia	199.16	1.63	0.00
Japan	191.70	1.57	8.40
Switzerland	38.08	0.31	0.77
Total Main Partners	8797.77	72.07	80.92
Total World	12208.10	100.00	100.00

Table 2-3: Ghana's exports to selected partners (2008 value and share).

Partner name	Exports value 2008 (millions of US$)	Share exports 2008 (%)	Share exports 1960 (%)
Netherlands	576.47	13.06	12.18
United-Kingdom	340.89	7.73	31.24
France	242.72	5.50	0.89
United-States	219.36	4.97	15.13
India	179.23	4.06	0.18
Malaysia	155.34	3.52	0.00
Germany	121.69	2.76	13.44
Belgium	114.79	2.60	2.92
China	85.02	1.93	0.43
Italy	83.94	1.90	5.66
Nigeria	68.07	1.54	0.77
Switzerland	64.82	1.47	0.00
Japan	56.46	1.28	0.77
Cote d'Ivoire	43.90	0.99	0.80
South Africa	15.95	0.36	1.14
Total Main Partners	2368.67	53.68	85.55
Total World	4412.76	100.00	100.00

Moreover, 1983-1984 correspond to a drastic turning point in Ghana's economy with the economic recovery program (ERP) and all the policies implemented subsequently. Quarterly Ghana total nominal exports and bilateral trade data (imports and exports) in millions of US$ were obtained from the Global Insight website and the actual source is the IMF/DOTS. Countries entering the nominal Ghana Cedi exchange rate index but also the TWFCPI were initially selected based on United Nations COMTRADE (2008) bilateral trade data. Quarterly bilateral currency exchange rates between US$ and all other currencies (Ghana Cedi, Belgium Franc, Chinese Renminbi, West African CFA Franc, French Franc, Deutschmark, Indian Rupee, Italian Lira, Japanese Yen, Malaysian Ringgit, Nigerian Naira, Dutch Guilder, South African Rand, Swiss Franc and British Pound) as well as the €/Ghana Cedi exchange rate are from the IMF/IFS (Global Insight). Quarterly CPI data are from the OECD database for the OECD members in addition to emerging countries (China, India and South Africa). For the other countries, data are from the Global Insight website and the actual source is the Department of Statistics of Malaysia and the IFS for Ghana, Nigeria and Côte d'Ivoire. All real data are expressed in 2000 prices.

2.3.2 Qualitative Analysis of Export Competitiveness

As stated several times, our objective is to analyze Ghana's export performance and competitiveness. The first part of this essay focuses on price competitiveness. We are here interested in covering all the other possible factors.

2.3.2.1 Data Sources

The study took place in Ghana from October, 31st 2011 to November, 25th 2011. The primary concern was to collect the perspectives and insights of the stakeholders of Ghana's agricultural export sector. Most export activities are located in the southern part of the country while northern regions (Northern, Upper West and Upper East) are more oriented towards food crops and subsistence farming. The population of interest in encompasses all stakeholders of Ghana's agricultural export sector regardless of the export crop. Before selecting the study participants, we identified the main categories of stakeholders namely; farmers, agro-processing companies, development agencies, ministries, government agencies, research institutions and universities (table 2-4). We had originally a more exhaustive list that included for instance commercial banks, freight forwarders and transporters. Data were collected either via focus group or personal interview (table 2-4). Focus groups are defined as a "research technique that collects data through group interaction on a topic determined by the researcher" (Morgan, 1996, p. 130) while interview is "a meeting of two persons to exchange information and ideas through questions and responses, resulting in communication and joint construction of meaning about a particular topic" (Janesick, 1998, p. 30). The segmentation according to stakeholders groups has two advantages. First, it ensures that the groups are homogeneous enough, an essential characteristic of focus groups and second, it allows us to make comparisons across groups. Focus groups have also to be diverse enough to obtain contrasting ideas. Sociologists generally recommend conducting focus groups of no more than ten people. For noncommercial topics, between six and eight is enough (Krueger and Casey, 2000). All focus groups were structured the same way:

First, we asked (orally) introductory open-ended questions to explore participants' perceptions about the evolution of Ghana's agricultural exports, the impact of exports on the growth of the country, and the livelihood of the people in addition to the eventual linkages between exports and food security" "Do you think that agricultural exports have increased during the past two decades?" "Do you think that agricultural exports have contributed to the growth of the countries" Do you feel that the production of crops for export has made you better off?" Then, participants were asked to reflect on the strengths, weaknesses, opportunities and threats (SWOT) of Ghana's agricultural export sector. Finally, based on the identified weaknesses and threats participants summarized the main problems of the sector. They also prioritized, ranking individually the problems. In order to facilitate the process, seven green buttons were given to each participant to be distributed across the problems and seven yellow buttons to evaluate the probability of resolving those problems (Louisiana State University Agricultural Center, 2001). The last part of the focus group was a brainstorm about potential solutions to the identified problems. We chose the SWOT analysis to structure the main part of the focus groups because it helps focusing on the topics of interest while encouraging the involvement of the participants. We realized that because it is a playful exercise, participants are very enthusiastic about the whole discussion. Personal interviews were semi structured. We asked general questions letting the interviewees express their perspectives on Ghana's export sector. In the first part we typically asked the interviewee to relate him/her or his/her institution to Ghana's export sector. For instance, we asked development agencies to talk about the projects or programs related to exports that

they have implemented in Ghana. In the second part, the interviewee had to give his/her opinion about the recent evolution of Ghana's agricultural exports: "In your opinion have volumes increased? " "What have been the main drivers or impediments to this evolution? " Based on the responses we incented the interviewees to brainstorm on Ghana's export sector future developments. "What opportunities do you see?" "What actions would have to be taken to develop exports further?" We also asked questions that explore the linkages between exports and food security but also exports and the growth of the country or people livelihoods.

In order to identify potential participants we used a combination of methods. Depending on the category of stakeholders we put emphasis either on internet researches or networking. All contacts were made by phone as this mode of communication is preferred in Ghana.

For the first category of stakeholders (FBOs) we proceeded as follows. In Ghana, regions are divided into districts and the Ministry of Food and Agriculture (MoFA) decentralizes its development programs and actions at the district-level (District Agricultural Development Units - DADU). The strategy was to locate agricultural extensionists within each DADU. The interested extensionists were then asked to arrange a group discussion with farmers of their respective district. Farmers are generally organized in farmer-based organizations (FBOs). Members of FBOs regularly meet with or without their extensionist, which facilitates the arrangement of focus groups.

We first interviewed producers of vegetables (onions, lettuces, chili peppers, okras and carrots) for export. The group was located in Denu, district Ketu South of the Volta region (figure 2-3). We chose the Ketu South because of its strategic location for the production and export of vegetables. At only few kilometers from Lomé, the capital of Togo, the Ketu South is also close to the coast, port infrastructure and Accra, the capital. Soils are mainly sandy which is suitable for the production of vegetables. The district is endowed with a dense water supply network especially in urban areas. Ten farmers were participating to the focus group which lasted two and a half hours. We gathered in the farm of one of the participants and member of the FBO.

In the second focus group, participants were producers of pineapples for export. All the participants were members of an FBO of the district of Akuapim South Municipal in the Eastern region. The district is characterized by a high percentage of population engaged in agriculture. Both cash and food crops are cultivated. The area of Fotobi (figure 2-3), where we conducted the focus group, is specialized in the production of pineapples. Major markets are close to Fotobi (Nsawam and Aburi). Accra is at only 50 km. Note that the district is also home of many agro-processing companies. Indeed, all the producers that participated in this focus group sell their pineapple production to a company that processes exotic fruits and exports to Europe. They were seven participants to the focus group including the extensionist. One of the participants was a woman. The focus group lasted two hours.

Table 2-4: Stakeholders types, participants and interview types.

Stakeholder type	Participants	Location (city or district, region)	Number of participants	Type of interviews	Transcribed/taped
Farmer Based Organizations (FBOs)	Vegetables FBO	Ketu South, Volta region	10	Focus group	Transcribed + taped
	Pineapple FBO	Akuapim South Municipal, Eastern region	7	Focus group	Transcribed + taped
	Cocoa beans FBO	Sekyere South, Ashanti region	11	Focus group	Transcribed + taped
Agro-processing companies	Blue Skies	Nsawam, Eastern region	3	Personal interview	Transcribed + taped
	Cocoa Processing Company (CPC - Cocobod)	Tema, Greater Accra region	1	Personal interview	Transcribed
Exporters	Papaya and Mango Producers and Exporters Association of Ghana (PAMPEAG)	Accra, Greater Accra region	4	Focus group	Transcribed + taped
	Sea-Freight Pineapple Exporters of Ghana (SPEG)				
	Vegetables Producers and Exporters of Ghana (VEPEAG)				

(Table 2-4 continued)

Stakeholder type	Participants	Location (city or district, region)	Number of participants	Type of interviews	Transcribed/taped
Donors/ Development agencies/ NGOs	Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance (ACDI/VOCA)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Agence Française de développement (AFD)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Deutsche Gesellschaft für Internationale (GIZ)	Accra, Greater Accra region	1	Personal interview	Transcribed
	International Fund for Agriculture Development (IFAD)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Japanese International Cooperation Agency (JICA)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Millennium Development Authority (MiDA)	Accra, Greater Accra region	1	Personal interview	Transcribed
Ministries	Ministry of Trade and Industry (MoTI)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Ministry of Food and Agriculture (MoFA)	Accra, Greater Accra region	1	Personal interview	Transcribed

(Table 2-4 continued)

Stakeholder type	Participants	Location (city or district, region)	Number of participants	Type of interviews	Transcribed/taped
Government agencies	Customs Excise and Preventive Services (CEPS)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Ghana Free Zones Board (GFZB)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Ghana Export Promotion Council (GEPC) or Authority (GEPA)	Accra, Greater Accra region	1	Personal interview	Transcribed
	Ghana Cocoa Board-Cocobod (CMC-Cocoa Marketing Company (Ghana) Limited)	Accra, Greater Accra region	1	Personal interview	Transcribed
Universities and research institutions	University of Ghana at Legon	Legon, Greater Accra region	3	Personal interview	Transcribed
	University of Cape Coast (UCC)	Cape Coast, Central region	4	Focus group	Transcribed + Taped
	Food Research Institute (FRI)	Accra, Greater Accra region	1	Personal interview	Transcribed

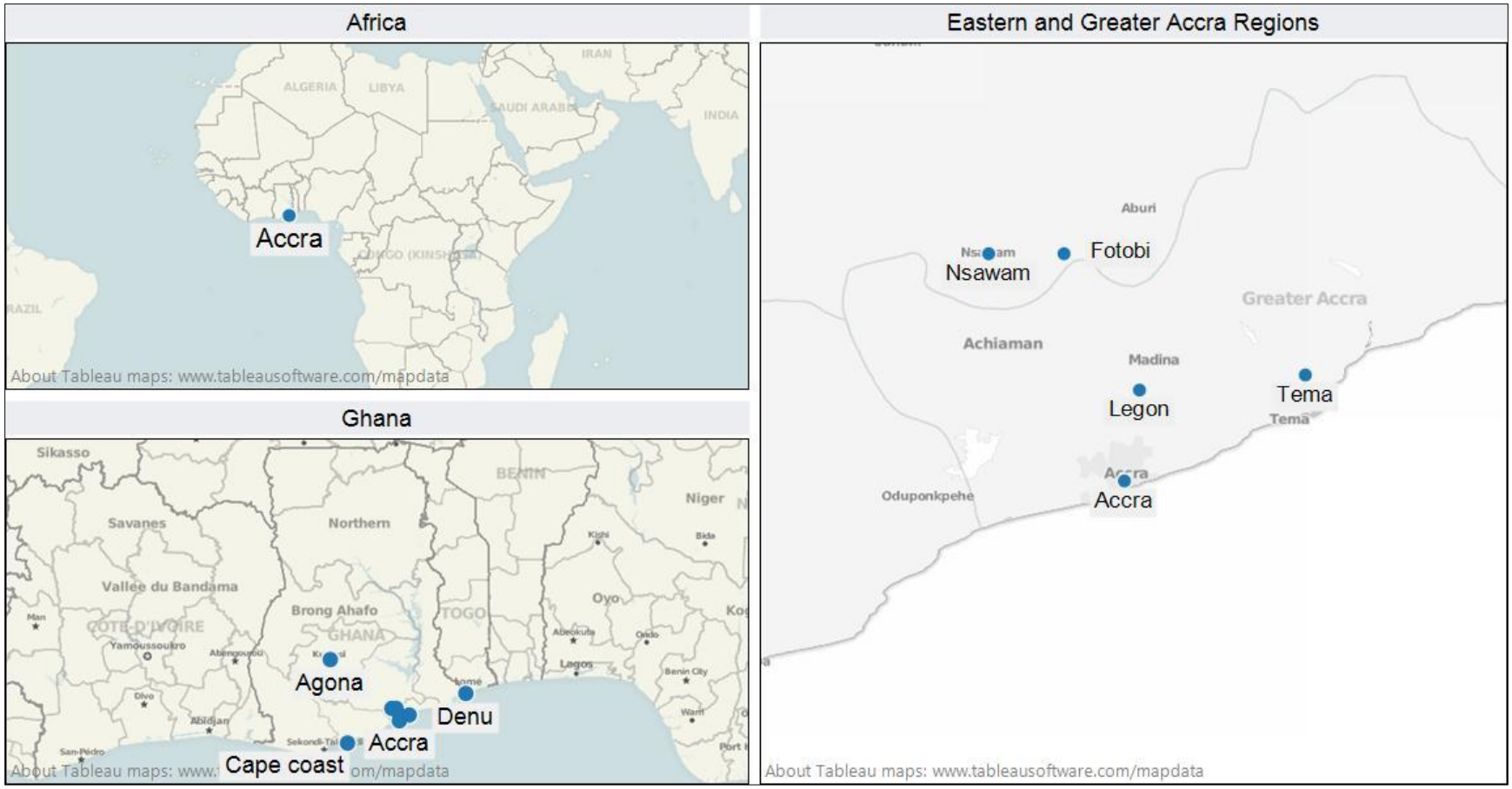

Figure 2-3: Interviews and focus groups location.

The third focus group was located near Agona, district of Sekyere South in the Ashanti region (figure 2-3). It was very close to Kumasi, the second largest city of Ghana. The Ashanti region is in the deciduous forest zone which is propitious to the production of cocoa, the main cash crop of the region. The focus group included nine producers and two extensionists. The participants were all producers of cocoa beans and members of the same FBO. One of the participants was a woman. The focus group lasted two and a half hours.

Agro-processing companies were identified through networking mainly. Representatives of two agro-processing companies were interviewed. The first company (Blue Skies) is located in the Eastern region in the surroundings of Nsawam (figure 2-3) and processes exotic fruits for the European market. The interviews were conducted on the site of the company. Three representatives have been interviewed namely, an agronomist as well as the production and technical managers. The company practices outsourcing. Small farmers in the area are contracted. They produce for the company that processes and exports but also participates at several stages of the production (harvest, spraying and technical advice). The second agro-processing company (Cocoa Processing Company) was in Tema in the Greater Accra region. It is in Tema that one of Ghana's two main sea ports is located. The company was operating in a free zone and it processes cocoa beans into cocoa butter and cocoa paste. A representative of the company was interviewed on the site.

Exporters are actually associations of producers-exporters. In order to identify potential interviewees, we used existing reports or studies on export development projects in Ghana redacted and implemented by diverse international institutions such

as the USAID. Once the contact information was found, we directly contacted potential participants. Three associations of exporters accepted to participate (4 participants) to a focus group that took place in Accra as the representatives of the associations were from different areas. One association exports pineapples by sea (SPEG), another exports mangoes and papayas by air (PAMPEAG) while the last one exports vegetables also by air (VEPEAG). The focus group was structured as for the FBOs and lasted approximately 2h.

The fourth category of stakeholders encompasses donors, development agencies and non-governmental organizations (NGOs). This category represents all the entities that are involved in the financing and implementation of development projects and programs including those related to the export sector. The Ghana Monitoring and Evaluation Technical Services Support Project (METSS) is financed by the USAID and implemented by a cohort of three institutions namely, the United States Department of Agriculture/Foreign Agricultural Service (USDA/FAS), the University of Cape Coast (Ghana) and Louisiana State University Agricultural Center International Programs. In the framework of this project a database of development assistance in Ghana was created. It contains all the recently ended, on-going and planned projects that have been implemented in Ghana by development partners along with specific information on each project such as objectives, activities, M&E methodology and impact. This was intended to be an exhaustive list of development projects and it was thus easy to identify organizations that have been involved in development projects related to exports. A total of six organizations (ACDI/VOCA, AFD, GIZ, IFAD, JICA and MiDA) have been interviewed. Those were generally

personal interviews (for one organization two persons were interviewed at the same time) that took place in the offices of the respective organizations, in Accra.

Finally, because they are public institutions that have been constantly playing an important role in Ghana's export sector development, the identification of relevant ministries, government agencies, universities and research institutions was straightforward. From the identification to the recruitment of the interviewees the research assistant facilitated the contacts information. For those institutions that have accepted to be part of the research, one representative or more were personally interviewed in their offices. We interviewed representatives of two ministries (MoFA and MoTI), four government agencies (CEPS, GFZB, GEPC and CMC), one research institution (FRI) and two universities (Cape Coast and University of Ghana at Legon). For the University of Cape Coast we organized a focus group of six professors and research assistants at the agricultural economics department. The structure of the focus group was the same as before.

For personal interviews we took notes while focus groups were taped. All interviews were transcribed shortly after.

2.3.2.2 Analysis of Interviews and Focus Groups

As mentioned previously, data were collected via focus groups but also personal interviews. Data collected in the first parts of the focus groups and data from personal interviews require the same type of analysis. The conversation was semi-structured and participants responses were detailed and could cover topics that may not be relevant for the purpose of this research. As such, qualitative coding is

unavoidable. “Coding means naming segments of data with a label that simultaneously categorizes and account for each piece of data” (Charmaz, 2006, p. 43). One approach would be to use preexisting categories of factors of performance and competitiveness as reviewed in the literature and coding the data in function of these categories. However, our objective is to identify factors that are relevant to Ghana’s agricultural export sector, create an analytic framework of Ghana’s export performance. Therefore, in this research, we chose to conduct coding as in grounded theory. Grounded theory encompasses the methodology and methods that can be used to analyze qualitative data when the main objective is to generate theory (Strauss and Corbin, 1997). The coding was actually performed in two phases. First, data are studied line by line (Esteberg, 2002). During this phase, the perceptions of the stakeholders are interpreted. This phase led to the creation of initial codes. As such, it is the “coding that leads to the development of theoretical categories” (Charmaz, 2006, p. 51) and not the other way around. In the second phase, the codes were reduced to the most important and larger segments of data were categorized with this set of codes. For each category we wrote a descriptive summary (Krueger, 1998), occasionally quoting participants[3]. Once the categories were well defined and described, we re-focused on the central purpose of the study and proceeded to the redaction of concluding remarks (Krueger, 1998).

[3] Quotations are anonymous.

2.4 Results

2.4.1 Analysis of Ghana's Export Price Competitiveness

2.4.1.1 Selected Currencies Weights and Evolution

Currency weights have been computed for the selected countries. As mentioned in the methodology, three types of weights have been used to construct the overall weights, namely, the import, export and third-competition weights. Since 1960, the importance of these selected countries in Ghana's trade has changed. Figures 2-4, 2-5, 2-6 and 2-7 illustrate these changes. To make the figures more readable and understand the main trends, we only represented annual weights which are based on annual trade data and we categorized the countries into five groups which are "Europe" (Belgium, France, Germany, Italy, the Netherlands, Switzerland and the United-Kingdom), "emerging countries" (China, India, Malaysia and South Africa), the United-States, Japan and other countries (Côte d'Ivoire and Nigeria).

Figure 2-4 depicts the evolution of import weights. At the independence (1957), Ghana was importing most of the goods and services from the United-Kingdom and other European countries. Overtime, imports from emerging countries have been increasing relative to imports from Europe. Imports from Nigeria have also gained importance such as today, imports from "other countries" are as important as imports from European countries.

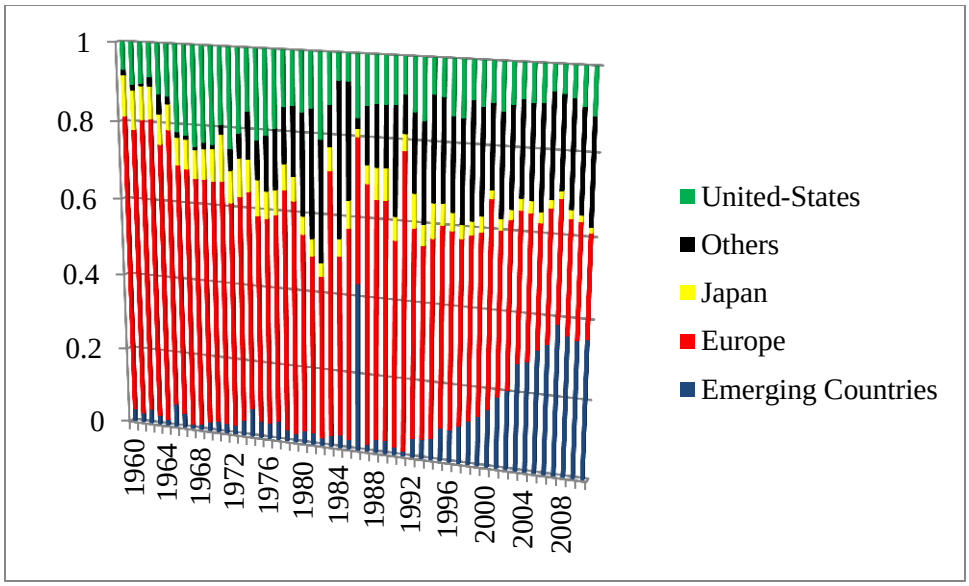

Figure 2-4: Annual import weights (1960-2010).

If we examine figure 2-5, we can see that European countries represent the bulk of Ghana's exports. Overall, their importance seems to have been constant although since the mid-nineties their share has been decreasing in aid of emerging countries. United-States' weight was higher during the sixties and seventies and Japan's weight was slightly higher during the middle of the studied period. Exports to other countries have been growing during the last decade.

The way third-competition weights were constructed makes China an increasing competitor of Ghana (figure 2-6). It is not surprising since China represents the bulk of imports of most Ghana's trading partners. European countries, Japan and the U.S. also appear to be important competitors of Ghana due to their omnipresence in international trade. If we could have limited the study to agricultural exports, the weights would have been most certainly different.

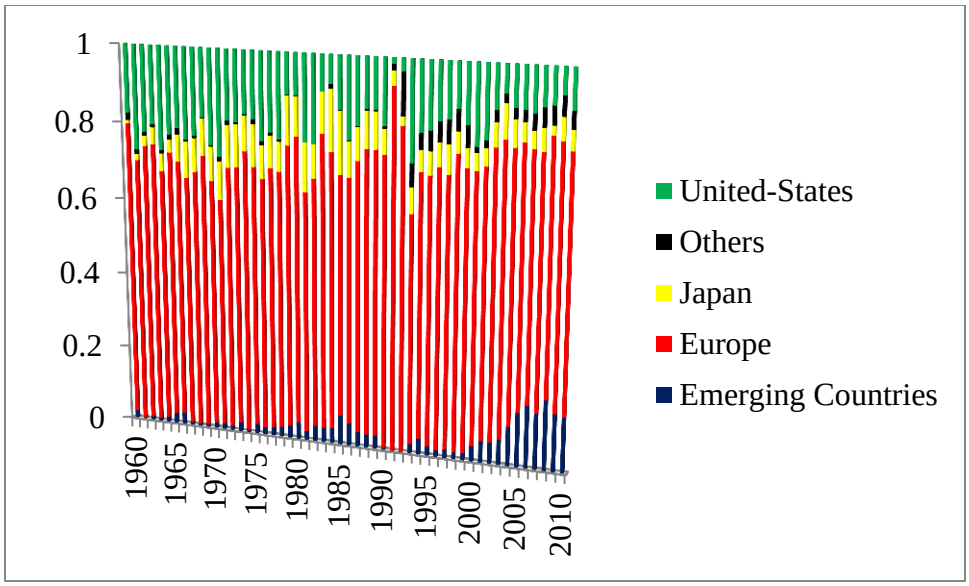

Figure 2-5: Annual export weights (1960-2010).

Finally, figure 2-7 presents the evolution of overall weights. The way these weights are computed gives more importance to import weights. Therefore, countries such as Nigeria present increasing weights. The overall weights also capture the increasing importance of emerging countries not only in Ghana's trade but also in the World's trade.

If we now look at the changes between 1960 and 2010 by country (table 2-5), the largest increase in the overall weight was for China followed by Nigeria. For both countries, this increase is mainly inflated by import weights. Export weights are small but have been increasing between 1960 and 2010. China also appeared to be the main competitor of Ghana in third countries but again, the results might have been different if we could have used bilateral agricultural trade instead.

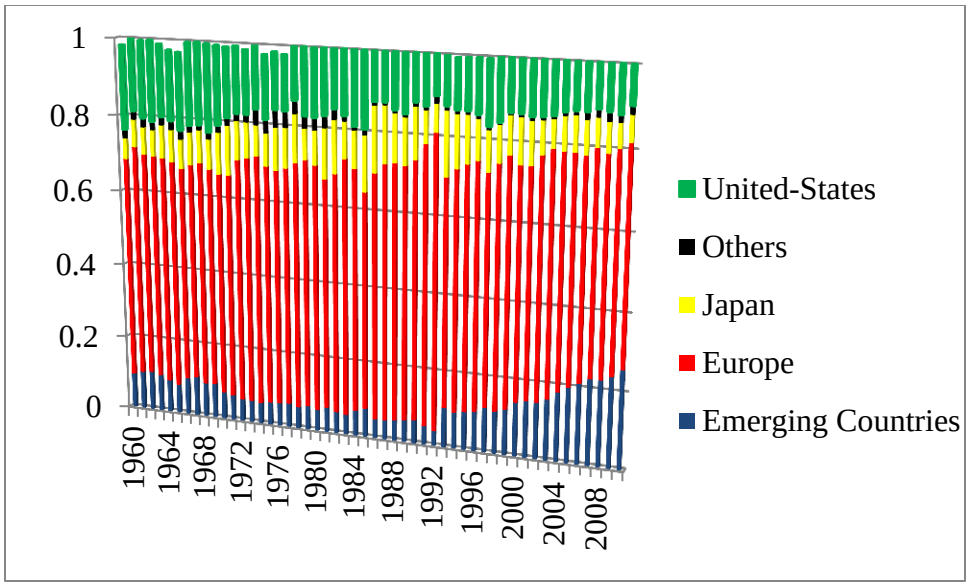

Figure 2-6: Annual third-competition weights (1960-2010).

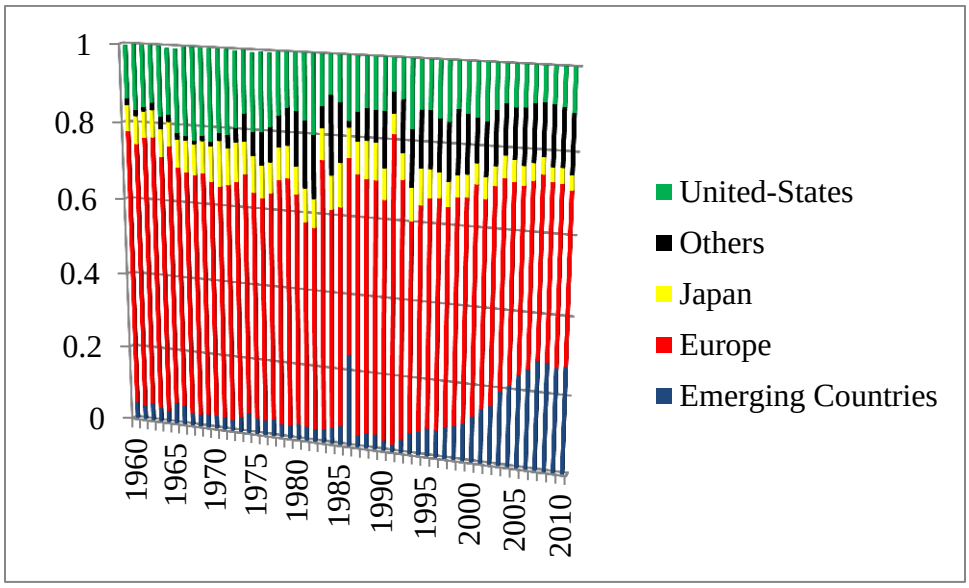

Figure 2-7: Annual overall weights (1960-2010).

Among the emerging countries, India has the largest export weight. Exports to this country are significant and growing. The weights of European countries have decreased especially for the U.K. who has the largest decrease. The decrease in the U.K. overall weight reflects a fall in all three weights (import, export and third

competition). Nonetheless, the U.K. export weight remains the largest after the Netherlands, suggesting that this country is still a strong export market for Ghana. France and Belgium are the two only European countries for which the overall weight has increased (table 2-5).

2.4.1.2 Review of Ghana's Exchange Rate and Monetary Policies

This section is a review of Ghana's exchange rate and monetary policies since the sixties. The objective is to provide enough background to interpret the movements of historical exports and the REER.

- **Ghana's Exchange Rate Policies: From Fixed to Floating**

Ghana adopted different trade regimes overtime. At the independence, Ghana's currency (Ghana Pound) was fixed to the British Pound. And, in the spirit of the Bretton Woods system, Ghana opted for a fixed exchange rate regime in the 60's (Aryeetey, Harrigan, & Nissanke, 2000). In 1960, Kwame Nkrumah became the first president of Ghana and in 1961 was enforced the Exchange Control Act which confers to the Bank of Ghana (BoG) the control of flows in foreign exchanges. The Act stipulates, among other things, that "no Ghana resident shall receive in Ghana any external currency as payments for services […] or goods" (Exchange Control Act, 1961, Act 71). As a consequence, a black market rapidly emerged. In 1965 a new currency was introduced, the Ghana Cedi. It was initially pegged to the British Pound and later, to the U.S. dollar (GHS 0.71/US$ in 1966). The Nkrumah's Government (1960-1966) policies resulted in large current account deficits (-212 million of US$ in 1965-Stryker, 1990).

Table 2-5: Weights of selected countries (1960 and 2010).

Weights	**Overall (*w*)**			**Import (μ)**			**Export (ε)**			**Third competition (τ)**		
	1960	***2010***	***Change***	***1960***	***2010***	***Change***	***1960***	***2010***	***Change***	***1960***	***2010***	***Change***
Belgium	3.88	5.65	1.77	1.71	3.38	1.67	3.41	8.31	4.89	8.68	7.55	-1.13
China	0.86	17.44	16.58	1.02	22.66	21.64	0.50	4.44	3.94	0.90	20.00	19.10
Côte D'Ivoire	0.69	4.74	4.05	0.89	8.54	7.65	0.93	1.63	0.70	0.03	0.26	0.23
France	4.04	7.30	3.25	2.49	5.70	3.21	1.04	10.35	9.31	10.14	7.42	-2.73
Germany	14.21	7.76	-6.46	13.31	3.10	-10.21	15.71	6.09	-9.62	14.51	18.73	4.22
India	1.62	4.90	3.29	0.99	6.01	5.02	0.22	5.41	5.19	4.27	2.17	-2.10
Italy	4.34	3.21	-1.13	2.42	2.24	-0.18	6.61	3.10	-3.51	5.90	5.25	-0.65
Japan	6.78	3.61	-3.17	10.38	1.38	-9.00	0.90	5.04	4.14	5.49	6.65	1.17
Malaysia	0.00	2.48	2.48	0.00	1.61	1.61	0.00	4.38	4.38	0.00	2.31	2.31
Netherlands	11.47	9.83	-1.63	11.71	5.04	-6.67	14.23	21.11	6.88	8.22	8.14	-0.08
Nigeria	1.02	9.91	8.89	0.44	17.44	17.00	0.90	2.91	2.01	2.28	1.84	-0.45
South Africa	1.97	2.93	0.96	1.19	5.01	3.82	1.33	0.34	-0.99	4.17	1.36	-2.80
Switzerland	1.40	1.83	0.43	0.96	0.25	-0.71	0.00	3.93	3.93	3.69	2.91	-0.78
United Kingdom	33.80	7.68	-26.13	45.43	6.12	-39.31	36.52	12.74	-23.78	7.84	5.73	-2.11
United States	13.46	10.73	-2.73	7.06	11.52	4.46	17.69	10.20	-7.48	22.04	9.67	-12.37
Total	100.00	100.00		100.00	100.00		100.00	100.00		100.00	100.00	

Therefore, in 1967, following the recommendations of the IMF, the second Ghana Cedi was introduced which led to a devaluation of 20% (GHS 0.86/US$ in 1967).Despite the breakdown of the Bretton Woods system, Ghana conserved a fixed exchange regime until the second half of the eighties. The Ghana Cedi was pegged to the U.S. dollar and largely overvalued as shown by the parallel market exchange rates. Indeed, the official exchange rate increased from GHS 1.02/US$ to GHS 3.45/US$ between 1970 and 1983 while black market exchange rates increased from GHS 1.64/US$ to GHS 76.58/US$ during the same period. This is believed to have negatively affected the competitiveness of Ghana's export sector (Aryeetey et al., 2000). Several discrete devaluations occurred nevertheless during this period (in 1971, 1973, 1978 and 1979). In particular, Busia's Government (1969-1972), recognizing the need to absorb the balance of payments (BoP) deficit, adopted a market-oriented strategy and devaluated the Ghana Cedi twice during his mandate. Other Ghanaian governments realized that a change in relative prices was necessary to improve the external payments position but this was mainly achieve through export taxes and import tariffs (Asuming-Brempong, 1998; Aryeetey et al., 2000). With the ERP (1983), Ghana's exchange rate regime started its transition from fixed to floating. From 1983 to 1986, a multiple exchange rate system was enforced. It consisted of a system of bonuses (to exporters) and surcharges (to importers) which led to the establishment of a multiple exchange rate system. Traditional (crude oil, essential raw materials, basic foodstuffs and capital goods) and non-traditional trade were subject to two different exchange rates (Aryeetey et al., 2000).

The two exchange rates were rapidly unified at GHS 30/US$ (January 1984-Aryeetey et al., 2000). According to Herbst (1993), this system was a way of embracing the undoubtedly necessary reforms while resisting to the dictate of the IMF who was promoting a radical devaluation. The multiple exchange rate system was really a transitory measure that allowed the Government to test the effect of devaluation without incurring the wrath of the people (Herbst, 1993). Between 1983 and 1986, periodic devaluations of the Ghana Cedi were announced by the government (Herbst, 1993). The Ghana Cedi depreciated from GHS 2.75/US$ in April 1983 to GHS 90/US$ in January 1986 (Aryeetey et al., 2000). In 1986, a two-window or dual exchange rate system was established (Bhattarai and Armah, 2005). Window one maintained a fixed exchange rate and encompassed traditional exports, government transactions and petroleum imports. The second window concerned all other transactions and used weekly foreign exchange auctions conducted by the BoG (introduced in September 1986). The Government rapidly abandoned the first window such that all transactions were governed by the weekly auction. This reform led to further devaluation of the Ghana Cedi (GHS 150/US$ in February 1987-Aryeetey et al., 2000). In 1988, the GoG took a giant step towards a floating exchange rate regime allowing the establishment of foreign exchange (forex) bureaux which depreciated even more the Ghana Cedi in real terms (Herbst, 1993 and Bhattarai and Armah, 2005).

The bureaux are privately owned and can freely buy and sell in the foreign exchange market. It is largely admitted that both auctions and forex bureaux have reduced the parallel market (Aryeetey et al., 2000). A floating exchange rate regime

was finally adopted in 1992 when the wholesale auction system (which succeeded to the weekly retail auction) was replaced by the interbank market (Bhattarai and Armah, 2005). The goal was to absorb the gap between the auction and forex bureaux exchange rates (Aryeetey et al., 2000). In 1992, the exchange rate was down to GHS 437/US$ (Aryeetey et al., 2000). Today both commercial banks and forex bureaux are operating in the foreign exchange market. We expect that Ghana's exchange rate reforms have positively impacted Ghana's exports.

- **Inflation: A Major Problem at the Heart of Ghana's Monetary Policies**

Reporting the view of many authors, we will state that inflation is the core issue of Ghana's economy. Our objective is here to give the reader enough background on Ghana's inflation to understand its possible influence on export price competitiveness. For a more detailed review on Ghana's inflation we refer to Chhiber and Shafik (1990), Sowa and Kwakye (1991), Younger (1992), Sowa (1994), Sowa (1996) and Ocran (2007).

The causes of Ghana's inflation are multiple and still disputed. Fiscal deficits and public debt are generally pointed as the main causes of a country's inflation. According to Headey and Fan (2008) the three main causes of inflation in Ghana are remittances, public spending and oil prices. These causes have been tackled in priority during the ERP. Moreover, shocks in food staple commodity markets such as rice and wheat which are highly imported in Ghana can pass through food prices and cause inflation. Indeed between 2007 and 2009, during the World food crisis, the annual inflation rate rose from 11% in 2007 to 19% in 2009 (figure 2-8). Changes in

food prices have a significant impact on Ghana's inflation as food represents most of Ghanaian households' expenditures. According to the Ghana Living Standards Survey (Ghana Statistical Service, 2008), food expenditures (actual + imputed) represent 50.9% of total annual expenditures. Note that Sowa (1994) reported that in the 1988-Ghana Living Standards Survey households were spending 65% in food.

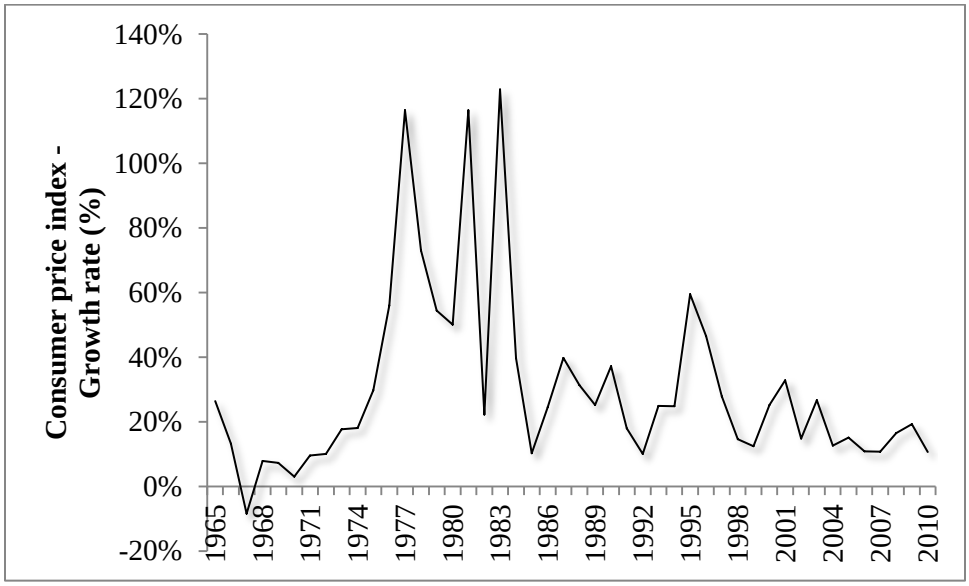

Figure 2-8: Ghana's annual inflation rate (CPI, 2000=100, 1964-2010).

Younger (1992) believes that increasing capital inflows have induced inflation. Indeed, since the beginning of the eighties donor assistance has increased in Ghana. This assistance takes the form of grants, loans and technical assistance and leads to foreign exchange accumulation, credit to the banking system and excessive public spending (Sackey, 2001). Chhiber and Shafik (1990) share this view and explain that capital inflows have led to strong aggregate demand and thus, inflation.

Younger (1992) argues that devaluation has brought significant inflation. Indeed, to be able to neutralize the increasing capital inflows imports should increase which is

impossible with a low Ghana Cedi. Exchange rate reforms may also have induced the so-called cost-push inflation caused by high import prices (Chhiber and Shafik, 1990). High economic growth is also often associated with inflation. Indeed Ghana's GDP has grown at a fast pace during the last two decades and short-run aggregate supply may not have kept up with the demand. Continuing with supply-side arguments, agricultural growth is specially intertwined with inflation as agriculture is an important sector of Ghana's economy and food is the bulk of Ghanaian expenditures. Sowa and Kwakye (1991) are advocates of this view and explain that inflation has been mostly influenced by real factors in Ghana (food production). Indeed, figure 2-8 clearly shows that inflation rates dropped between 1995 and 1999 which corresponds to a phase of high agricultural growth (Glover-Meni, 2008).

Prior to 1983, the monetary management in Ghana was based on direct controls in accordance with Ghana's economic goals (The Bank of Ghana, 2012). In particular, money supply was controlled by interest rates, sectoral credit ceilings and reserve requirements. Although the Bank of Ghana Act (1963) fixed the money supply growth to 15% per annum; money supply grew tremendously during the sixties and to a larger extent, the seventies (40% per year between 1972 and 1982-Sowa, 1994). This was in part due to large public deficits that were financed by the BoG. Since the ERP, the GoG has committed to tight monetary and fiscal policies but inflation rates remain high. Figure 2-8 shows to which extent the ERP allowed Ghana to control inflation as the rate went down from 120% in 1983 to 10% in 1985. In 1992, the bank of Ghana adopted a market-based system of monetary management (The Bank of Ghana, 2012).

The year 2002 is another turning point. Indeed, in an article of Burke (2008), Opoku-Afari explains that in 2002 Ghana embraced a new set of monetary and fiscal policies. The Bank of Ghana operated for the first time independently (Bank of Ghana Law, Act 2002) and the monetary policy committee (MPC) was created. The current official goals of the MPC are to "maintain stable prices conducive to balanced and stable economic growth as well as to promote and preserve monetary stability" (The Bank of Ghana, 2012). Since 2002, the interest rate is the main monetary policy instrument and it is set by the BoG in accordance with Ghana's inflation targets, employment and economic growth objectives. The BoG (MPC) publishes its policy rate decisions periodically (figure 2-9). This led not only to a greater transparency of Ghana's monetary policy framework but also to a decrease in inflation. Indeed, inflation rates were cut by half between 2001 and 2002. Finally, in 2007 (Burke, 2008), price stability (low inflation) became the main objective of Ghana's central bank. In particular, the medium-term objective became to maintain single-digit inflation (Bank of Ghana, 2012). To achieve this objective, inflation targets are set annually, based on the CPI (The Bank of Ghana, 2012). Successfully, in September 2011, the year-on-year inflation was 8.4% (Ghana Statistical Service, 2011).

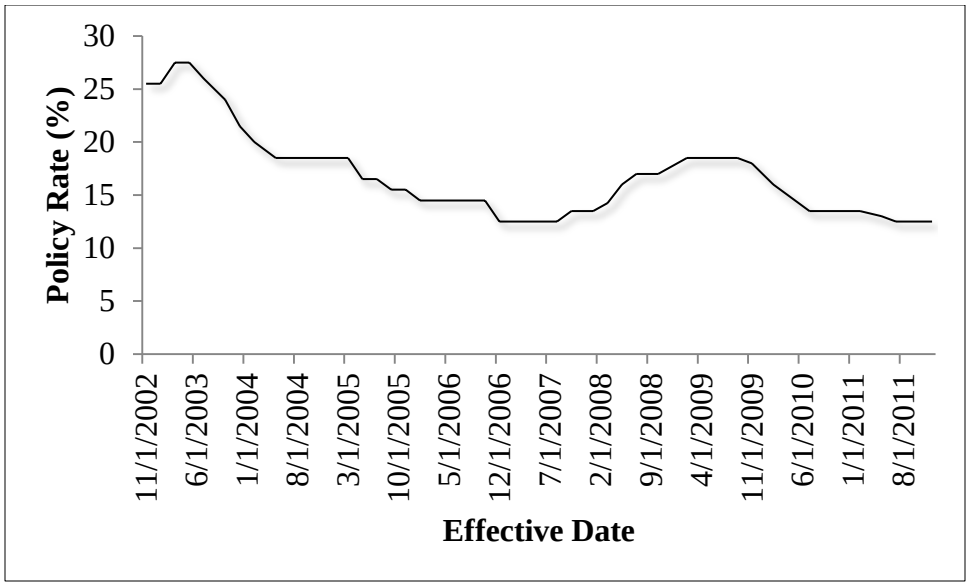

Figure 2-9: Bank of Ghana's policy rate.
Source: The Bank of Ghana (2012).

As a final comment, it appears that during the past decade Ghana's inflation rates have been low and inflation volatility has declined (figure 2-8). This suggests a relationship between inflation uncertainty and the level of inflation. There is extensive theoretical and empirical evidence on this relationship and two hypotheses have been tested in the literature. An increase in the level of inflation can cause inflation uncertainty because of greater monetary policy uncertainty (e.g., Friedman, 1977). Other authors (e.g., Cukierman and Meltzer, 1986) have shown that is actually higher inflation uncertainty that leads to an increase in inflation.

2.4.1.3 Evolution of the Ghana Cedi Trade-Weighted Index (REER)

Figures 2-10 and 2-11 show the evolution overtime of the annual and quarterly real effective exchange rates respectively. Overall, the downward trend suggests that Ghana's export price competitiveness has improved. From 1964 to 1975 the REER is fairly stable. In 1975, Ghana entered a period of macroeconomic and

political instability, governments followed one after another and the second oil shock (1978-79) occurred. No major exchange rates or monetary policies were implemented but the context of instability and increasing public debt pushed Ghana's inflation rates at their highest. Then, when the ERP started (1983) the REER fell drastically. The period between 1983 and 1986 corresponds to the implementation of a multiple exchange rates system and a series of discrete devaluations. After a brief increase in 1986, the REER fell again with the introduction of the 2nd window (September 1986). The adoption of a floating exchange rate regime in 1992 slightly improved Ghana's competitiveness. The REER was stable during the nineties and decreased again at the beginning of the 21st century, when further macroeconomic reforms took place (Bank of Ghana Act). Since then, the REER has remained stable. To summarize, we would say that after 1983, the improvement in price competitiveness was first due to exchange rates reforms and then to monetary reforms.

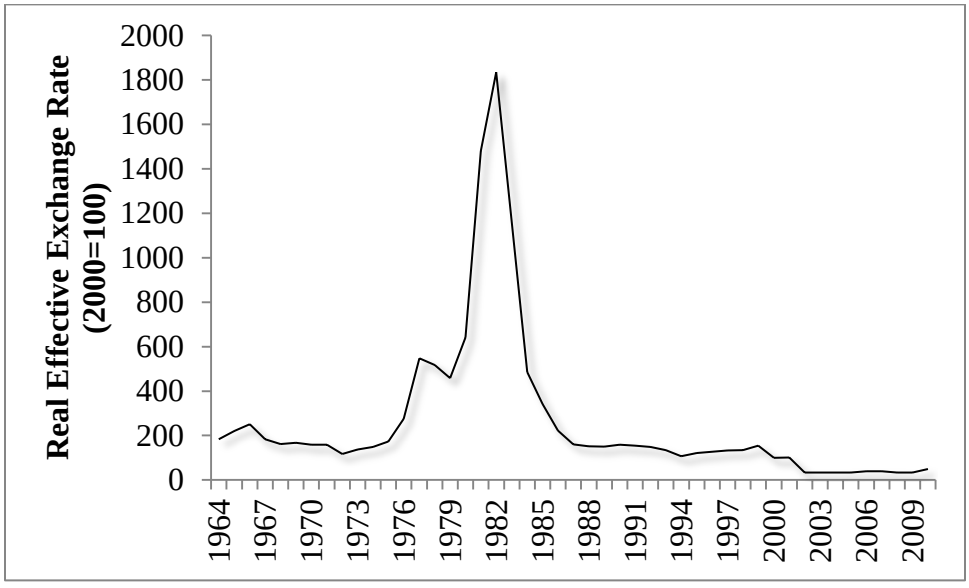

Figure 2-10: Ghana's annual real effective exchange rate (1964-2010).

Figure 2-12 represents the evolution of Ghana's CPI relative to the trade-weighted CPI. We can see that since 1984, Ghana's price levels have increased continuously. This might support both hypotheses that exchange rate reforms and increasing foreign capital inflows have caused inflation. Until the end of the nineties, Ghana's inflation, as measured by the CPI, was lower than foreign inflation and fairly stable. With the turn to the 21st century, Ghana's inflation exploded and has become largely over foreign inflation. Although not presented here we found that the NEER counted for much of the real effective exchange rate variability.

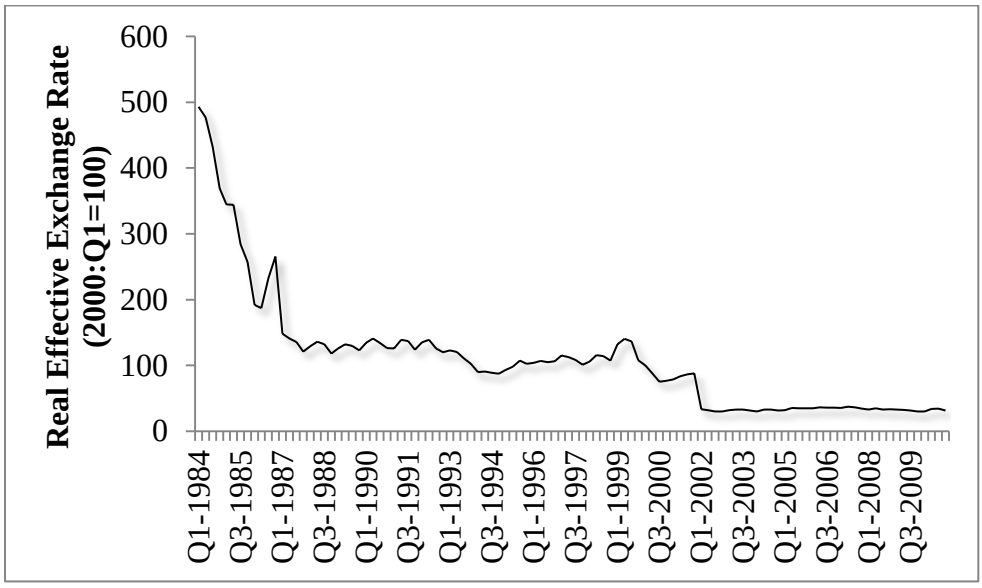

Figure 2-11: Ghana's quarterly real effective exchange rate (1984:Q1 to 2010:Q4).

The difference between price levels in Ghana and in its trading partners, although very pronounced, did not influence as much the trend of the REER. This result corresponds to the observation of Bhattarai and Armah (2005).

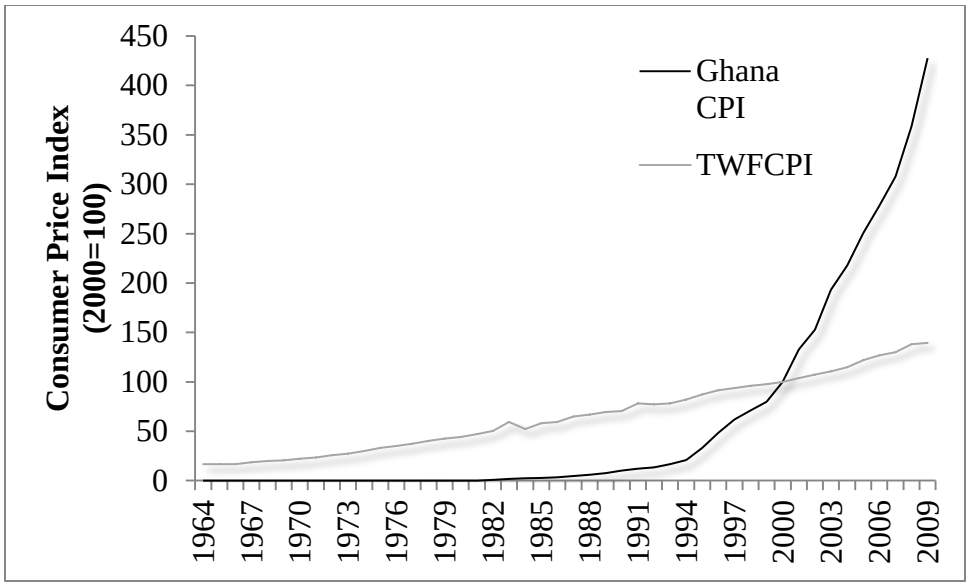

Figure 2-12: Ghana's annual CPI and trade-weighted CPI (1964-2010).

2.4.2 Factors of Export Performance from the Perspective of Ghana's Agricultural Sector Stakeholders

Using grounded theory, the analysis of the data collected during the interviews and focus groups has led to the generation of 17 different factors of export performance (table 2-6).

2.4.2.1 Agro-Climatic and Environmental Factors

Ghana's agro-climatic conditions are generally perceived as a competitive advantage of its export sector. For some productions, the type of climate (frequency of raining seasons) allows several harvests per year (e.g., mango and cocoa).

Also, the cycle of production can be shorter in Ghana than in other major players of the sector (e.g., baby corn relative to Kenya) which allows Ghana's producers to harvest several times. Another major strength of Ghana is its location.

Table 2-6: List of export performance and competitiveness factors based on stakeholders' perspectives.

	Factors	Definitions
1	**Agro-climatic and environmental factors**	Characteristics of climate, agro-ecology, location and environmental issues
2	**Infrastructure**	Irrigation system, transport system, post-harvest infrastructure and food industry equipment
3	**Human resources**	Labor availability and quality, training and extension programs
4	**Product characteristics**	Emphasis on aggregate production: horizontal and vertical diversification, quality
5	**Factors of production and transportation**	Availability and costs of good quality inputs and raw materials, transportation costs
6	**Foreign direct investment**	Settlement of foreign companies
7	**Technology and standards**	Analysis of production systems, land productivity, technology level and adoption, role of research, standards and certification
8	**Finance**	Financial capital access and adequacy, interest rates
9	**Laws and regulations**	Laws, land tenure, contract farming, export procedures and regulations
10	**Market information, knowledge and promotion**	Foreign market knowledge, data availability, price information, products promotion
11	**Uncertainty and risk**	Crop failure, crop yield risk, crop insurance policy, price volatility, market availability
12	**Farmers' organizations, participation and other social dynamics**	FBOs, communication between stakeholders, farmers and other stakeholders participatory approaches
13	**Macroeconomic stability, policies and other Government-related incentives**	Macroeconomic and political stability, exchange rates and monetary policies, sectoral policies, state control and privatization reforms
14	**Demand conditions**	Trends in foreign markets, principal/mature markets, shocks, tastes and preferences, global trade rules, tariff and non-tariff barriers. Trends in domestic markets
15	**Market structure**	Main competitors Market and firms size, number of producers, number of buyers
16	**Institutional support**	Governmental institutions and international agencies support (initiatives and programs)
17	**Price incentives**	Export prices trends

Compared to its competitors, Ghana is closer to major export markets (i.e., Europe). Ghana also shares borders with three countries: Côte d'Ivoire (West), Togo (East) and Burkina Faso (North). Producers living in borderlands benefit from expanded markets. They can export or sell locally depending on demand conditions. Note however that most of the trade occurring across borders is not declared.

Although profitable and increasingly exported, fruit and vegetable productions are heavily dependent on water supply and irrigation systems. This explains the concentration of these productions in the Southern part of the country. On the other hand, pest-related risks are lower in the North where there is only one raining season. Mango production is currently expanding in the North for that very reason.

Agricultural development programs and policies have been successful at exploiting specificities of Ghana's agro-ecological zones. It has been determinant in Ghana's export development. The expansion of crops for export (e.g., pineapple) has led to environmental issues from deforestation to soil fertility reduction. Eventually, these issues can hamper crop yields and prevent producers from obtaining certifications centered on good agricultural practices. During the focus groups with fruit producers, the theme of environmental issues was recurrent which was surprising at first. It is not until after that the link between environmental issues and the GlobalGAP (good agricultural practices) certification was established.

Another growing concern is climate change. Extreme weathers like droughts and floods are more frequent and seasons are less and less predictable.

2.4.2.2 Infrastructure

The lack of infrastructure has been pointed as one of the main impediments to the development of Ghana's exports. Northern Ghana, the driest and poorest part of the country, is especially devoid of infrastructure. "The development of physical infrastructure would render agriculture more attractive there." "The development of vegetable productions for export is possible in the North but the lack of infrastructure is the limiting factor."

Poor infrastructure may impede the adoption of new technologies. For instance the commercial production of MD_2 pineapples requires cooling the fruits immediately after harvesting in order to maintain quality and shelf-life. At the time of the MD_2 introduction in Ghana, there were no appropriate facilities.

Poor irrigation infrastructure limits the expansion of fruit and, to a great extent, vegetable productions and put a ceiling on crop yields. "Irrigation is not pursued enough, if there is no water there is no point giving fertilizers and seeds." The performance of irrigation systems is also linked to electricity supply. Power supply is irregular in Ghana. There are frequent power cuts that limit the use of pumps and sprinklers and affects production. A regular power supply is crucial for the development of fruit and vegetable productions and agro-processing. Indeed, power cuts cause breaks in value chains (cold chains). In addition, agro-processing activities require filtered water. The reinforcement of value chains has been recently identified as a strategy to increase the value of Ghana's production and exports. In the chain of activities, post-harvest management requires infrastructure for storage and to handle merchandise in ports. This type of infrastructure are still lacking in Ghana. Upstream,

supply chains are impeded by transport. Road networks are limited and in bad condition. Access to farms is thus difficult. “When it rains roads are unmotorable.” Constant roadwork delays traffic. Rail transport would reduce delays considerably. There are already rails in Southern Ghana but thedac are not developed enough for cargo. The Ghana Free Zones Board is planning developing the rail for the second park (free export zone). This project is however on hold because of limited funds. Indeed, the development of free zones requires important quantities of physical and financial capital. The Board buys the land and does the initial provision of infrastructure (power, water, roads…). Companies established in free points are generally agro-processing companies and do not benefit from the same infrastructure existing in the park. They can however ask the Board for assistance. For instance, the Board can put pressure on the electricity company of Ghana to bring electricity where export businesses are settled.

International agencies have significantly contributed to the development of infrastructure that reinforces value chains: irrigation systems, feeder roads, graded laboratories, grain drying facilities, warehouses and cargo centers. Once constructed, the management of these infrastructures is transferred to the public sector. The lack of public infrastructure is felt as a weakness. “Because there are no public infrastructures we [agro-processing companies] have to invest individually.” It also supposes that small producers have to be linked to agro-processing companies or larger producers (out-grower schemes) that have the financial capacity to invest in infrastructure. Some international organizations have pushed the formation of out-grower schemes and provided support to the settlement of foreign agro-companies in

Ghana by funding irrigation systems and other infrastructure. From the interviews and focus groups, we noticed the lack of communication between potential users of infrastructure and funders. At the time of the field work, participants were complaining that there was a storage facility at the airport in Accra but that it was not used. “It is a policy failure!” What they did not know is that the cargo center had not been inaugurated yet. It is now operating.

It also appeared that the cocoa sector does not suffer from the lack of infrastructure like in the other sectors, save the cocoa processing industry. “The cocoa sector benefits from strong infrastructure.”

2.4.2.3 Human Resources

- **Business/Entrepreneurial Skills**

Public stakeholders would like farmers to be more market/business oriented. It is generally small-scale farming that is associated with non-commercial agriculture. Public stakeholders also gave the impression that commercial crops are not the main activity of cocoa farmers. “Cocoa is often not the main activity of producers and we try to make them see cocoa production as a business.” On the contrary, farmers believe that they are more and more business-oriented. When comparing themselves to their parents, producers say that they are doing business and scientific farming. “Our parents were just farming. […] We look at potential buyers before starting cultivating.” Also, it appeared that farmers producing export crops devote the largest proportion of their arable land to export crops. For instance, pineapple producers are

using on average 15% of their farm for the production of food crops (e.g., cassava and plantain).

There is an apparent need to support farmers to create business plans. For instance, having a solid business plan would facilitate farmers' access to loans. This could be accomplished through training. In the agro-processing industry, the lack of entrepreneurship and expertise has also been cited as one of the main weaknesses.

- **Training and Extension**

One of the components of capacity building is human resource development through training. The need for capacity building has been pointed by public stakeholders (including universities) as an essential element for Ghana's export competitiveness. "To make Ghana's products more competitive, we need business capacity building." "The lack of capacity building is one of the challenges to overcome in order to develop Ghana's export sector […] Stakeholders need more training." Farmer-based organizations (FBOs) have a major role to play in capacity building. MiDA's mission in Ghana was to train farmers. In this perspective, MiDA centers its training programs on group dynamics, commercial development of FBOs in addition to technical advice. Farmers having received MiDA training were generally pleased with the program.

Farmers recurrently denounce the lack of training and extension. They particularly identify the need for training programs on certification. "GlobalGAP represents a good opportunity but to be certified we need training." Farmers also express the need for training on soil management, plant protection and material

handling. Farmers think that extension services from MoFA are limited and inadequate. Some interviewees explain that this inadequacy is due to agricultural students' poor training. On the contrary, vegetable producers believe that with more training from MoFA they could produce more. Cocoa farmers recognize that extensionist support is a major strength of the cocoa sector. However, they seem concerned with the quality of extension services. "Extensionists should be more numerous and well-motivated." "I would like to see extensionist going to the farms, see the trees, the lands and offering advice." Small-holders supplying agro-processing companies or large farms receive free technical advice from agronomists employed by those companies. Trials and demonstrations are run on farm and farmers can learn. Not only farmers need training. Some agro-processing companies are "participating to training on developing technologies to take advantage of the growing market". The pineapple sector has been partly rescued with training to which MoFA, buyers and international agencies have contributed. Producers value the services that they received. "We learn through training."

- **Labor**

Business owners including farm owners are "resilient", "strong", "stubborn" and "full of hope" and this is perceived as an advantage of Ghana's export sector. However, farmers are aging and their level of education is generally low which impedes technology adoption. The average age of farmers is 55 when life expectancy is 64 in Ghana. The size of the potential labor force is also perceived as an advantage of Ghana's export sector. Nevertheless, if labor is potentially available, farmers encounter difficulties to find people willing to work either permanently or

temporarily. Vegetable and some fruit productions are labor intensive and the seemingly lack of labor has become a problem. Different factors can explain the lack of labor. First, in Northern parts of the country there is migration to the South. Second, youth and educated labor are not interested in working in agriculture. "Students graduating in agricultural sciences are not going back to farming. They are taught how to make agriculture a profitable business. They acquire the necessary knowledge. This creates a potential pool of educated farmers but none go back to farming even with incentive packages." […] "They are 700,000 unemployed graduates in Ghana, 20% in agricultural sciences and another 20% in business." "There is a low interest of youth and educated people for agriculture. They don't perceive it as a business." According to a survey conducted by the University of Cape Coast (UCC) half of students graduating from agricultural sciences don't want to work in the agricultural sector and the other half want to work preferentially in the export sector that they perceive as more lucrative. The third problem is that labor is shared among different activities. "Everybody is working." "Casual labor is scarce because it is shared between different activities (fishing, vegetable production, salt production…)." Fourth, the hardness of farm work is also a problem. "You have to weed often." Faced with the lack of labor and intensity of the work, producers feel the need to replace labor with technology.

In the pineapple sector, stakeholders seem less concerned about labor availability. Farmers were explaining that labor is available because jobs are well-defined. "Workers are specialized in the different activities of the farm. […] They know what they have to do and at what time of the year." "They are ready to work."

"It is their primary occupation." In the cocoa sector labor was also less a concern. It seems that farms are taken over by the new generation. "We don't want our legacy to be spoiled". And labor is generally available. "If you can pay them, they will work."

Labor is not only unavailable but also of low quality. Some interviewees were saying that labor is often unqualified and uncommitted. The level of education is low and it is difficult to teach them how to work. Some business owners have come up with innovative systems of rewarding workers. Each worker or two are allotted a portion of the land. They can use the techniques they want as long as the job is done. Lastly, some farmers can't afford to pay extra-familial labor. "Even if labor is available, it is simply too expensive."

- **Expertise**

What transpired from the interviews is the necessity to think export development in terms of regional or sectoral expertise. Regions that have been traditionally producing a commodity have acquired expertise throughout the years which should be the foundations of export development programs. For instance, the cotton sector is currently revived in northern regions "where they have technical knowledge." Pineapple production was established in the pineapple belt long before the Government decided to develop non-traditional exports. It is actually when programs or business initiatives do not take into account this existing expertise that production fails. For instance, the adoption of the MD_2 pineapple failed because of a lack of expertise in the management of new varieties and in particular in post-harvest management. The production of smooth cayenne or other traditional pineapple

varieties should have been reinforced in priority. Farmers established in traditional zones of production also see their expertise as strength. In this perspective, the GEPA has developed Export Production Village Schemes to take advantage of the expertise of producers. They have identified areas or villages where there is a product that has been traditionally produced and provide support for its expansion.

Foreign companies settling in Ghana also bring their expertise. They are generally well-established in other countries before coming to Ghana. This explains their success and transfer of expertise can occur for the benefit of the whole sector.

2.4.2.4 Products characteristics

- **Diversification**

The diversification of Ghana's export base occurred at different levels. At the national level, the campaign of diversification started in the mid-nineties. The development of non-traditional exports was the product of a Government's initiative to decrease Ghana's dependence on cocoa, gold and timber exports. Horticultural productions were the main target. That's when the boom of pineapple and chili pepper happened. Chili pepper is now called "the express cocoa." It is as lucrative as cocoa, it is produced by small-scale farmers but has a shorter production period. One of the main objectives of the creation of free export zones was also to encourage the diversification of exports. Foreign agro-processing companies settled in Ghana and introduced innovative products such as fresh-cuts fruits that are produced for exports.

At the regional level, diversification has been pushed in regions that were less export-oriented (North). Productions such as Shea nuts, mangoes, cashews and

soybeans are today expanding in Northern regions. At the farm-level, new activities have been introduced to increase farmers' revenue especially during the lean season. For instance, honey and snails productions have started to complement cocoa farming. Producers also make and sell sub-products of their main crops (e.g., cocoa butter soaps).

- **Quality and Volumes**

All stakeholders of the cocoa sector agreed that Ghana's cocoa beans are of good quality compared to other countries. Indeed, in future markets Ghana cocoa beans are classified in group A meaning that cocoa beans are delivered at a premium price ($160/ton on Oct 31, 2012). The quality of cocoa beans and consequent premium contributes to export growth. "It pushes production and exports." On the contrary, vegetable productions quality is generally pointed as an important weakness of the sector. In order to be competitive in export markets constant quality and constant supply are required. And yet Ghana's vegetable production is ensured by numerous small-scale farmers. Quality may also be intertwined with volumes. Producers have to fill containers before being able to ship. It is particularly the case of vegetable producers. "If we would do more volumes, we could shorten shipment time." If shipment time increases, products quality decreases. It is precisely because vegetables are produced at small-scale that producers can't meet volumes requirements. "We need more surface area to fill a container." There are also problems with packaging and food safety. As a result, vegetable exports are limited to low-end markets and merchandise is often rejected. Producers and exporters denounce the lack of quality control at the national level. "Farms have their own

quality control." Producers recognize that neighboring countries are producing better quality vegetables. Consequently, Ghana suffers from neighboring countries competition in third markets but also domestically. It is the case with Niger's onions. There was a bit of controversy around the quality of exotic fruits and in particular pineapple. Stakeholders from the public sector attribute Ghana's pineapple crisis (after the introduction of the MD_2) to the quality of traditional varieties that could not be maintained. "Smooth Cayenne lost its market share […] it was their fault […] they don't do the right thing." Interviewed agronomists were further explaining "they are not applying well fertilizers and they harvest too early, so the natural flavor is not there." Producers-exporters are on the contrary confident that their pineapples are close to the "natural taste". They have the feeling that the problem comes from consumers that do not know what a pineapple or a mango is supposed to taste. "The consumer is educated by the wholesaler/supermarket. […] In Europe you buy a mango and before it ripens it is already dehydrated, and you eat a mango that has the taste of a cucumber."

- **Value-added Agriculture and Agro-processing**

Agro-processing is growing in Ghana and foreign companies have played an important role in the development of the agro-processing sector. Companies operating in free export zones have to process and export 70% of their production. The establishment of foreign agro-processing companies also encourages production as they multiply market opportunities for producers. For instance, the opening of canneries (tuna) has induced an increase in fish extraction.

Innovations do not only come from foreign companies settled in Ghana but also from research institutions and local businesses including producers. For instance, the Food Research Institute (FRI) has released several innovative agro-processed products such as spices, dry fruits and convenient forms of maize, roots and tubers. These products and equipment have been perfected to export to European countries where important West African communities have settled. The reinforcement of cassava value chains and the development of cassava processing into starch, gari and flour for export markets represent a sizeable opportunity and would involve a large portion of Ghana's population.

In order to develop Ghana's agro-processing sector, a consensus has emerged that value chains will have to be reinforced. "Support is provided to all actors along the value chain to make Ghana's agriculture competitive both at the national and international levels." Three factors could strengthen value chains namely, FBOs, extension services and product standardization. During the field work, we could observe that the concept of value chain has been generalized at all levels of the agricultural export sector. For instance, in higher education, all agricultural sciences courses now integrate the concept of value chain.

Note, that these trends do not transpire from agricultural export figures as most of agro-processed products fall into the second sector of the economy (manufactures).

2.4.2.5 Factors of Production and Transportation

- **Inputs Costs and Supply**

There are two dimensions to inputs that can explain Ghana's export performance namely, availability of inputs and their costs. In the agro-processing sector, there is a problem of raw materials supply. For instance, the domestic supply of milk and sugar, essential components in the production of chocolate products, is very limited. Agro-processing companies have to import those raw materials. Milk is imported in powder and has to be reconstituted. Imports of raw materials inflate costs of production and so are packaging and equipment imports. Ghana's cocoa processing factories should have a competitive advantage since they do not have to import the main input which is cocoa beans. However, stakeholders explain that because Ghana's cocoa beans are more expensive, cocoa processing is limited. "We would have to use cocoa beans from Ghana only." This would decrease the competitiveness of Ghanaian cocoa processing companies compared to companies in Europe that can blend beans according to the market price. Foreign-owned cocoa processing companies established in Ghana are backward-integrated. They produce intermediate products (e.g., cocoa butter) and are owned by companies in Europe that produce end-products. Backward integration strategies result in cost savings and competitiveness increases. Government-owned cocoa companies do not have price discounts on cocoa beans compared to foreign-owned companies.

The development of free export zones has increased the settlement of foreign-owned agro-processing companies in Ghana. It allows them to locate close to raw materials. The same idea is behind free export points as companies can settle in rural

areas. It is particularly important in the case of fresh fruits or vegetables as they have to be processed rapidly. The problem of raw material supply can also be seasonal. For instance, fruit-processing companies settled in Ghana will only be seasonally supplied by Ghanaian producers (e.g., mango). The rest of the year they will buy from other African countries. Fruit agro-processors notice that fruits produced in Ghana are generally more expensive. This issue has pushed some agro-processing companies to delocalize some of their operations in other countries.

Agro-processing companies are generally supplied by small-holders in a so-called out-grower scheme. And to avoid the problem of inconsistent supply they require a minimum surface area.

Talking with producers, we also felt a problem of access to high quality inputs. “Vegetable productions have potential but there is a lack of seeds.” For instance, imported seeds from neighboring countries are not certified. “They come with diseases.” In vegetable productions, high quality seeds are imported from Europe which inflates costs of production. Some producers prefer importing seeds from African countries, providing that they are of good quality. Alternatively, producers use recycled seeds to reduce costs. It is the case of Asian vegetables. And, although this production represents a good opportunity for export, production fails partly because of poor quality seeds. Producers were also complaining about ineffective or “fake” agro-chemicals.

The adoption of new technologies such as new varieties can drastically increase costs of production to which small farmers have to adjust. For the MD_2

pineapple “you need plastic mulch and control more fungal diseases.” “Costs of production are twice higher.” “At the introduction of the MD_2 farmers had to buy planting materials that were very expensive and they lost their business.”

Producers-exporters were complaining about how fast costs of production were increasing compared to output prices. Among the most cited costly factors of production are irrigation, power, agro-chemicals, organic matter, certified seeds and machines. High costs of production are believed to be one of the main weaknesses of Ghana’s vegetable productions.

- **Transportation**

The proximity of Ghana to the main export markets might explain why transport costs were rarely pointed as a factor decreasing Ghana’s export competitiveness. However, some farther markets remain untapped (e.g. the U.S.) because they would imply to sell in upper-end markets in order to maintain profit margins. Despite this proximity, freight is expensive. Oil prices strongly influence freight unit costs. Maritime freight, if feasible, is cheaper. That explains why the demand for sea-freight produce has been growing in export markets. But in order to grasp this opportunity, Ghana’s producers-exporters have to find reliable and regular vessels.

Domestically, transportation can be a limiting factor to the development of new zones of productions. “The development of vegetable productions is limited in the North by high transportation costs.”

2.4.2.6 Foreign Direct Investment

Two of the most important factors that have contributed to the growth of foreign direct investment (FDI) in Ghana are the country macroeconomics and the free zone Act. Democracy, good governance, enhanced business environment and political stability have attracted FDI while free zones have accommodated it. The primary objective of free export zones was to encourage export-oriented foreign investment. Amongst companies operating in free zones, 40% are Ghanaians and 60% are foreign-owned or joint venture. International agencies have also encouraged the establishment of some large commercial farms with the intention to increase small producers' market opportunities. "Foreign companies are very important. They significantly contribute to the economy of the country." "The establishment of international companies has been important in Ghana's export sector development." "They generally perform better than Ghana's companies and their performance in international markets encourages production and exports." Many foreign companies have settled in Ghana for agro-processing. In fact, free zone policies are more advantageous for agro-processing companies, especially those located in rural zones. Companies in free zones do not pay corporate taxes for ten years. After this grace period, agro-processing companies will pay taxes at a reduced rate. Reduced rates apply to all types of companies settled in rural zones. FDI can also support the development or revival of certain sectors of production. It is the case of cotton production that is carried out by three foreign companies. The initiative was governmental and each company has received concessions for cotton production. Foreign processing companies often come to Ghana as a mean to expand their

operations, being closer to raw material supplies and sometimes closer to export markets. Foreign cocoa processing companies have emerged at the beginning of the 2000's. Nuts processing companies from India are another example. Instead of importing nuts from Ghana, processed them in India and export to Europe; they started to process directly in Ghana.

2.4.2.7 Technology and Standards

- **Production Systems**

All interviewees, except producers-exporters, qualify Ghana's production systems as "traditional" and "inefficient". Crops of extraction such as cocoa beans and shea nuts are managed traditionally. "Shea nuts are cultivated in the wild. This is a disadvantage compared to Burkina Faso or Mali where they have succeeded in domesticating the crop." "Farmers produce cocoa in a traditional way […] like their parents and grand-parents used to do."

More intensive/technical productions such as vegetables and fruits suffer from a misuse of agro-chemicals. Fluctuations in cotton production and exports are due to an inconsistent use of pesticides and fertilizers. "Farmers do not know how to produce well because they do not use the same quantity of resources for the crop from one year to another." Some interviewees were attributing the pineapple crisis to poor production practices. "Some small pineapple farms have collapsed… those who don't listen." But the fundamental issue is more that small producers cannot afford the inputs required to manage these crops properly.

Some interviewees have also brought the problem of monoculture that favors pest outbreaks.

- **Productivity**

There is a consensus that crop yields are not at their full potential and that the marginal effect of fertilizers would be high. Stakeholders of the sector base this belief on the yields that are obtained in neighboring countries but also comparing average yields to research station or on-farm trials yields. For instance Ghana average cocoa yield is 350 kg/ha while it is 600 kg/ha in Côte d'Ivoire. With these benchmarks in head, in order to increase national production projects and programs focus on crop yields increase instead of surface expansion, promoting and supporting the use of fertilizers.

- **Research**

Several export sectors have been supported by scientific research. For instance, recent cocoa production growth is partly due to research. "Research had a huge impact." "The CSSVDCU[4] has supported replanting with disease resistant trees." The seed production unit (SPU) has also supplied farmers with high-yielding hybrids. Cocoa farmers value national research efforts and view them as an opportunity to further expand cocoa production and exports. "They can help us improving yields and meet quality standards."

In the other sectors, there is on-going research on shea nut cultivation; oil palm sector research is carried out by the Oil Palm Research Institute (OPRI) and the

[4] Cocoa Swollen Shoot and Virus Diseased Control Unit

release of Legon 18, a variety of chili pepper developed at the University of Ghana, has propelled exports of chili peppers. Nevertheless, the general view is that research is lacking in vegetable and fruit productions. National research on fruits and vegetables is limited "because they don't have the resources but also because there is a disconnection between research and farmers' needs."

Vegetable producers denounce the focus on food crops. "Most research is on cassava and maize; the most produced and consumed crops." Indeed, roots and tubers productions have been supported by several programs including the root and tuber improvement (and marketing) program (RTIP and RTIMP - IFAD). Vegetable producers also feel the need for research on climate change such as the cultivation of drought-resistant varieties.

The FRI is carrying out innovative research on roots and tubers processed forms in particular. Compared to other West African countries, it seems that Ghana is ahead in food sciences research. At the regional level, there is an initiative between West African countries to cross-fertilize ideas on selected crops in R&D. Public-private partnerships in the area of R&D is limited. Stakeholders "wish there would be more team up with the private sector." The private sector consults research institutions as there is little R&D in the private sector, "because of a lack of scientific knowledge." Research is mainly funded by donor agencies.

- **Standards and Certification**

Standards represent an opportunity to expand Ghana's agricultural exports but are currently more felt as a threat by stakeholders. Small farmers can't meet the high

standards that prevail in export markets. For Ghana, “exporting represents too many constraints.” “Export markets are bounded by stringent rules.” Standards prevent producers from exporting. “It is a too complex market where Europe is the main importer and imposes high standards.” For some productions, Ghana has the potential to export to new markets but standards requirements are difficult to meet. “Quality standards are like disguised trade barriers.” For instance, Ghana produces Kobi which is salted tilapia that could be exported to the U.S. But that would imply to apply a certain type of treatment to achieve the required percentage of dryness. Currently, Ghana’s producers-exporters do not have the means to achieve those standards. In a more and more globalized market standards are always higher. “Standards have changed and are higher and higher.” For instance, since the European Union has harmonized its import requirements, rules are becoming stricter. It used to be easier to export to Europe as some countries were more lax than others. Ghanaian producers-exporters also feel that the U.S. has more stringent rules than Europe. “Countries that have fruit flies can’t export to the U.S.”

Recognizing the importance of quality standards in a country export performance and competitiveness, Ghana’s stakeholders have recently supported the certification to GlobalGAP (prev. EurepGAP). Although this certification represents a good opportunity for fruit and vegetable sectors, small producers encounter difficulties to adopt the practices required to be certified. “They need training and financial support.” As a consequence, vegetable productions are confined to low-end markets. “If you want to export to more profitable markets, you need to be certified and be able to package.”

In the cocoa sector, there are certifications that represent opportunities to tap niche export markets (e.g., organic, UTZ and rainforest). Certified cocoa beans attract a premium (e.g., organic: 20% and rainforest: $200/ton). Foreign companies can approach producers to be certified, they act as licensed buying companies. Producers perceive Fair Trade as an opportunity but agro-processing companies find Fair Trade not advantageous. "Europeans force us to do Fair Trade but importers reduce each year the price they pay to us."

- **Technology Adoption**

The MD_2 pineapple variety is a technological innovation that had a strong influence on Ghana's export sector. Stakeholders point out that it is the market that has driven the introduction of the MD_2 in Ghana in 2004. The adoption was slow and uneven which hampered Ghana's competitiveness momentarily. One of the barriers to its adoption was the cost of production. The MD_2 is more expensive to produce than traditional varieties. Producers had to acquire planting material. And this had to be done rapidly in order to maintain Ghana's market share in the pineapple export market. The express multiplication of planting materials has been supported by a cohort of research institutions and organizations. In addition, MD_2 pineapple production systems are more technified and costly. For instance, the MD_2 is more sensitive to pathogens (e.g., Phytophthora) than traditional varieties. It has also been reported that the MD_2 pineapple cannot be planted in contours in order to assure proper drainage. Large farms were able to start producing MD_2 in part because the unit cost of planting material was lower for them. While small farms were lagging, the MD_2 was increasingly demanded in export markets at the expense of traditional

varieties such as the Smooth Cayenne. Many small producers lost their farms and some export-oriented groups or cooperatives collapsed (e.g., Farmapine).

Stakeholders of Ghana's pineapple sector believe that more technology adoption such as mechanization is needed to increase the country's competiveness.

Beside costs of production there are other factors preventing technology adoption especially from small farmers. Education has been cited as one of these factors as well as a lack of trust towards technology. The latter relates more to new varieties or products. Stakeholders have reported several cases in which farmers were incented to adopt new varieties or products for which there was no market. Small-scale technology is also often misused. Farmers do not use properly technological packages. They try to adapt them, use only some parts. They "re-invent" them what leads to their failure. For instance, the cocoa high-tech package includes fertilizers that had to be applied during the raining season. A farmer was complaining to an extensionist about the low quality of the package "it bends my cocoa". But the farmer was fertilizing after the raining season (in the heat). There are also cases of farmers that use insecticides on vegetables instead of cocoa or farmers that double the dose to make them more effective. Finally, precision agriculture is seen has a potential technology to adopt in the future for cocoa production. The necessity of exploring precision agriculture has been driven by increasing concerns about climate change and the dangerous reliance on rain-fed agriculture.

2.4.2.8 Finance

Finance is perceived as one of the most important impediments to the expansion of Ghana's export sector. "Funding is hard to come by." And "pay-back is difficult."

First of all, financial capital is expensive. The Bank of Ghana fulfills its objective of price stability by setting interest rates at high levels (15%). Consequently, commercial banks interest rates are close to 30%, thus discouraging entrepreneurship and investment in the agricultural sector. Some stakeholders explain that high interest rates are also the product of a vicious circle. Small producers borrow from banks, cannot reimburse because their businesses are not profitable enough to fulfill payments, and, as a consequence, banks will increase interest rates even more. But "with high interest rates how farming can be profitable?"

The problem of high interest rates was not broached as much as we were expecting. The access to capital is more problematic than its cost. "When you arrive to banks and present yourself as a cocoa farmer, negotiations don't even start." Farmers have expressed the need to access to long-term loans and this for several reasons. Some need long-term loans because their production is seasonal. For instance, cocoa harvest is concentrated during the main season which corresponds to the principal money entry. They have to rely on this capital the rest of the year. Second, some farmers have the desire to make long-term investments such as expanding their farms. "If you go to the bank and say that you want to expand your farm for cocoa farming, they will never give you a loan." "If you have two hectares and want to expand your surface area, it is impossible to get a loan." "If you have the

land and want to start cultivate it, you need money to do the planting, cultivate and pay labor." Third, long-term investments are also necessary to adopt new technologies. "Farmers are aware of the technologies that are required to increase production and exports but do not have the financial resources to adopt them."

Another striking issue is that loans are not adapted to agriculture and in particular to long cycle crops. "Financial services have to be agriculture specific." "They do not take into account running costs." "Mango trees start producing after 3 to 5 years while loans have to be repaid after 6 months." "Pineapple can take up to 14 months to produce." "Cocoa trees start to produce after 4 to 5 years." "Loans are just for typical commercial purposes. Farmers cannot pay back rapidly. You have to take into account production cycles."

Further, farmers have difficulties to access loans because they do not have collaterals. Some stakeholders believe that producers that have certified or graded products have a better chance to borrow from banks. "Your certified product can be used as collateral."

We identified several initiatives that producers are taking to get round these financial issues. Farmers can turn to diverse money lenders instead of borrowing from banks. "Banks are not prepared to invest in agriculture." They can borrow from colleagues or receive loans from buyers. We raised the question of the role of agricultural development banks (ADB) which are scattered in the whole country. The ADB was created to support the development of agriculture but according to some

farmers “they are useless.” “When you want to save money with them it is easy but when you want loans it is a different story.”

Governmental institutions or international organizations can also momentously fill the gap between the sector financial needs and financial capital supply. For instance, KfW has created the out-grower and value chain fund (OVCF) to fill the gap between short-term and long-term financial services. Also, the export development and investment fund (EDIF) mandate is to provide loans to support farmers that want to start a business in the export sector. However, farmers rather think that the EDIF is unserviceable. They explain that the EDIF grants funds to commercial banks but banks do not promote these funds as they have their own funds that are more expensive. MiDA has a credit component to support the MD_2 adoption. The Cocobod supports financially the whole sector by borrowing money at low interest rates (2-5%). Cocoa beans are offered as collateral to obtain cheap loans. The MoTI has also momentously supported pineapple production levying importers on some commodities and used these revenues to support the first pineapple farmers.

Finally, contract farming can help farmers to finance their activities. It gives to banks the guarantee that farmers will be able to reimburse loans. In the rubber and oil palm sectors there are tripartite schemes between farmers, industrials and banks. The French agency of development (AFD), who supports the project, makes a loan to the Bank of Ghana (BoG). This allows the BoG to give capital to commercial banks that in turn will offer low-cost loans to farmers. Interest rates are as low as 7%. These loans enable farmers to plant trees and wait the necessary 5 years (oil palm) and 7 years (rubber) to start harvesting and generate revenue. Likewise, agro-processers

supplied by small-holders (out-grower scheme) can link them to banks. They can also advance money to them and retain accordingly when they supply.

Farmers have also expressed the need to be helped and trained in business plan writing in order to be more prepared to negotiate with loan providers.

2.4.2.9 Laws and Regulations

- **Laws**

There are a couple of laws that have been identified by stakeholders as important factors in the expansion of Ghana's export sector. The first is the Free Zone Act (1996) that frames the development of free export zones in Ghana. The explicit objectives were to create employment, attract FDI, introduce new technologies, expand the export base and increase foreign exchanges. A more recent law is the Plants and Fertilizer Act (2010) that should contribute to the expansion of Ghana's fruits and vegetables exports. This law has been prepared by MiDA and MoFA and should improve produce quality and allow farmers-exporters to receive higher prices.

- **Land Tenure and Use**

The access to land and the ability to choose its usage appears to be problematic in Ghana. Land is particularly expensive compared to other African countries. "Outright purchase is not easy." Moreover, land tenure systems are complex because they integrate both customary and common laws. Most lands are owned by chiefs, communities and families. "The chiefs or family heads are the ones that decide the use of lands."

Farmers, and in particular those living in peri-urban areas, expressed the lack of security in terms of land tenure. Some farmers who were renting their land explained that owners can take back the land to lend for other uses (e.g., church, housing) at any time.

Farmers cannot possess vast extensions of land because it is owned by families. Ownership is joint. “At times, land can be there but you start farming and family members can come and claim the land even if they have never worked it. It is for the entire family.” Families do not allow one single member to work individually on a large surface area. They divide the land between family members. Most are farmers but “the problem is when some want to produce cassava while others want to do cocoa.” Cocoa farmers were explaining that in a sense, cocoa certifies ownership. “Cocoa prevents people from stealing your land.”

Because lands are divided between family members the acquisition of large parcels is difficult. “So, if a father has ten children, you divide the land into ten. If you want to acquire 1,000 hectares you may have to see 10,000 people. It is thus difficult to buy large portions of land. Even if the Government would like to acquire land, it will have to deal with and compensate many land owners. They have to solve this issue of land tenure!” For some farmers, the dimension of the parcels is actually an advantage. “We are not rich and if we want to expand we can only buy parcels of less than 2 hectares.”

In the case of out-growers schemes, we encountered different types of land ownership. Sometimes farmers own their land, other times the company buys the land and puts farmers to cultivate.

Some farmers have come up with potential solutions to the problem of land tenure and use. “District assemblies could enforce district land use policies to demarcate areas on which you can’t build. If you are a land lord and you are in an agricultural area but are not interested in farming, you will have to lend your land to farmers via long-term contracts.”

All growers agreed that urbanization represents a threat to the development of the agricultural sector. “As population grows, farm land is taken for housing.”

- **Contracts**

Out-growers schemes and contract farming have been expanding in Ghana. These types of partnerships are typically developed either between small growers and a larger farm that is in measure of exporting or between growers and agro-industrials or agro-processing companies. These partnerships have a huge potential to develop Ghana’s export sector. Vegetable producers were explaining that out-grower schemes represent a good opportunity for the vegetable export sector to expand. “Out-growers have access to large markets thanks to the presence of big guys. Big guys are also able to give small farmers access to certification. It is also a good opportunity to improve product quality and access high-end markets.” Nevertheless, they are some limitations to the well-functioning of these partnerships and their impact on Ghana’s export sector. First, contract farming per se exists only in the rubber and palm oil

sectors. Out-grower schemes are more informal. Sometimes there are not even contracts or contacts are not respected or well specified. “The problem is that people don’t understand contracts.” “The reasons of their failure are beyond economics. It is not about how formal a contract is but how it reflects social bounds.” Other stakeholders have denounced abuses from buyers. “They come and pick what they want. For the rest, it is the responsibility of the famer to find other buyers.” “The integration of small holders in the export market would be greater if nucleus farms would buy a fix percentage each year.” “Consistency is important. […] For cashews for example, sometimes producers pack the nuts and nobody comes to pick them up.” Producers are not always paid.

Private stakeholders urge the Government to develop policy documents on out-grower schemes and contract farming. “We need a small team to review policy documents of the MoTI and MoFA and to include guidelines on out-grower schemes and contract farming.”

Some were also arguing that contract farming does not work for products that can be sold and consumed locally. It functions well for production such as rubber but no as much for vegetables or fruits. There are also problems with palm oil as red oil is consumed in Ghana.

- **Procedures and Regulations**

Stakeholders mentioned some regulations and procedures that have seemingly contributed to the expansion of Ghana’s export sector. For instance, an interviewee explained that a large proportion of producers of non-traditional exports are illiterate.

Thus, the CEPS has recently simplified the forms required to export and provided exporters with assistance to fill those forms. Moreover, the CEPS has been trying to automate documentation in order to speed up export formalities and procedures. Exporters don't have to send the documentation by mail anymore. They are already automates in Tema, Accra airport, Takoradi and Aflao (Togo border). Another regulation that may have contributed to the growth of exports is the obligation for companies operating in free export zones to export more than 70% of their production. There are rigorous controls but monitoring is difficult for companies that are not in the park.

2.4.2.10 Market Information, Knowledge and Promotion

International companies operating in Ghana are generally "doing better" than Ghanaian-owned companies. It is because foreign companies had already their export markets before settling in Ghana. "They start with something." It is the case of Indian-owned companies that produce fresh vegetables in Ghana for export. They were already exporting Asian vegetables to the U.K. "Indian businesses are still operating while Ghanaians have given up."

In order to increase their visibility in export markets, Ghanaian exporters are participating to trade fairs such as Fruit Logistica. Exporters explain that it gives them the opportunity to establish strong linkages with export markets, interact with importers, receive orders and introduce new products such as dry fruits. In line with promotion strategies, the whole horticultural sector is trying to create a brand for export called "Ghana Fresh".

An important component of market information is prices. Unfortunately, there is no price information on non-traditional exports. Farmers themselves do not record prices and for those that have to go through an agent to be able to export, the lack of price information is a serious disadvantage. Some non-governmental organizations are trying to promote e-trade. Market prices are sent by text message as cell phones are the most popular mean of communication in Ghana.

According to many stakeholders, the recent expansion of Ghana's exports was also due to market research. We learned that the diversification of Ghana's export base into non-traditional products was the fruit of market research carried by the Government. They looked for products with high demand. The horticultural sector was specially targeted and it is the pineapple production that responded. Sea-freight pineapple exports were also developed after thorough research on the opportunities that represented this market. That is when appeared the association of sea-freight pineapple exporters.

2.4.2.11 Uncertainty and Risk

- **Insurance**

The lack of insurance policies in agriculture has been recognized as one of the main threats to the expansion of the agricultural sector and exports. Cocoa producers were illustrating the need for crop insurance: "You can't predict the weather. At times you will have lots of rain and at other times you don't have rain at all and yields will be very low." Farmers were suggesting that the Government could approach insurance companies to incite them to institute some type of insurance policy for

farmers. “If there are no insurances, there are no incentives for farming.” Some of them were remembering that few years ago some politicians talked about enforcing insurance policy “for when something happens to you.” Farmers are worried of what may happen when they will get too old to work in their farm. “If our farms are in bad times, the Government will not do anything so if we had insurances we could stay at float.”

- **Price Volatility and Market Security**

Agricultural markets and agricultural export markets in particular, are characterized by high price volatility. It is a challenge that Ghana’s export sector will have to overcome. “Price changes are due to the lack of roads, intermediaries and poor infrastructure.” Prices are especially volatile in the horticultural sector. “The problem with vegetable productions is that prices are volatile. It is a risk that small producers are not willing to take.” Cocoa prices are also very volatile but the centralized system guarantees minimum prices to farmers. “The producer is protected.” Some interviewees believe that because Ghana’s cocoa beans attract a premium, prices are relatively stables. The Ghana cocoa Board (Cocobod) used to oversee coffee production and commercialization as well. But since the liberalization of the coffee market in Ghana, production and exports have declined tremendously. “It is because of the coffee crisis which hit coffee producers and the fact that the Cocobod was not guaranteeing prices anymore.”

In addition to stable prices, export performance is linked to market security. From producers’ point of view, a force of Ghana’s cocoa sector is the “availability of

ready markets". "The problem with Ghana's agricultural sector is the lack of markets but it is not the case of cocoa. Cocoa producers have a ready market and that's the main reason behind cocoa growth." In the same area where cocoa producers were interviewed, citrus are also grown but "people are pulling down citrus trees and replace them with cocoa because there is no market for citrus." The key to produce and export more is that farmers need incentives in terms of markets. If there is a secure market, production and productivity increases will follow.

Out-grower schemes and contract farming guarantee a market for small producers and this encourages production. Pineapple producers were explaining: "because we have sure markets [agro-processors], we are encouraged to give our best in production." Some producers-exporters supplied by out-growers have been successful in obtaining fixed prices from their customers. As a consequence, they can in turn guarantee a fixed payment to their producers.

Note however that some stakeholders argue that it is a mistake to concentrate Ghana's resources on exports. "It is too risky because exports are highly specialized. Domestic markets are less risky."

2.4.2.12 Farmers' Organizations, Participation and Other Social Dynamics

An advantage of Ghana's agriculture is that producers are organized in groups, the so-called farmer-based organizations (FBOs). FBOs have encouraged large-scale farming and enable small producers to participate in export markets. Farmers groups are mainly focused on production and they rarely commercialize

together. Note however that when the boom of pineapple happened, farmer groups were created to cooperate in order to export directly (e.g., Farmapine).

Group dynamics have been encouraged by international organizations such as MiDA. Vegetable producers were very satisfied with MiDA training. “They deal with group dynamics.” Today, a large proportion of Ghana’s production and exports is supported by those group dynamics. “We work in group and it is one of the strengths of the sector.” Group dynamics take place for advice, support and information. “We can also borrow from colleagues money or even seeds”. “We sell individually but share price information.” “Through acts of collaboration between farmers (e.g., advance of planting material), even small farmers can produce pineapples.”

Group dynamics are also powerful for transfer of technology or techniques between farmers. “Farmers come from other parts of the country to learn from us.” “Those who are listening are making it and they are starting to make an impact on those that are not listening.” Likewise, companies are learning from each other’s. Successful companies are pooling companies to enter the market. “Companies have established themselves because they have seen the success story of others.”

Nevertheless, group dynamics will have to be strengthened in the future as there is still some lack of organization between producers. In particular, there is a lack of organization and coordination in terms of marketing strategies. Vegetable farmers were explaining that they would like to organize themselves to spread planting and harvesting. “If prices of carrots are high today, everybody will jump into the production of carrots without thinking that prices will drop.” FBOs may also

represent an opportunity to tackle financial issues such as access to credit. “Models of FBOs can use credit facilities.” “FBOs can be a group collateral.”

Another key of a strong export sector is the possibility for different stakeholders to share their mutual needs. For instance, a horticultural task force is currently created. “A horticultural task force is important. It gives the opportunity to ask for better services from the government.” The whole agricultural sector needs a platform to share mutual needs (e.g., farmers and financers).

The growth and competitiveness of the sector also depends on how independent stakeholders can be in terms of identifying their needs and act on them. “One way of increasing Ghana’s competitiveness is to build organizational capacity so that stakeholders can identify their own needs and provide adequate services in order to decrease the dependency of the sector on donors.” As an illustration, in the framework of smallholders’ certification, GIZ has created manuals so that farmers can develop their own quality management system which is based on a more generic one. “It will make them more competitive.”

2.4.2.13 Macroeconomic Stability, Policies and Other Government-Related Incentives

- **Macroeconomic Stability**

All stakeholders agreed that political stability, democracy and good governance were the main reasons behind Ghana’s agricultural exports take-off. “First, it is about policies and second, it is about political stability.” “Political stability means that loans are respected and that there is a functional judiciary system.” However, political instability in neighboring countries represents a threat to the

sector. “When there are problems in neighboring countries they close their borders and we can’t export.” “If we are not careful, what happened in Côte d’Ivoire can happen in Ghana.” Exports are intertwined with the macroeconomic environment. It is one argument against an export-oriented economy for some stakeholders. “Exports depend on the macroeconomic environment while food security stabilizes the economy.” As stressed in the previous sections, inflation has been a chronic issue in Ghana but recently inflation rates have fallen under 10% thanks to Government efforts. Exporters were associating inflation risks with exchange rates risks. “Inflation is not a problem anymore because Ghana imports and exports in U.S. dollars. […] The US$ is still a good barometer.” Some stakeholders were skeptical about the official inflation figures. “The Government will tell you that inflation rates are around 10% but we know it is more. If the Cedi is pegged to the US$ inflation is also fidgeted with it. It means that exporters suffer a lot. […] When you buy things it is not 10% but 20%, if not more. It is a challenge to pay employees in national currency.” For cocoa producers inflation is inconvenient because producer prices are announced at the beginning of the year and price levels (factor of productions) may increase throughout the year.

Some stakeholders have identified policies and Government intervention as major strengths of Ghana’s export sector. However, others have denounced the lack of consistency, continuity between successive Governments. “There is a lack of consistency in policy formulation in agricultural development programs. People are now advocating for a National Policy so that even if there is a change in government, policies will remain in force.” As an illustration, cocoa farmers were explaining that

precedent governments were organizing massive spraying but that spraying has decreased with the current Government.

- **Policies**

Policies were also a recurrent theme in the interviews and focus groups. Stakeholders have identified several policies or reforms that have strongly contributed to the performance of Ghana's export sector.

First of all, interviewees have confirmed that exchange rate regime reforms have contributed to the expansion of exports. "With floating exchange rates, exports became cheaper." "Devaluation contributed to export growth." Although Ghana's exchange rate regime is officially floating, some exporters feel that the Ghana Cedi is still pegged to the US$. "The Government pegs the Cedi to the US$. The Cedi becomes more expensive when you bring any foreign currency but the US$. If you bring any other currency it is not as strong as before and that can make you lose a lot of money. It is a big challenge."

Second, the liberalization of the foreign exchange retention system has also supported the growth of the sector. "Before the establishment of the 2nd window, export receipts were in Cedi […] there were foreign accounts (off-shore funds) […] exporters could retain up to 35% of their proceeds in a foreign currency. Now, there are no restrictions for non-traditional exports."

The above-mentioned arguments were generally given by stakeholders of the public sector or Academia. They believe that trade liberalization in general was the number one factor of exports development.

Third, exports have always been the subject of policies. “There were twelve different regimes of governments in Ghana and they always included a package to boost exports. […] The most impacting set of policies was the ERP.” Agricultural exports expansion was also due to sectoral policies. The agriculture services sub-sector improvement programme (AgSSIP) preceded by the national agricultural research programme (NARP), has supported the horticultural sector. The FASDEP and METASIP seek to create incentives for private investments in the agricultural sector. Some stakeholders acknowledge the role of private investments in “ownership sustainability” in reference to the need to decrease the dependency on donors. Those policy documents have specific objectives and actions that emphasize the potential role of exports in the increase of Ghana’s competitiveness and people incomes. Recently, policies have also been enforced to empower youth and entrepreneurs to do business and engage in agricultural exports.

Subsidies prevail in the cocoa sector. The Cocobod sponsors 80% of the fertilizers price. The Cocobod has also supplied millions of cocoa hybrid seedlings. Stakeholders of other sectors emphasize the need for subsidies for the development of exports. In vegetable productions they “need fertilizer subsidies and support to have access to good seeds.” “Inputs are costly, subsidies could help.” Stakeholders of “neglected” sectors are aware of the actions that the Government can potentially take. “The Government encourages the production of food crops like rice by using receipts from cocoa exports to subsidize inputs for food crops.”

The Government was systematically identified as the main initiator of export development programs: the rehabilitation of cotton and coffee, the development of the

horticultural sector, rubber and the campaign of diversification in general. As such, stakeholders always expect more from their Government. As a matter of fact participants of focus groups often pointed Government potential actions as the only way of solving problems or, conversely, as the main thing to blame. “Government support is inadequate. Sometimes you need to spray outside the window at which the Government is organizing spraying. We have to buy our own products.”

Finally, several stakeholders were complaining that the focus of public policies has recently shifted from exports to domestic food production. “Everybody focuses on food production and there is no policy effort to increase exports.”

- **Public Ownership and Privatization**

Despite decisive reforms towards the liberalization of Ghana’s economy, the Government remains the main shareholder of several sectors. For instance, cocoa is fully owned by the Government and it is estimated that 80% to 90% of the cocoa chain is Ghanaian-owned. Nevertheless, in the 90’s the system was partially liberalized (internal marketing). Today, around 90 licensed buying companies (LBC) are allowed to buy cocoa from Ghana producers. In the past only the produce buying company (PBC) was enabled to buy cocoa beans from producers. From the LBC warehouses, cocoa beans are transported to the Cocobod warehouses and from there, the Cocobod takes control. Some interviewees from Academia were arguing that some of these registered companies could also export.

Most stakeholders believe that the centralized system is an advantage of Ghana’s cocoa sector. Down-stream, the cocoa processing company (CPC) benefits

from being partially owned by the Government. For instance, they can pay the beans once the company has sold its production. The CPC was the only cocoa processing company until the cocoa sector was partially liberalized. Now, several foreign cocoa processing companies have settled in Ghana such as Cargill, ADM and Barry Callebaut. Cocoa sector stakeholders were comparing Ghana's cocoa sector with Côte d'Ivoire and Nigeria who have liberalized their cocoa industry. "This had a negative impact on the quality of their cocoa […] farm practices have deteriorated." Stakeholders believe that international institutions did not force Ghana to fully liberalize the cocoa industry because "Ghana's system is efficient enough." At the same time, they were recognizing that the disadvantage of a centralized system is that the efficiency is low. "When it is centralized, you don't care about costs." Coffee and shea nut productions are also overseen by the Cocobod but have been liberalized.

The cotton industry used to be wholly owned by the Government but with the structural adjustment programs cotton production has been privatized and managed by a multitude of small private companies. This, in addition to declining prices, has contributed to the vanishing of the cotton industry. Now, the cotton sector is in a phase of revival. Private-foreign-owned companies ensure the production while the Government owns the ginning part.

Finally, the horticultural sector is private and the governmental support to this sector has declined since they are now "moving on their own." The objective of international organizations operating in Ghana is to "create a strong private sector."

2.4.2.14 Demand Conditions

- **Opportunities and Limitations**

Stakeholders regularly mentioned where their products were exported and pointed some new market opportunities in terms of productions or geographic regions along with their limitations. They also identified the high and growing demand in export markets as an opportunity to expand their sector.

The supply of cocoa is increasing and so is the demand. Western Europe remains the biggest consumer of Ghana's cocoa beans but this market is now saturated. The potential for growth is in China, India, Russia and Japan. But these emerging markets do not have a strong chocolate culture. As an illustration, 40,000 to 50,000 tons are exported to Japan, 40,000 tons to China and 100,000 tons to the U.K. when the U.K. population is much smaller. The export potential to China and India is limited by the purchasing power in those countries. "A chocolate bar is too expensive for their per capita income." There are also opportunities in Eastern Europe particularly in Kazakhstan who buys 60,000 to 80,000 tons. However, they mainly buy processed beans from European and Malaysian companies. Exports to the U.S. are very limited. "There is no potential of growth in the U.S. because they are looking for low prices and are willing to cut back on quality." The U.S. buys more from Côte d'Ivoire. Cocoa products are not consumed in Ghana that is why the sector relies so heavily on exports. "The industry is driven by export markets where cocoa is processed. Anytime that there is a problem in those countries, Ghana's cocoa exports are affected. For instance during the recession and problems in the Eurozone, the price of cocoa butter went down drastically." Likewise, the crisis in Europe had an

impact on fruit processing companies' sales. "Sales used to grow at a rate of 20% per year but during the past four years sales have grown by only 5-6%." For fruit processing companies Europe and in particular the U.K. is the main export market. However, it is now a mature market and there might be opportunities in Germany, France and Spain. Exports to the U.S. are difficult because there is a lot of competition. Eastern European countries also represent a potential market but they are less used to handle fresh products. "They don't understand the concept of shelf life."

Some of the rice produced in Ghana is exported to African neighboring countries. Shea nuts are processed into butter and exported to the U.K. for cosmetics companies such as the Body Shop. Cashews are exported to India were they are processed. Yams are exported to the U.K. where they are sold in Asian markets. Europe is the main importer of Ghana's vegetables. They are often sold in Asian markets too. Winter is an opportune time to export to Europe (high demand) but it corresponds to the dry season in Ghana. Winters can be problematic. "When there is snow planes can't land." Vegetable producers do not feel affected by the European crisis because "it is food". Oil palm used to be produced for the domestic market but with the biofuels boom it started to be exported. Citrus are mainly exported to West Africa but they are also increasingly exported to Europe. Spain, Israel and South Africa dominate the citrus market (Europe imports) but they can't supply more. There is an opportunity for Ghana. The demand for fresh pineapple is high and growing. The Middle East represents a sizeable opportunity "but you need good trading terms." Finally, there is a growing demand for rubber in China and India.

- **Tastes and Preferences**

Stakeholders recognize that changes in tastes and preferences represent a risk for Ghana's export sector. Stakeholders need to be aware of these changes and respond quickly. Sometimes, it involves adopting new varieties or production practices and smallholders need support to make those changes. "Smallholders can't invest in production systems […] that would make them meet markets needs and preferences." "We have to help producers to meet consumers' preferences." The MD_2 pineapple is the perfect illustration of how changes in tastes and preferences can disrupt the whole sector. "That's what the market wanted." "They did not want the Smooth Cayenne anymore." "We export MD_2 because U.K. consumers prefer this pineapple variety. […] It is more yellow." In the case of sea-freight pineapples, Ghana's sector has been very reactive. In the mid-nineties, producers-exporters noticed that Europe was importing more sea-freight pineapples because it is cheaper than air-freight. Once they identified this trend and the opportunity that it represented, producers-exporters constituted a group to explore maritime transport possibilities. Another example is orange exports. "The problem was that because Ghana's oranges were green they were not well accepted by European consumers."

- **International Rules of Trade and Agreements**

There are several trade agreements from which Ghana's export sector can benefit. Ghana is eligible for the African growth and opportunity act (AGOA). Some sectors such as the textile industry have bloomed since the inception of the AGOA. However, the benefits seem more limited in the agricultural export sector. "On paper,

the AGOA seems full of opportunities but in reality it presents a lot of bottlenecks." The AGOA appears to be more restrictive than Europe's economic partnership agreements (EPAs). Ghanaians consider the restrictive standards of quality as the main trade barriers. "There is a lot of rejection because our products can't meet quality standards." High quality standards are not only in the U.S. and Europe. For instance, stakeholders were explaining that exports to South Africa are limited because they impose quarantine. Some countries have also enforced import quotas on some agricultural products. This is the case of bananas in Europe and this discourages production. "Trade barriers are the main threat to Ghana's exports expansion." Surprisingly, there were not many references to the economic community of West African states (ECOWAS) and its potential opportunities.

- **Domestic Market**

In Ghana, domestic and export markets are perceived as competing markets. While export rules are increasingly stringent, domestic demand increases and producers are turning to the domestic market. For instance, vegetable productions are remunerative but rejection rates are very high in export markets. In parallel, the domestic demand for vegetables is growing. "With oil discoveries, tourism and increasing investment in Ghana, there is a growing need for fresh vegetables from hotels and restaurants." In the horticultural sector, 50% of exports are rejected and go to the local market. But the domestic demand for vegetables and fruits has actually been growing following the expansion of those productions for export. "In the 80's or 90's if you asked a Ghanaian to name a fruit he would have said either an orange or a banana. Now fruits are becoming a good indicator of the kind of trends Ghanaians are

moving into. And the export sector had a role in highlighting the importance of this kind of products." We met several vegetable producers that actually stop exporting to sell locally. The domestic market is attractive because it is less risky and quality standards are lower. Export prices are generally higher but the tendency is reversing. Domestic prices are also more visible. Moreover, in case of shocks in the export market, exporters such as agro-processing companies can increase momentarily their sales in the domestic market. For instance, with the European crisis, domestic sales have been increasing at the expense of exports. When the conditions become better, companies do not always switch back to export markets. Hence, in a sense, domestic markets represent a threat to the expansion of exports but it is only the case for crops that are consumed in Ghana. For instance, the domestic demand for cocoa is limited by the purchasing power in Ghana. The price of a chocolate bar is half the daily wage of a Ghanaian. "The cocoa export sector is successful because cocoa is not consumed in Ghana."

2.4.2.15 Market Structure

- **Global**

Internationally, the horticultural sector is very competitive. Ghanaian producers recognize that they are less competitive than producers from Latin America. "They know what they are doing." Those countries are producing the same crops than Ghana and are competing with Ghana in third markets like Europe. "They are well-established; their costs are lower because they have been in the business for a while, they use technology, they are producing more efficiently, the quality is better. These countries are regular suppliers and they are taken more seriously." Ghanaian

producers were naming Costa Rica and Trinidad y Tobago as the principal competitors. They have mechanized farms. Consequently, plant density is higher. In Costa Rica pineapple density is 30,000 suckers/acre while it is between 20,000 and 24,000/acre in Ghana. Ghanaian fruit exporters feel threatened by big players such as Del Monte. “We had a niche market with air pineapples but it is now going down because of Del Monte’s efforts to take the market from us.” These big players may come with new varieties that disrupt market trends (e.g., MD_2). They can also manipulate prices. In Africa, South Africa is an important competitor. “South Africa serves markets such as Malawi and Kenya and they are scared that Ghana would take those markets.”

- **Domestic**

Ghana’s production is ensured by millions of small-scale farmers. In the cocoa sector, it is estimated that there are 5 millions of cocoa producers. Farms are generally smaller than one hectare. Shea nuts are also produced at small-scale by women mainly. For vegetable and fruit productions, the largest farms (nuclear farms) have been able to invest in new systems of production and are supplied by small producers (out-growers). Nucleus farms had already their export markets. Out-growers models have been developed by international organizations such as MiDA and ACDI/VOCA. Small producers that have enough surface area to be able to market are linked to nucleus farms. The latter fertilize, plough and supply seeds to the small farmers who pay back in nature. Nucleus farms have between 250 and 2700 suppliers. This type of partnership has allowed small producers to participate to the export market. “In the North the only way of exporting is to be an out-grower.” The out-grower scheme is

recognized as one of the main factors of Ghana's export growth. "For me, what have driven export growth are the big companies with their out-growers." Small fruit or vegetable producers that are not part of an out-grower scheme have to rely on agents if they want to export. They are very few agents that come to buy and they come with their price. There is no competition.

As mentioned previously, out-grower schemes take the form of contract farming in the case of rubber and oil palm industries. Close to 2,500 rubber producers supply the Ghana Rubber Estates Ltd. Producers have 4 hectares on average. In the palm oil sector, Twifo Oil Palm Plantation (TOPP) is supplied by 500 out-growers who cultivate 6 hectares on average. There are not many cooperatives in Ghana. Some have been formed during the pineapple boom but have collapsed at the peak of the crisis.

2.4.2.16 Institutional Support

Stakeholders have either emphasized how their sector benefited from institutional support – "Institutions have facilitated exports and the local industry" – or pointed the lack of institutional support.

There was a real commitment of the Government to invest in the agricultural sector and "the results are visible". Two governmental structures have had a prominent impact on Ghana's export sector namely, the Ghana Export Promotion Council (GEPC – now GEPA) and its partner the Export Development and Investment Fund (EDIF). The EDIF is a governmental fund that was created to promote exports. The EDIF transfers funds to commercial banks (designated financial

institutions) from which producers-exporters can get loans (concessionary loans). The EDIF has also sponsored exporters to go to international trade fairs. The Cocobod is also a strong institution that supports the whole cocoa sector. The pineapple sector has received Government help. Concessionary loans were granted and large plantations could settle.

International organizations have also largely contributed to the development of Ghana's export sector. For instance, in order to facilitate the transition to the MD_2 the World Bank, GIZ and USAID have joined their efforts. "The pineapple industry tried to overcome the challenges through Government, donor agencies and bank support." International organizations often work hand in hand with the Government. The MoFA is a key partner of GIZ in market-oriented programs. And the currently implemented horticultural task force is led by the private sector but in cooperation with MoFA and GEPA. Research institutions can also provide assistance to the private sector. For instance, the FRI assists with start-up equipment small and medium enterprises.

Institutional support has ceased in some key areas of export performance. For instance, irrigation systems were built before the ERP. With the disengagement of the Government, irrigation systems started to deteriorate. Some international organizations have tried to establish a participatory irrigation management system but when the project ended, the Government withdrew its support. Institutional support has also been uneven. Vegetable producers attribute the low performance of their sector to the lack of support. "We did not have the sweet story of fruit producers-exporters. […] Because we did not have Governmental support, we have been and

still are going through hard times. […] We had to build small pack houses in the Central region that have taken us years. […] The EDIF gave minimum support."

The millennium challenge account (MCA) Ghana Compact signed between Ghana and the U.S. Government has had an important impact on Ghana's agricultural export sector. This multi-millions grant was signed in 2006 and lasted five years. A new compact is going to be signed and if the recently ended one was centered on agriculture, the next one will most likely focus on energy. The recent oil discoveries in Ghana might justify this choice. In addition, food security has now become the number one priority of international agencies operating in Ghana. It seems that those agencies as well as the Government are shifting resources from the export sector to the production of staple foods. What would be the impact of those changes on Ghana's agricultural export sector is an open question.

2.4.2.17 Price Incentives

Export prices are generally more attractive than domestic prices. "When products are exported prices are far better than locally." But "export prices are going down." Margins are also considerably higher in export markets which motivate exporters-producers. "Margins in pineapple production are motivating." But again, "margins are shrinking." In out-grower schemes, producers and their buyer agree on a price. "Prices are based on prevailing costs at the beginning of the year." "We bargain prices with farmers. Both parties look at their cost of production." Producers were however complaining: "production costs increase throughout the year." Producers that are not part of an out-grower scheme do not have fixed prices. They are at the mercy of a handful of agents. If they want to export, they take the price that

they are offered at the time of harvest. Producers of fruits and vegetables are more and more turning to the domestic market, "local buyers are paying higher prices." They are also more numerous than intermediaries in the export sector. "You will find a lot of dealers in fruits that flock to the various farms to buy produce."

The expansion of some sectors is due to high and increasing export prices. For instance, the main driver of Ghana's rubber sector is the price of natural rubber which has almost continuously increased since 2001.

Producer prices have been intensively discussed with stakeholders of the cocoa sector. Producer prices are set at the beginning of the season and are based on forward sales (projected revenue). In 2011, the price was $200/ton or $140/bag. Cocoa producers were complaining about the time at which prices are announced. "The Government announces cocoa prices (opening of the season) at a moment that is not convenient for us." They also feel that prices are too low. "Price increments are not attractive. Last year, the bag of cocoa beans was paid only 5 Cedis more than last year. We felt insulted. Input prices grow faster than cocoa prices." During the main season, cocoa producers can receive bonuses but during the lean season "you don't have anything, you just take the price. […] So, everybody is waiting for the main season to come and when the Government declares the opening of the cocoa season, it takes a long time. […] We are forced to take loans from outside."

2.5 Discussion

Ghana's recent export performance was the main motivation for this study. Indeed, for the past thirty years total exports have been growing steadily. Agriculture

is a strong pillar of Ghana's economy and export sector; surprisingly, recorded growth rates for agricultural exports were not as high as in the aggregate. Based on this observation, this research sought to understand the movements of Ghana's agricultural exports identifying factors that may have had an influence on export performance.

The literature extensively reviewed in this research has pointed the complexity of export performance and competitiveness concepts. In particular, the collection of existing theories suggests that appreciating a country's export performance with price factors only would be too restrictive; and calls for a more elaborate analytical framework. Thus, this research combined quantitative and qualitative methods attempting to identify the most relevant factors in Ghana's agricultural export performance. As explained in the third section, in order to measure export price competitiveness, this research proposed a new trade-weighted index (effective exchange rate) that takes into account Ghana's most recent and relevant trading patterns, captures all type of competitions (i.e., Ghana's market, foreign country's domestic market and third-country market) and uses time-varying weights. The effective exchange rate (nominal and real) is computed annually and quarterly from the early sixties to 2010, using secondary data. Other possible factors of export performance have been identified, defined and illustrated based on Ghana's agricultural export sector stakeholders' perceptions and using grounded theory. Data were collected through interviews and focus groups that were conducted during one month in Ghana. This study has revealed a plethora of factors that have shaped Ghana's export development.

First, the results clearly confirm that Ghana's export price competitiveness, as measured by the real effective exchange rate (REER), has improved over the past thirty years (figures 2-10 and 2-11). Our index successfully captures the reforms and policy enforcements that have occurred during the studied period. In particular, the index suggests that the improvement in export price competitiveness has been the fruit of exchange rates and monetary reforms that have taken place since the inception of the economic recovery program in 1983. Indeed, the major depreciation of the REER occurred between 1983 and 1986 and corresponds to the transition from a fixed to a floating exchange rate regime in Ghana. In the early 2000's when important monetary reforms took place (i.e., Bank of Ghana Act in 2002), the REER depreciated further and since then it has been stable. The upward trend of total export volumes since 1983 (figure 2-1) corresponds to the depreciation of the REER. However, total export growth has accelerated during the past decade while the REER has remained stable suggesting that total export performance cannot only be attributed to improvements in price competitiveness. Likewise, the computation of the annual REER overtime has revealed a weak relationship between agricultural export performance and export price competitiveness (REER). This result corresponds to Fosu (1992)'s finding that the response of agricultural exports to changes in real exchange rates has been inelastic. All the above suggests that non-agricultural exports have been the most responsive to REER changes.

Second, discussions with stakeholders have revealed that there are many other factors that have driven Ghana's agricultural exports. Many of these factors are in line with the theories presented in the literature review. For instance, the role of quality in

trade (Linder, 1961) and the positive impact of foreign direct investment (FDI) (Graham and Helpman, 1985) have been confirmed. Our results also coincide to findings of previous empirical studies. Like Agyeu-Mensah (2010), we found that trade barriers, competition in export markets, lack of governmental support, lack of market information, incapacity to meet standards (quality, packaging, labeling) and to supply regularly, difficult repatriation of outcome and inadequate labor have negatively affected Ghana's export performance. Our results also correspond to some of the findings of Sarpong and Wolf (2008). In particular, we found that export performance has been impeded by limited access to capital which negatively impacts the investment behavior of Ghanaian firms. Participants to our research expressed their desire to invest more. However, interest rates are too high and commercial banks are not ready to invest in agriculture. Another problem pointed by our research is that loans are not adapted to the agricultural sector. For instance, the grace period is less than 6 months while most crops for export start producing after several years (e.g., cocoa and mango). As Sarpong and Wolf (2008), we found that larger firms are more likely to exports but our study further shows that foreign firms settled in Ghana have an advantage in exporting compared to domestic companies (due to better market knowledge for instance). As in Cook (2000), we identified export free zones as an important instrument of export performance. They have attracted FDI and encouraged foreign as well as national agro-processing companies to export Ghanaian products. Our study revealed that exporting procedures have become easier and progressively computerized since Cook's survey (2000). However, the lack of infrastructure, due to limited funds, remains an issue. In Ghana, free zones are administered by a Board.

Thus, their development depends on public funds. As a matter of fact, the project of a second park has been delayed because of the lack of funds and the recent development of export processing activities has occurred through the multiplication of free points.

New factors have also emerged such as the uncertainty towards crop failure and land tenure, farmers' organizations, contract farming and out-grower schemes. The definition and illustration of some of these factors helps to understand why agricultural exports have not evolved in unison with aggregate exports and export price competitiveness (REER).

Our research also presents several methodological contributions to the existing literature. Indeed, other measures of export price competitiveness, found in the literature on Ghana's exports fall short of crucial methodological aspects. And, as a consequence, they poorly take into account changes in trade patterns and policies and only partially reflect Ghana's true competitiveness. Opoku-Afari (2004) raised those concerns and attempted to correct the shortcomings of existing indices proposing an alternative real exchange rate. However, Opoku-Afari's index did not include third-market competition and omitted important trade partners of Ghana such as China, India and Malaysia. The IMF also proposes a real effective exchange rate but we would advise against the use of "black box" measures of competitiveness. The self-computation of the REER allows discerning the effect of inflation, nominal effective exchange rates, bilateral exchange rates and trading patterns (evolution of countries' weights).

Although our index marks a real improvement in the measure of Ghana's price competitiveness, we recognize that the trade-weighted scheme used in this research might introduce some biasedness. As countries' market shares change due to exchange rates appreciation or depreciation, the weight of a country in another country's trade is endogenously determined by the inclusion of exchange rates in the index. However, the use of weights *per se* is needed because changes in market shares are not only functions of relative changes in exchange rates. Also, the REER is more practical. Omitting weights would require including all the possible bilateral exchange rates while the trade-weighted scheme takes into account the volume of trade. Finally, the REER allows accounting for policy effects.

We recognize also that the use of total trade instead of agricultural trade to construct the REER is an important limitation in the analysis of agricultural export performance. As more data become available on agricultural trade, future research on agricultural exports will have to use agricultural trade data to construct the real effective exchange rate.

The combination of methods used in this research and in particular the use of grounded theory and reliance on stakeholders' perceptions to define an analytical and theoretical framework of export performance is novel. It contributes to the production of relevant results that are in connection with the reality of the country and the agricultural export sector. Compared to the existing empirical literature, the use of grounded theory constitutes a real improvement as it does not restrict the analysis to preconceived frameworks of export performance. For example, a short-coming of Agyeu-Mensah (2010)'s study was that participants had to rate factors of export

performance that were pre-identified by the author in the literature. Moreover, Agyeu-Mensah (2010) collected data from employees of one company (oil mill) only while the methods used in our research allows analyzing Ghana's agricultural exports across most stakeholders groups and sectors in a limited time.

The results of this research point towards new levers that would have to be pulled for future agricultural export developments. Indeed, we found that the real effective exchange rate has been low and stable since the turn of the 21st century. Because the REER cannot fall much lower, exchange rates and monetary policies might become ineffective and export volumes will be trapped at low levels. We would prudently say that Ghana's export sector is in an "exchange rate trap" and export volumes would have to be increased via other factors. Many of them have been identified in this research and should be the object of future policies.

In particular, policies that frame the promotion and marketing of Ghana's products are needed to increase exports and especially non-traditional exports. The economic integration of Ghana in several trade areas (e.g., ECOWAS) represents an opportunity to expand Ghana's exports. As shown in this research, the GEPA and other institutions have tried to promote non-traditional exports conducting market study to identify specific products and countries as well as supporting the participation of Ghana to trade fairs (e.g., Fruit Logistica). However, in order to fully take advantage of those markets, export promotion policies would have to be enforced and financial resources increased.

The Bank of Ghana faces the challenge of setting a policy rate that would control inflation with minimal impact on investment. Although inflation rates have been recently brought under 10%, the policy rate remains around 15%, one of the highest in the world. High interest rates discourage investment and entrepreneurship in the agricultural sector and have significant effects on the distribution of income and wealth. Thus, future research may focus on finding an equilibrium interest rate (i.e., the rate at which the supply of and demand for money are equal). In the context of this dissertation, finding an equilibrium interest rate that contributes to low price inflation, which may lead to exchange rate stability, will result in less fluctuations in interest rates that currently characterize capital markets in Ghana (e.g., interest rates ranging from 5-30% depending on the lending source).

As a final remark, it is important to emphasize that a large portion of Ghana's population is employed in the agricultural sector. And, considering that the export sector requires more labor, development programs that will encourage and support the participation of small-holders in the export sector are highly desirable. In this spirit, out-grower schemes are key but their functioning would have to be framed by policies and laws. The effects of organizations such as out-grower schemes but also free export zones are large and call for more research.

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3 MACROECONOMIC ASPECTS OF GHANA'S EXPORT PERFORMANCE

3.1 Introduction

Ghana is the economic success story of Africa. In 2011, its gross domestic product (GDP) growth was as high as 14.4%[5]. This growth is seemingly related to the development of exports, an important sector of Ghana's economy (37% of GDP[6]) that has increased at a fast pace for the past three decades. This performance is the fruit of Ghana's steady commitment to stabilize its economy and boost its export sector. Since 1983, many market-oriented reforms have been implemented. Two of the key macroeconomic reforms were the realignment of exchange rates and inflation control. Both of these reforms have drastically improved Ghana's export price competitiveness as captured by the real effective exchange rate (REER) (figure 3-1). The transition to a more liberalized, specialized and export-oriented economy may have increased Ghana's exposure to risk. Indeed, despite efforts to reinforce other sectors of the economy and diversify its export base, Ghana remains heavily dependent on export receipts that come from a limited number of commodities and countries. Export demand theory suggests that foreign income and price competitiveness are the main determinants of a country's export performance as measured by changes in export volumes. But unpredictable exchange rates lead to revenue uncertainty. In this case, decision theory suggests that, to avoid losses, export firms will not be willing to make investments such as adopting new technologies, diversifying their productions or expanding their operations. The effect is accentuated

[5] GDP Growth Annual (%). World Development Indicators, The World Bank (2012).
[6] Exports of Goods and Services (%GDP). World Development Indicators, The World Bank (2012).

if producers are risk-averse (e.g., Hooper and Kohlhagen, 1978) and if risk management tools are limited, which is generally the case in developing countries. As a result, in the aggregate, export volumes will fall.

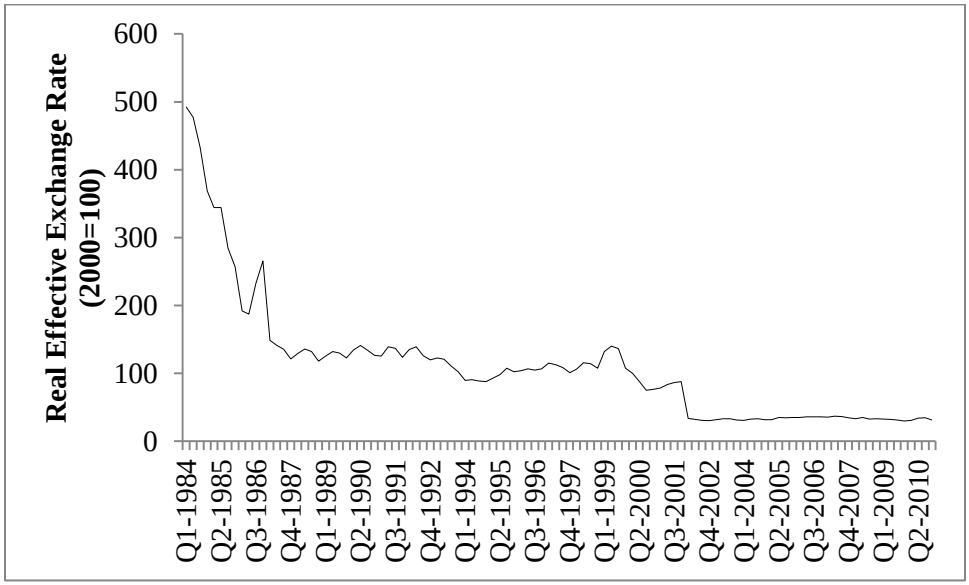

Figure 3-1: Ghana's export price competitiveness (REER) — 1984:Q1 to 2010:Q4.

In this context, a question emerges: "Do exchange rates, inflation and foreign income have had an effect on Ghana's export performance and if so, how?" The null hypotheses that this research seeks to test are: 1. Price competitiveness and foreign income have not *caused-in-mean* Ghana's export volumes. 2. Exchange rate volatility *has not impacted* Ghana's export volumes. To test the first hypothesis, we recognize the possible endogeneity between export volumes, exchange rates and foreign income and analyze their causal relationships estimating a vector autoregressive (VAR) model. The presence of unit-roots in one or more variables conditions the choice of the methodology to test for Granger causality. The use of a lag-augmented VAR model (Toda and Yamamoto, 1995 & Dolado and Lütkepohl, 1996 - TYDL) has gained in popularity because it does not require any pre-testing but it may suffer from

loss of power especially in small samples. Some of the unit-root tests found in the recent literature and employed here, have good size and power properties that increase their accuracy and may provide some guidance to causality testing. To test the second hypothesis, we draw from financial econometrics models and their underlying theories. Recognizing that the relationships between volatility processes are dynamic and that volatility can be best depicted as a (Generalized) autoregressive conditional heteroskedasticity (GARCH) process, we use multivariate volatility models (multivariate GARCH-in-mean to be exact). The essay is organized as follows. In section 2, we survey the empirical literature on export demand and its determinants. Section 3 introduces the theoretical framework and the methodology. Section 4 summarizes the results. Section 5 provides concluding remarks and discusses some policy implications.

3.2 Review of the Empirical Literature

In the 1950s literature, export demand was mainly defined as a function of relative prices. Studies generally found a negative and inelastic relationship - elasticity values ranging between -0.5 and -1.0 (Orcutt, 1950). Relative prices have often been defined as the ratio of export price indices. Consumer indices, wholesale/producer prices and GDP deflators can also be used. The influence of exchange rates was not taken into account until the collapse of the Bretton Woods system. Most authors use bilateral exchange rates, especially against the U.S. dollar. However, as pointed by Ott (1987), multilateral weighted exchange rates are more useful as they avoid erroneous generalizations and allow for third-country impacts. Subsequent to Johnson (1958)'s statement that export demand depends critically on

the world's income elasticity, foreign income has been included in export demand models along with relative prices. Studies have generally found a positive and elastic relationship (e.g., Houthakker and Magee, 1969). Goldstein and Khan (1978) notice that if a country's exports correspond to the residual demand of the rest of the world the elasticity may not be positive. Developing countries are usually residual suppliers (Mullor-Sebastian, 1990). In pioneer studies, export demand was measured regressing (ordinary least squares - OLS) a set of limited variables on export volumes. Overtime, models have been increasingly refined by: 1) relaxing assumptions; 2) adding more information, and 3) using modern econometric techniques. In the mid-eighties, studies using dynamic models started to flourish in the export demand literature and VAR or VEC models have been widely used to test both long and short-run effects of relative prices and foreign income on export volumes. A straightforward extension to this approach is to test for Granger causality. Surprisingly, very few authors have analyzed causal relationships in the framework of export demand models.

Export demand models have also been augmented with measures of volatility and in particular exchange rate volatility. It is intuitively argued that the impact of exchange rate volatility is significant and negative but the alternative hypothesis has also been considered. The vast empirical literature has however failed to resolve this ambiguity. Different measures of exchange rates can be found in the literature. As a rule of thumb, early literature uses nominal exchange rates while real exchange rates are more commonly found in latest works. McKenzie (1999) concludes that the impact of using one or another is trivial. Both effective and bilateral exchange rates have been used but very few works have looked at "third-country" exchange rates

effects. The diversity of methodologies that can be found in the literature is vast. Bahmani-Oskooee and Hegerty (2007) listed more than ten types of volatility measures. The most commonly used approach appears to be a moving standard deviation (e.g., Koray and Lastrapes, 1989). However, with the advancements in financial econometrics that have taken place in the 80's, an increasing number of studies started to model exchange rate volatility as a GARCH process. This approach allows capturing the unpredictable part of volatility and is considered by some authors as the most efficient (e.g., Seabra, 1995). Studies have generally included exchange rate volatility in linear regressions or in VAR/VEC models. A major drawback of these approaches is their inefficiency as, independently from the measure of volatility, the estimation is always done in two steps. Conversely, the multivariate GARCH-in-mean (MGARCH-M) model allows the joint estimation of exchange rates conditional volatility and its impact on trade. McKenzie (1999) emphasized both the usefulness and underuse of MGARCH-M models. To our knowledge, only Kroner and Lastrapes (1993) have modeled the effect of exchange rate volatility on exports using a MGARCH-M model. The research review of Bahmani-Oskooee and Hegerty (2007) reveals that no new contribution to the literature has used MGARCH-M models since McKenzie (1999)'s research review. The unpopularity of these models could be due to their complexity. Indeed, the number of parameters to be estimated increases rapidly with the number of variables and lags. Consequently, large samples are required to use these models, complicating the analysis at the sectoral level and for developing countries.

To our knowledge, only Sackey (2001) and Bhattarai and Armah (2005) have analyzed Ghana's export demand. They both applied cointegration techniques and confirmed the existence of a long-run equilibrium between exports and its determinants. Sackey (2001) found a positive relationship between foreign income and export performance while Bhattarai and Armah (2005) found a negative relationship (although not significant). Both studies concluded that Ghana's currency depreciations led to an improvement in Ghana's export performance. Only Sackey (2001) analyzed causal relationships and found that export volumes have been caused by real effective exchange rates but not by foreign income. Note that none of these studies have taken into account exchange rate volatility. Also, they confined their work to annual total exports from 1962 to 1996 (Sackey, 2001) and 1970 to 2000 (Bhattarai and Armah, 2005). An analysis of agricultural exports only seems important considering the share of agricultural exports in total exports (35.3%[7]). Note also that both studies used exchange rates that may not reflect Ghana's trading patterns. Indeed, Bhattarai and Armah (2005) simply used bilateral exchange rates between the US$ and Ghana's currency, the Ghana Cedi, while Sackey (2001) opted for a trade-weighted exchange rate that only included France, Italy, Japan, the Netherlands, Germany and the U.S. as Ghana's main trading partners.

3.3 Theoretical Framework, Methods and Data

3.3.1 Theoretical Framework: Export Demand and Decision Theories

One way of explaining export performance is to embrace the theory underlying export demand models. The above-reviewed literature showed that it is also the most

[7] Own calculations based on FAOSTAT (Food and Agriculture Organization-FAO, 2012) data.

adopted approach in empirical studies. Two main models and their respective sets of assumptions are defined in the theoretical literature namely, the imperfect substitutes model and the perfect substitutes model. We chose to adopt the theory underlying imperfect substitutes models for several reasons. First, this model dominates the empirical literature whether studied trade flows are mainly composed of differentiated goods or not. Second, non-traditional exports[8] share in Ghana's total exports has increased considerably. Third, the validity of the law of one price for commodities remains controversial. The imperfect substitutes model of a country's *i* exports to the rest of the world can be expressed as follows:

$$X_i^d = f(Y^*, P_i), \tag{1}$$

where X_i^d is the demanded quantity of exports, Y^* is the world income and P_i is the relative price. The theory predicts that Y^* has a positive impact on X_i^d while P_i has a negative impact. The model also involves a supply equation. However, the empirical literature generally assumes that supply price elasticities are infinite (Goldstein and Khan, 1985). This assumption allows collapsing the theoretical model into a single equation (export demand) which is convenient for estimation purposes. The derivation of the econometric model relies on consumer demand theory. In most empirical studies the underlying demand theory is simply assumed. However, Senhadji and Montenegro (1998) remarkably derive the export demand equation in an optimization framework and we will here summarize their modeling.

[8] For the most part, nontraditional exports do not fall in the primary commodity category in Ghana.

Assuming that there are two countries namely, the exporter (home country) and the importer (rest of the world). Assuming further that in the importing country, infinitely-lived consumers face the decision of consuming from their domestic endowment (d^*) and the imported good (m^*). The representative agent maximizes its utility subject to a lifetime budget constraint as follows:

$$\text{Max } E_0 \sum_{t=0}^{\infty}(1+\delta)^{-1}\, u(d_t^*, m_t^*). \tag{2}$$

$$\{d_t^*, m_t^*\}_{t=0}$$

$$\text{S.T. } b_{t+1}^* = (1+r)b_t^* + (e_t^* - d_t^*) - p_t m_t^* \tag{3}$$

$$e_t^* = (1-\rho)\bar{e^*} + \rho e_{t-1}^* + \varepsilon_t^* \tag{4}$$

$$\lim_{T\to\infty} \frac{b_{T+1}^*}{\prod_{t=0}^{T}(1+r)^{-1}} \tag{5}$$

- δ is the consumer subjective discount rate.
- *r* is the world interest rate.
- b_{t+1}^* is the stock of home bonds at *t+1*. If it is positive, it is held by the foreign country and if it is negative, it is held by the home country.
- e_t^* is the stochastic endowment.
- p_t is the price of the home good relative to the foreign good.

The first order conditions are:

$$u_t^{d^*} = \lambda_t. \quad (6)$$

$$u_t^{m^*} = \lambda_t p_t. \quad (7)$$

$$\lambda_t = (1+\delta)^{-1}(1+r)E_t\lambda_{t+1}. \quad (8)$$

Assuming further that:

$$u(d_t^*, m_t^*) = A_t(d_t^*)(1-\alpha)^{-1} + B_t(m_t^*)(1-\beta)^{-1}, \quad (9)$$

with α, β>0

$$A_t = e^{a_0+\epsilon_{A,t}}. \quad (10)$$

$$B_t = e^{b_0+\epsilon_{B,t}}. \quad (11)$$

- A_t and B_t are exponential stationary random shocks to preferences.
- $\epsilon_{A,t}$ and $\epsilon_{B,t}$ are stationary shocks.
- α and β are curvature parameters.

From (9) the partial derivative of $u(d_t^*, m_t^*)$ with respect to d_t^* yields to:

$$u_t^{d^*} = A_t(d_t^*)^{-\alpha}. \quad (9')$$

Equalizing (5) and (8'):

$$\lambda_t = A_t(d_t^*)^{-\alpha}.$$

$$\Leftrightarrow d_t^* = A_t^{1/\alpha}\lambda_t^{-1/\alpha}. \quad (12)$$

Likewise, the partial derivative of $u(d_t^*, m_t^*)$ with respect to m_t^* yields to:

$$u_t^{m^*} = \frac{B_t}{1-\beta} \times (1-\beta) \times m_t^{*-\beta}. \quad (9'')$$

Equalizing (6) and (8"):

$$m_t^* = {B_t}^{1/\beta} {\lambda_t}^{-1/\beta} P_t^{-1/\beta}. \quad (13)$$

Substituting (9), (10) and (11) into (12) and taking the logs:

$$\log(m_t^*) = \frac{1}{\beta}(b_0 - a_0) + \frac{1}{\beta}\left(\epsilon_{B,t} - \epsilon_{A,t}\right) + \frac{\alpha}{\beta}\log(d_t^*) - \frac{1}{\beta}\log(p_t). \quad (14)$$

Observe that $m_t^* = x_t$ and $d_t^* = GDP_t^{*}$[9]. Giving $c_0 = \frac{1}{\beta}(b_0 - a_0)$; $\epsilon_t = \frac{1}{\beta}\left(\epsilon_{B,t} - \epsilon_{A,t}\right)$ yields to the export demand equation:

$$\log(x_t) = c_0 + \frac{\alpha}{\beta}\log(GDP_t^*) - \frac{1}{\beta}\log(p_t) + \epsilon_t. \quad (15)$$

Assuming potential feedbacks between the variables in (15), the model becomes a vector autoregressive model of order *k* (VAR(k)):

$$\begin{pmatrix} Log(x_t) \\ Log(p_t) \\ Log(GDP_t^*) \end{pmatrix} = \begin{pmatrix} \alpha_{10} \\ \alpha_{20} \\ \alpha_{30} \end{pmatrix} + \begin{pmatrix} \psi_{1,1}^1 & \psi_{1,2}^1 & \psi_{1,3}^1 \\ \psi_{2,1}^1 & \psi_{2,2}^1 & \psi_{2,3}^1 \\ \psi_{3,1}^1 & \psi_{3,2}^1 & \psi_{3,3}^1 \end{pmatrix} * \begin{pmatrix} Log(x_{t-1}) \\ Log(p_{t-1}) \\ Log(GDP_{t-1}^*) \end{pmatrix} + \cdots +$$

$$\begin{pmatrix} \psi_{1,1}^k & \psi_{1,2}^k & \psi_{1,3}^k \\ \psi_{2,1}^k & \psi_{2,2}^k & \psi_{2,3}^k \\ \psi_{3,1}^k & \psi_{3,2}^k & \psi_{3,3}^k \end{pmatrix} * \begin{pmatrix} Log(x_{t-k}) \\ Log(p_{t-k}) \\ Log(GDP_{t-k}^*) \end{pmatrix} + \begin{matrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{matrix} \quad (16)$$

In accordance with decision theory, the model given in (15) should include a measure of volatility. Volatility makes exporters more uncertain about the revenues they will receive which eventually decreases trade volumes in the aggregate

[9] Note that in Senhadji and Montenegro (1998) framework $d_t^* = GDP_t^* - x_t^*$

(Krugman and Obstfeld, 2003). The effect of uncertainty on trade increases with the degree of risk aversion, an assumption that we follow in this research. Given the model in (15), there is at least one source of volatility that could affect export volumes namely, exchange rates. Traders can limit this risk using foreign exchange markets and the more they are risk adverse, the more they will cover in the foreign exchange market (Ethier, 1973). We nevertheless assume that a portion of the foreign exchange exposure remains uncovered (Hooper and Kohlhagen, 1978) and that this proportion is greater in the case of developing countries where forward markets are underdeveloped (Canales-Kriljenko, 2004). Cushman (1986) highlighted the importance of taking into account "third-country" exchange rates risk providing theoretical and empirical considerations to their effect on trade. Substitution effects (imports/exports from one country to another) are the bedrock of Cushman's theory but we have also to consider that most countries do not trade with their own currencies but with the so-called vehicle currencies like the Euro and the US$.

3.3.2 Econometric Methods

In order to measure if some variables have affected export performance, we shall test causal relationships as defined by Granger (1969). The choice of the methodology directly depends on the properties of the series. Thus, prior to causality testing, the order of integration of the series is determined. If the series are found to be stationary, a VAR model shall be entertained. If the variables are integrated of the same order, a VECM would be the most appropriate. If the series are *d-integrated* and non-cointegrated, the VAR model would be estimated in *d-differences*. Finally if the

order of the variables is uncertain or if the variables are of different order (e.g., *I(0)* and *I(1)*), causality should be tested following the TYDL procedure.

From the above, we understand the importance of correctly identifying the model that would approximate the true data generating process (DGP) of the series. Dickey-Fuller - DF (1979) and Phillips-Perron - PP (1988) unit-root tests are uncontestably the most widely used to identify the order of integration despite proven drawbacks. DF tests assume that errors z_t are iid with zero mean. This restrictive assumption creates severe size distortions. Monte Carlo studies have shown inaccuracies in the size of DF-type tests, especially in the presence of large and negative MA coefficients. Both augmented Dickey-Fuller (ADF) and PP tests were intended to palliate to this drawback by accommodating dependent errors. ADF tests follow a parametric approach and assume that the error structure is autoregressive. PP tests (Z_α and MZ_t) are more flexible and involve the semi-parametric estimation of the long-run variance $\sigma^2_{z,lr}$ with Kernel estimators. However, PP tests also suffer from size distortions when the root of the error process is close to one, in part because of the use of Kernel estimators. Modified PP tests (MZ_α, MZ_t and MSB – Stock, 1990), used in combination with an autoregressive estimator of the long-run variance instead of a Kernel estimator, notably improve PP tests size properties (Perron and Ng, 1996). Monte Carlo simulations have shown that DF-type tests have also low power. The use of generalized least squares (GLS) as a detrending method notably improves the power of unit-root tests. Elliot, Rothenberg and Stock (1996) popularized this method in a DF framework (ERS tests or DF^{GLS} tests). Ng and Perron (2001) brilliantly integrated GLS detrending techniques to modified PP tests in an attempt to ally the

size properties of modified PP tests with the power properties of GLS-detrending-based tests (M^{GLS} tests). Another extension to their tests is the use of GLS-detrending to estimate the long-run autoregressive variance ($\bar{M}^{GLS}$). More importantly, their work tackles the problem of lag length selection that arises when estimating the long-run variance with the autoregressive spectral density estimator (Perron and Ng, 1996). They provide a new class of selection criteria (MIC) that do not suffer from the over-fitting problems of other criteria (AIC and BIC) in presence of large and negative MA errors. A slight modification of these criteria is the use of OLS-detrended data instead of GLS-detrended data in their construction (Perron and Qu, 2007). Lag length selection is not only an issue in M-tests. Indeed, some DF-type tests involve the selection of the number of lagged differences to include in order to whiten the residuals. Wu (2010) has considered this issue in DF-GLS tests (ERS tests). They show that the use of sequential t-test to select the lag length improves the power of DF-type tests.

The TYDL approach is a simple procedure that involves the estimation of a VAR(k) in levels where *k* is the optimal lag length based on some selection criterion (e.g., AIC). Once the lag length is determined, a VAR(p=k+dmax) is estimated where *dmax* is the maximum order of integration. This procedure is valid only if $dmax \leq k$. Considering the following VAR equation from (16):

$$\log(X_t) =$$

$$\alpha_{10} + \sum_{i=1}^{p} \psi_{1,1}^{i} \log(X_{t-i}) + \sum_{i=1}^{p} \psi_{1,2}^{i} \log(P_{t-i}) + \sum_{i=1}^{p} \psi_{1,3}^{i} \log(GDP_{t-i}^{*}) + \varepsilon_{1,t}. \quad (17)$$

In order to test the null hypothesis that *P* does not Granger cause *X*, the linear restriction H_0: $\psi_{1,2}^{1} = \cdots = \psi_{1,2}^{p} = 0$ is imposed and the modified Wald (MWALD) test is computed. Asymptotically, this test has a $\chi^2_{(J)}$ distribution (*J* is the number of restrictions), even in the presence of integration or cointegration (Toda and Yamamoto, 1995). One of the drawbacks of this approach is that the results may suffer from an over-fit of the VAR model (Toda and Yamamoto, 1995). A direct consequence is their poor performance in small samples as shown by Zapata and Rambaldi (1997).

In order to measure the impact of exchange rates risk on export volumes, we estimate a bivariate GARCH-M model. Different MGARCH models are available to support the study of GARCH-in-mean effects but the constant-correlation model of Bollerslev (1990) is used here. The advantage of this model is that the number of parameters to be estimated is relatively low. It is however quite restrictive as it assumes a time-invariant conditional correlation. As in a univariate GARCH model, a MGARCH consists of a mean equation and a variance equation. In our case, the mean equation corresponds to a VAR model. As indicated by its name, the estimated variances are actually conditional variances. Each one follows a GARCH process and models volatility. The measurement of volatility's effects implies augmenting the VAR with the conditional variances. The resulting model is a VAR-MGARCH-M model. As an example, the bivariate VAR(k)-GARCH(1,1)-M model is detailed

below. It is constituted of an augmented bivariate VAR(k) where $Y_{1,t}$ and $Y_{2,t}$ are the rates of change of export volumes and exchange rates ("own-country" or "third-country") respectively:

$$Y_{1,t} = \beta_{10} + \beta_{11,t-1}Y_{1,t-1} + \cdots + \beta_{11,t-k}Y_{1,t-k} + \beta_{12,t-1}Y_{2,t-1} + \cdots + \beta_{12,t-k}Y_{2,t-k} + \beta_{13}\sigma_{1,t}^2 + \beta_{14}\sigma_{2,t}^2 + a_{1,t}. \quad (18)$$

$$Y_{2,t} = \beta_{20} + \beta_{21,t-1}Y_{1,t-1} + \cdots + \beta_{21,t-k}Y_{1,t-k} + \beta_{22,t-1}Y_{2,t-1} + \cdots + \beta_{22,t-}Y_{2,t-k} + \beta_{23}\sigma_{1,t}^2 + \beta_{24}\sigma_{2,t}^2 + a_{2,t}. \quad (19)$$

Assuming GARCH(1,1) errors, the volatility equations can be expressed as:

$$\begin{pmatrix}\sigma_{1,t}^2 \\ \sigma_{2,t}^2\end{pmatrix} = \begin{pmatrix}\alpha_{10} \\ \alpha_{20}\end{pmatrix} + \begin{pmatrix}\alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{11}\end{pmatrix} * \begin{pmatrix}a_{1,t-1}^2 \\ a_{2,t-1}^2\end{pmatrix} + \begin{pmatrix}\gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22}\end{pmatrix} * \begin{pmatrix}\sigma_{1,t-1}^2 \\ \sigma_{2,t-1}^2\end{pmatrix}. \quad (20)$$

Assuming further that the conditional correlation between $a_{1,t}$ and $a_{2,t}$ is time-invariant ($\rho_{12,t} = \rho_{12}$) which implies that $\alpha_{12} = \alpha_{21} = \gamma_{12} = \gamma_{21} = 0$, the volatility equations reduce to:

$$\sigma_{1,t}^2 = \alpha_{10} + \alpha_{11}a_{1,t-1}^2 + \gamma_{11}\sigma_{1,t-1}^2. \quad (21)$$

$$\sigma_{2,t}^2 = \alpha_{20} + \alpha_{22}a_{2,t-1}^2 + \gamma_{22}\sigma_{2,t-1}^2. \quad (22)$$

Observe the number of parameters to be estimated. It grows with the number of variables, of lags included in the VAR and the GARCH models. For a bivariate VAR(1)-GARCH(1,1)-M, the number of parameters to be estimated is 17. Consequently, we are not able to simply augment the model in (16) with exchange rate volatility measures. Two bivariate models are estimated instead; one with "third-

country" exchange rates and one with "own-country" exchange rates. While economic series rarely follow a GARCH of a higher order than (1,1), the assumption of a VAR(1) would be in most cases too restrictive and misleading. Thus, the best-fitting VAR model will be used instead. The whole model is simultaneously estimated with maximum likelihood estimation (MLE) methods and using the algorithm Broyden-Fletcher-Goldfarb-Shanno (BFGS). Of particular interest is the significance of exchange rate volatility in the export volume equation although we do not rule out the possibility that the volatility of exports growth may also have an effect on exchange rates changes. To test that exchange rate volatility has an effect on export volumes, we will test: $\beta_{14} = 0$.

3.3.3 Data

In order to test the first hypothesis, this research uses annual data from 1970 to 2009 and analyzes both total and agricultural exports. Annual Ghana's total nominal exports in millions of US$ are from the IMF, Direction of Trade Statistics (DOTS). Total export volumes (TX) were obtained deflating annual total exports with an export price index. Annual Ghana's agricultural nominal exports in millions of US$ are from the trade statistics database of the FAO (FAOSTAT). Agricultural exports (AX) were deflated with the export value index computed by the FAO. In an attempt to reflect Ghana's trade patterns, we use REER for relative prices and trade-weighted foreign GDP (TWFGDP) for World income. Both indices have been computed by the author. The base year is 2000. All the above variables were log-transformed and they can be identified with the LN prefix. To test the second hypothesis, we use monthly data. "Third-country" effects are measured using bilateral

nominal exchange rates between the US$ and the Euro. Ghana's monthly real total exports are from the IMF/DOTS. Exchange rates are from the Global Insight website (diverse sources). The analysis runs from January 2002 (circulation of the Euro) to February 2012. To study "own-country" exchange rate risk effects, we use nominal bilateral exchange rates between the Ghana Cedi (GHS) and the US$. The analysis uses data starting on January 1984.

3.4 Results

3.4.1 Hypothesis 1

For annual exports (total and agricultural), unit-root tests (appendices 1 to 4) indicate that the maximum order of integration is $dmax=1$[10]. The lag length k of the VAR model is selected using the Akaike information criterion (AIC), Hannan-Quinn criterion (HQ), Schwarz criterion (SBC) and final prediction error criterion (FPE), assuming that $MA=0$. For annual total exports, the results in table 3-1 are based on the estimation of a VAR model with a time trend and a dummy variable (1983=1). Using a maximum lag length of 6, all the criteria give $k=1$. For annual agricultural exports, we did not include a deterministic trend after examination of the plot overtime (appendices 5 and 6). The four criteria result in $k=1$. The adequacy of these models was confirmed by the results of diagnostic tests (Jarque-Bera for normality and a portmanteau test for serial correlation). To test for Granger non-causality, we therefore entertained a VAR(2) in levels for both total and agricultural exports. Tables 3-1 and 3-2 summarize the estimated coefficients for total exports and agricultural exports respectively.

[10] Although not presented here the results of other unit tests (e.g., Zivot and Andrews) led to the same conclusion.

Table 3-1: Estimated VAR(2) — Annual real total exports — 1970 to 2009.

Variable	Parameter	Standard Error	T-Value	P-Value	Significance
Intercept	13.579	7.497	1.810	0.080	*[11]
$LNTX_{t-1}$	0.436	0.160	2.720	0.011	**[12]
$LNREER_{t-1}$	-0.429	0.128	-3.350	0.002	***[13]
$LNTWFGDP_{t-1}$	0.099	0.473	0.210	0.835	
$LNTX_{t-2}$	0.204	0.144	1.420	0.167	
$LNREER_{t-2}$	0.022	0.146	0.150	0.880	
$LNTWFGDP_{t-2}$	-0.763	0.488	-1.560	0.129	
DV (1983=1)	0.497	0.258	1.930	0.064	*[11]
Linear trend	0.020	0.010	2.070	0.047	**[12]

For total export volumes, of the two main determinants of export demand, the REER is the only significant (table 3-1). Its effect is negative has expected. Neither the REER nor the TWFGDP have a significant effect on agricultural export volumes (table 3-2).

Table 3-2: Estimated VAR(2) — Annual real agricultural exports — 1970 to 2009.

Variable	Parameter	Standard Error	T-Value	P-Value	Significance
Intercept	-8.104	4.330	-1.870	0.071	*[11]
$LNAX_{t-1}$	0.440	0.162	2.720	0.011	**[12]
$LNREER_{t-1}$	0.048	0.109	0.440	0.660	
$LNTWFGDP_{t-1}$	0.584	0.362	1.610	0.118	
$LNAX_{t-2}$	0.063	0.158	0.400	0.693	
$LNREER_{t-2}$	-0.009	0.107	-0.080	0.936	
$LNTWFGDP_{t-2}$	0.212	0.369	0.570	0.570	
DV (1983=1)	0.372	0.226	1.650	0.110	

Table 3-3 summarizes the results of the MWALD tests. For total exports, we strongly reject the null hypothesis that REER have not caused total export volumes. We nevertheless fail to reject the null of non-causality from either the REER or TWFGDP to agricultural export volumes.

[11] Variable significant at 10%.
[12] Variable significant at 5%.
[13] Variable significant at 1%.

Table 3-3: Granger Non-Causality Tests (MWALD).

Null hypothesis	F-Stat	P-Value	Significance
REER ↛ Total real exports	8.540	0.004	***[14]
TWFGDP ↛ Total real exports	0.030	0.855	
REER ↛ Agricultural real exports	0.160	0.694	
TWFGDP ↛ Agricultural real exports	2.050	0.156	

3.4.2 Hypothesis 2

The estimation results of the best-fitting models are reported in tables 3-4 and 3-5. Unit-root testing indicated that all variables (monthly "own-country" and "third-country" exchange rates as well as export volumes) were *I(1)* which suggests that the models had to be estimated in log-differences. Volatility measures were included in levels and we chose to use their square root (standard deviation). Prior to estimation, we fitted a vector ARMA (VARMA) to model the dynamics of the mean equations. The final specification of the VARMA model was based upon the ACF and PACF, Ljung-Box Q-statistics and normality tests. To model exports and "third-country" exchange rates dynamics, we did not include either lags of the other variable or constant terms in the mean equations. For exports and "own-country" exchange rates, five lags of each variable were needed in order to whiten the residuals of the mean equations. We maintained the assumption of a GARCH(1,1) for the variance equations in both models. In tables 3-4 and 3-5 we included the estimated coefficients along with the T-Statistics and the P-values. We constantly found that past changes of export growth ($\beta_{11,t-k}$)have had a significant and negative effect on current export growth. For the first lag ($\beta_{11,t-1}$), the magnitude of the effect was of the same order in the two models.

[14] Causality significant at 1%.

Table 3-4: Estimation results for monthly exports and €/$ — 2002:01 to 2012:02.

Parameter	Coefficient	T-Stat	P-Value
$\boldsymbol{\beta_{11,t-1}}$	-0.515	-50.030	0.000
$\boldsymbol{\beta_{22,t-1}}$	0.259	16.482	0.000
$\boldsymbol{\beta_{13}}$	2.141	50.590	0.000
$\boldsymbol{\beta_{23}}$	-0.373	-22.027	0.000
$\boldsymbol{\beta_{14}}$	-13.722	-89.962	0.000
$\boldsymbol{\beta_{24}}$	2.272	16.934	0.000
$\boldsymbol{\alpha_{10}}$	0.048	252.595	0.000
$\boldsymbol{\alpha_{20}}$	0.000	45.371	0.000
$\boldsymbol{\alpha_{11}}$	0.045	38.966	0.000
$\boldsymbol{\alpha_{22}}$	0.059	62.534	0.000
$\boldsymbol{\gamma_{11}}$	-1.060	-136.168	0.000
$\boldsymbol{\gamma_{22}}$	0.427	19.342	0.000
$\boldsymbol{\rho_{12}}$	-0.140	-1.452	0.146

In the second model (table 3-5), the effect is slowly decaying overtime ($\beta_{11,t-1} > \beta_{11,t-2} > \beta_{11,t-3} \ldots$). Past changes of €/$ ($\beta_{22,t-1}$)had a positive and significant effect on current changes (table 3-4) which was expected given that the Euro has generally appreciated relatively to the US$ since its introduction.

Table 3-5: Estimation results for monthly exports and GHS/US$ - 1984:01 to 2012:02.

Parameter	Coefficient	T-Stat	P-value
$\boldsymbol{\beta_{10}}$	-0.105	-1.873	0.061
$\boldsymbol{\beta_{20}}$	-0.034	-4.692	0.000
$\boldsymbol{\beta_{11,t-1}}$	-0.397	-12.075	0.000
$\boldsymbol{\beta_{12,t-1}}$	-0.005	-4.590	0.000
$\boldsymbol{\beta_{21,t-1}}$	-0.805	-2.539	0.011
$\boldsymbol{\beta_{22,t-1}}$	0.288	4.094	0.000
$\boldsymbol{\beta_{11,t-2}}$	-0.235	-6.261	0.000
$\boldsymbol{\beta_{12,t-2}}$	-0.005	-3.441	0.001
$\boldsymbol{\beta_{21,t-2}}$	0.479	2.026	0.043
$\boldsymbol{\beta_{22,t-2}}$	-0.004	-0.086	0.931
$\boldsymbol{\beta_{11,t-3}}$	-0.129	-2.936	0.003

(Table 3-5 continued)

Parameter	Coefficient	T-Stat	P-value
$\boldsymbol{\beta_{12,t-3}}$	0.000	-0.013	0.989
$\boldsymbol{\beta_{21,t-3}}$	-0.199	-0.896	0.370
$\boldsymbol{\beta_{22,t-3}}$	-0.082	-2.056	0.040
$\boldsymbol{\beta_{11,t-4}}$	-0.019	-0.390	0.697
$\boldsymbol{\beta_{12,t-4}}$	0.001	0.826	0.409
$\boldsymbol{\beta_{21,t-4}}$	-0.189	-0.858	0.391
$\boldsymbol{\beta_{22,t-4}}$	-0.038	-1.480	0.139
$\boldsymbol{\beta_{11,t-5}}$	-0.058	-1.423	0.155
$\boldsymbol{\beta_{12,t-5}}$	0.002	2.641	0.008
$\boldsymbol{\beta_{21,t-5}}$	-0.458	-2.116	0.034
$\boldsymbol{\beta_{22,t-5}}$	0.003	0.142	0.887
$\boldsymbol{\beta_{13}}$	0.608	1.993	0.046
$\boldsymbol{\beta_{23}}$	0.216	5.206	0.000
$\boldsymbol{\beta_{14}}$	0.056	0.260	0.795
$\boldsymbol{\beta_{24}}$	0.254	7.852	0.000
$\boldsymbol{\alpha_{10}}$	0.001	4.127	0.000
$\boldsymbol{\alpha_{20}}$	0.000	0.740	0.459
$\boldsymbol{\alpha_{11}}$	0.048	4.554	0.000
$\boldsymbol{\alpha_{22}}$	2.631	8.814	0.000
$\boldsymbol{\gamma_{11}}$	0.910	154.192	0.000
$\boldsymbol{\gamma_{22}}$	0.155	5.904	0.000
$\boldsymbol{\rho_{12}}$	0.103	1.898	0.058

Table 3-5 suggests feedback effects ($\beta_{12,t-k}, \beta_{21,t-k}$) between GHS/US$ and Ghana's exports changes in the mean equations. Table 3-4 and 3-5 also report the impact of "own" volatility on the mean of exports and exchange rates (β_{13}, β_{24}). Both models give similar results. "Own" volatility has impacted positively and significantly exchange rates and export volumes changes. We will now focus on the impact of exchange rate volatility on exports (β_{14}), which was one of the two hypotheses that this research intended to test. For the model including "third-country" exchange rates, we can see (table 3-4) that the effect of exchange rate volatility on export volumes growth is negative and significant. We thus strongly reject the null hypothesis that exchange rate volatility did not impact Ghana's exports. Conversely,

table 3-5 shows that the impact of "own-country" exchange rate volatility on export volumes growth is not significant. However, export volumes volatility has positively and significantly impacted the changes in GHS/$ exchange rates (β_{23}). The significance of the γ's and α's variables in both models suggests that our assumption that export and exchange rates volatilities follow a GARCH process was correct.

3.5 Discussion

This research comes at a time when Ghana and many other countries that have followed the growth framework recommended by the IMF are at a crossroads. For the past thirty years Ghana has implemented market and export-oriented reforms. In particular, exchange rates and monetary policies have improved Ghana's price competitiveness (REER), which is, with foreign activity, one of the key determinants of a country's export performance. As such, it seemed relevant to look back at these three decades of reforms and measure if they have been the cause of Ghana's recent export performance. The liberalization of Ghana's economy may have also increased the exposure of exporters to risk such as exchange rate volatility, and as a consequence, hampered export volumes growth.

In order to test the hypothesis that both price competitiveness and foreign income have not caused-in-mean Ghana's export performance, we followed the TYDL procedure which consists in estimating a lag-augmented VAR model and used a modified Wald statistic. This choice was supported by results from the most recent unit-root testing procedures. We decided to analyze both total and agricultural exports given the importance of agricultural products in total exports. We used annual data from 1970 to 2009. Export performance was measured by export volumes, price

competitiveness by REER and foreign activity, by the trade-weighted foreign GDP. Based on the causality tests, we conclude that while total export volumes have been driven by REER, none of the two assumed main factors of export performance have caused agricultural export volumes.

To test the hypothesis that exchange rate volatility had not impacted Ghana's export growth, we wanted to measure the effect of both "own-country" and "third-country" exchange rate volatility as the latter have been generally overlooked in the literature. We drew from financial econometrics and used two bivariate VAR-GARCH-in-mean models. Although rarely used in agricultural economics works, this type of models presents many advantages. In particular they allow simultaneously estimating the conditional variances (volatility) and mean equations which confer these tests efficiency. We used monthly real exports and nominal exchange rates. Considering that the Euro and the US$ are the two main vehicle currencies for Ghana's exported products, we used monthly €/US$ exchange rates to test "third-country" effects and GHS/US$ to test "own-country" effects. After estimation of the two models, it seems that "third-country" exchange rate volatility have deeply depressed Ghana's export growth while Ghana's exchange rate volatility did not have had any effect. A plot of the US$/€ and GHS/€ (figure 3-2) illustrates why GHS/US$ exchange rate volatility did not have any effect on Ghana's export growth. Both exchange rates have moved closely together for the past ten years.

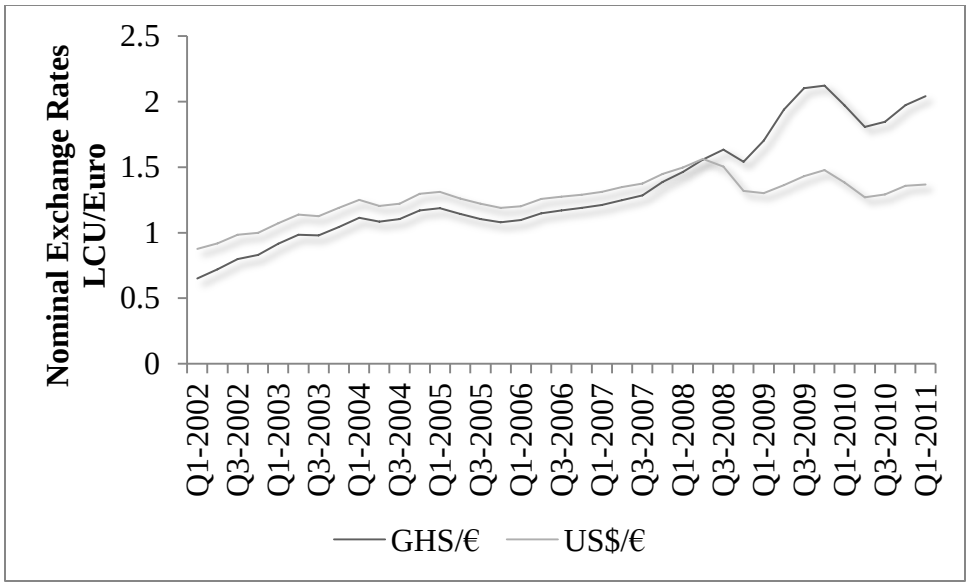

Figure 3-2: GHS/€ and US$/€ bilateral nominal exchange rates overtime (Q1:2000-Q1:2011).

Further, the negative impact of €/US$ exchange rate volatility might be more linked to Ghana's trade patterns than to the effects depicted by Cushman (1986). Indeed, the European Union is Ghana's main export market. Moreover, Ghana exports mainly raw materials (e.g., cocoa beans) that are processed in Europe and exported to the rest of the World. Most World trade is done in US$. Thus, European exporters are those facing a foreign exchange risk (€/US$). Assuming risk aversion under profit maximization; if foreign exchange risk increases European exporters might decrease their production which will lead to a decrease in imports from Ghana. As such, this analysis associates third-country effects to a decline in total derived demand.

What the results first tell us is that the policy framework that has been followed by Ghana under the recommendations of the IMF and other bilateral and multilateral agencies has successfully encouraged exports. Improvements in price

competitiveness via inflation control and exchange rates realignment have been the principal drivers of total export volumes. This conclusion may encourage other developing countries to consider some of these reforms to frame their development strategies. After all, Ghana has not only been successful at developing its export sector but also at fulfilling its development goal of becoming a middle-income country by 2020.

Second, the lack of causation between price competitiveness and agricultural exports can be explained by our original assumption that exports are imperfect substitutes. In particular, it might suggest that agricultural exports are obedient to the Law of One price. Third, for both total and agricultural exports, foreign activity did not seem to have influenced export performance. We would have expected that as the World income has been recently steadily growing, the demand for Ghana's products would have increased. This could confirm that Ghana is a residual supplier (Goldstein and Khan, 1978); and that other factors than prices and foreign activity have driven Ghana's agricultural export performance. Therefore, sectoral and export promotion policies will have to be enforced to develop Ghana's agricultural exports further.

Future research will have to consider and measure the effect of non-price factors on Ghana's exports growth and in particular in the agricultural sector. When longer time series become available for Ghana, the bivariate MGARCH-M model could be expanded to include all relevant factors of export performance. In particular, the effect of foreign income volatility on Ghana's exports would be interesting to study considering that impact of global recessions in Ghana's trading partners may have increased their income volatility. Third, we have seen that Ghana's export

growth accelerated at the beginning of the 2000's (appendix 5), date at which major changes in monetary policies occurred and decreased inflation. There is actually theoretical evidence on the relationship between inflation uncertainty and the level of inflation (Cukierman and Meltzer, 1986). Therefore, it would be interesting to test the relationship between inflation uncertainty and Ghana's exports (via the REER channel) using the MGARCH-in-mean model. Finally, the analysis of third-country exchange rate effects could be investigated further (level and volatility). Indeed, the impact of third-country exchange rates on Ghana's exports can actually be analyzed at two different levels. To illustrate this argument, we shall consider the example of Ghana and Côte d'Ivoire that are both exporting cocoa beans to Europe (e.g., Germany) where cocoa beans are processed and exported to countries such as the U.S. On the one hand, if the U.S. dollar appreciates relative to the Euro, the U.S. demand (primary demand) for chocolate products from Germany will increase. Thus, Germany's total demand of cocoa beans (derived demand) will also increase and, as a result, Ghana's exports of cocoa beans will grow. On the other hand, if Côte d'Ivoire's currency (CFA) appreciates relative to the Euro holding the GHS/€ constant, the derived demand of cocoa beans from Ghana might also increase. Future research should seek to determine through which channel third-country exchange rates impact Ghana's exports the most.

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4 CHOOSING LAG ORDER in NON-CAUSALITY TESTING

4.1 Introduction

The determination of the lag length is a key step when studying dynamic relationships between economic variables. Causality analysis, a popular field in applied economics, illustrates this statement. Causality here refers to Granger causality (Granger, 1969). In that conceptual framework, causality from X to Y is tested imposing zero restrictions on the parameters of lags of X in the equation of Y. Series are generally modeled jointly but the type of model depends on the properties of the series. If the series are stationary, a vector autoregressive (VAR) model is estimated in levels, if they are unit-root non-stationary, a VAR model in first differences is preferred while if they are cointegrated, a vector error correction model (VECM) is entertained. Statistical tests can help to determine the dynamic and interaction properties of the series and decide which estimation procedure to use. Causality analysis is thus conditioned on pre-testing (unit-root and cointegration tests) which may create important biases. In this context, Toda and Yamamoto (1995) as wells as Dolado and Lütkepohl (1996) have developed a procedure (hereafter TYDL) that does not require any pre-testing as non-causality tests can be performed regardless if the series are integrated or cointegrated. More precisely, the TYDL procedure consists in estimating a lag-augmented VAR model in levels and using modified Wald tests (MWALD) for non-causality.

According to Toda and Yamamoto (1995) any lag selection procedure can be used to determine the VAR model lag length. In practice, authors often choose the lag

order based on some information criterion such as the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC or BIC). Likelihood ratio (LR) tests can be used and their finite sample correction version (Sims, 1980) is preferred in small samples. Recently, some authors have assessed the impact of lag order selection in the context of unit-root tests (e.g., Ng and Perron, 2001) and cointegration tests (e.g., Qu and Perron, 2007). Their studies were based on the observation that unit-root and cointegration tests may suffer from size distortions and power loss if the lag order is not appropriately selected. In particular the AIC and SBC lead to severe size distortions when the data generating process (DGP) of the series includes a moving average term (MA) with a large and negative root. Multivariate DGPs with MA terms are referred to infinite order VAR or VARMA models and are in fact very common in economic series. For instance, Yap and Reinsel (1995) found that U.S. interest rate series (Federal fund rate, 90-day Treasury Bill rate and 1-year Treasury Bill rate) can be best modeled by a vector autoregressive moving average model (VARMA). In practice, this type of process is approximated by a VAR model of finite order *k*. In that case, lag order selection methods selection might lead to too parsimonious models (Qu and Perron, 2007).

In this context, this research seeks to investigate the impact of lag order selection on non-causality tests. We provide simulation evidence comparing some of the most frequently used selection methods (SBC and LR tests) in terms of their selected lag order distribution and finite sample properties of the resulting non-causality tests. It is hoped that this research will give guidance to practitioners when testing for non-causality using the TYDL procedure.

The essay is organized as follows. In the next section, the TYDL procedure is presented. Important conclusions emanating from theoretical works on lag order selection in VAR processes are also summarized. In the third section, the Monte Carlo experiment is described. In the third section, results are summarized and in the last section, guidance on how to select the lag order in practice is provided and possible future research is discussed.

4.2 Literature Review

The review of literature is organized to first provide a presentation of the so-called TYDL procedure. We then review some simulation studies that have assessed the impact of lag order selection in the framework of VAR models.

4.2.1 Presentation of the TYDL Procedure

To present this procedure in a way that is consistent with apply works, we will describe, without loss of generality, the special case of a bivariate (N=2) VAR with true lag order *k=2* and without an intercept:

$$Y_t = A_1 Y_{t-1} + A_1 Y_{t-2} + \varepsilon_t, \quad (1)$$

where $Y_t = (Y_{1t}, Y_{2t})'$; $A_1 = \begin{pmatrix} {a_{11}}^1 & {a_{12}}^1 \\ {a_{21}}^1 & {a_{22}}^1 \end{pmatrix}$; $A_2 = \begin{pmatrix} {a_{11}}^2 & {a_{12}}^2 \\ {a_{21}}^2 & {a_{22}}^2 \end{pmatrix}$; $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$

and ε_t has zero mean and the positive-definite variance-covariance matrix Σ_ε. If *vec* is the operator that stacks the columns of the matrices A_1 and A_2, then the coefficients can be stacked in one column as follows:

$$a_2 = vec[A_1\ A_2] = [{a_{11}}^1\ {a_{21}}^1\ {a_{12}}^1 {a_{22}}^1 {a_{11}}^2\ {a_{21}}^2\ {a_{12}}^2 {a_{22}}^2]'.$$

Suppose that we are interested in testing the non-causality from Y_2 to Y_1, the null hypothesis (H_o) of non-causality is equivalent to imposing the zero linear restrictions on the parameters of the lags of Y_2 in Y_1:

$$H_o: Ra_2 = s \text{ and } H_1: Ra_2 \neq s, \tag{2}$$

where $R = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$ and $s = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.

Providing an estimator of the coefficients *a's* that asymptotically satisfies the central limit theorem (e.g., ordinary least squares – OLS or maximum likelihood estimator – MLE)*:*

$$T^{\frac{1}{2}}(\hat{a}_2 - a_2) \xrightarrow{(weakly\ convergence)} N(0, \Sigma_2),$$

the following Wald statistic can be constructed (Dolado and Lütkepohl, 1996):

$$\lambda_w = T(R\hat{a}_2)'^{\left(R\hat{\Sigma}_2 R'\right)^{-1}}(R\hat{a}_2). \tag{3}$$

This statistic has an asymptotic χ^2 distribution with the number of degrees of freedom corresponding to the number of restrictions. In the above-described example, in (2) there are *q=2* restrictions and this is equal to the number of rows in *R*. However, if Y_t is *I(d)* the previously described property does not hold anymore. As explained by Dolado and Lütkepohl (1996), the reason is that the rate of convergence is faster than $T^{1/2}$. In that case, Wald tests may not have standard asymptotic properties. To counter this problem in practice, both Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) have shown that it suffices to augment the VAR with the number of extra lags equal to *d*, the maximum order of integration. In our

example (equation (1)), if we assume that the order of integration of the series is at most *d=1* we would estimate a VAR(p) in levels with $p = k + d = 2 + 1 = 3$. The MWALD test is then performed exactly as described above. The implementation of this procedure in available statistical softwares such as SAS® is explained in Rambaldi and Doran (1996). It implies, notably, estimating in a seemingly unrelated regressions (SUR) framework.

4.2.2 Lag Order Selection in VAR Models

As highlighted above, lag order selection is a crucial step when estimating vector autoregressive models. Estimating a VAR model with the wrong lag length can lead to biased results regardless of the study context. The literature abounds with studies that have assessed the impact of lag order selection in different contexts including forecasting performance, impulse response analysis, cointegration and causality tests. Lütkepohl (1985) compared ten lag selection methods (LR tests, Partial autocorrelations - PAC, Final Prediction Error - FPE, AIC, SBC, CAT, Shibata, Hannan-Quinn-HQ, zero-order and max-order) in the context of forecasting. Giving emphasis to the simple case of a bivariate VAR(1), Lütkepohl (1985) found that the SBC was the criterion that chose the correct lag order most often for all sample sizes (T=40, 100 and 200). The HQ criterion gives similar results but systematically estimates a higher lag order than SBC.

An estimator is consistent if, as *T* goes to infinity, $\hat{k}$ converges in limiting distribution to *k*, the true lag order (Lütkepohl, 2005):

$$\text{plim}_{T\to\infty}\, \hat{k} = k. \qquad (4)$$

Further, a VAR order estimator is strongly consistent if the limiting distribution of $\hat{k}$ converges to *k* with a probability of 1 (almost surely):

$$P\{\lim \hat{k} = k\} = 1. \quad (5)$$

A lag selection criterion that results from an estimator that is asymptotically (strongly) consistent, it said to be (strongly) consistent (Lütkepohl, 2005). Lütkepohl (1985) findings show that both SBC and HQC are consistent. This also implies that asymptotically, the SBC and HQC are unbiased estimators.

SBC and HQC have also the best forecasting performance. The FPE, AIC, CAT and Shibata tend to overestimate the true lag order and as the sample size increases, they become equivalent in terms of lag order selection and forecasting performance. Lütkepohl (1985)'s results hold for higher dimensional VAR models and processes with moving average terms.

Assuming that causal relationships between money growth and inflation exist, Jones (1989) compared two classes of lag selection methods. The first class includes *ad hoc* approaches such as arbitrary lag specifications and rules of thumb lag length. The second class refers to statistical research criteria and Jones (1989) chose the FPE, BEC (Bayesian estimation criterion) and PH t-tests (Pagano and Hartley t-tests). Jones (1989) implemented Granger causality tests between eight pairs of inflation and money growth measures. He found that the BEC performed worse. This criterion tends to select short lag length that does not allow covering causality. One of the *ad hoc* approaches (i.e., use eight lags for quarterly data) actually performs the best at detecting causality between money growth and inflation.

In macroeconomics, authors are often interested in estimating impulse response functions in VAR models to describe how economic variables respond to shocks. Ivanov and Kilian (2005) sought to produce empirical evidence on the impact of lag order selection and provide guidance in the context of impulse response analysis. Using three different processes (monthly and quarterly VAR models and quarterly VECM) constructed from actual economic data, they compare six lag selection methods (SBC, HQ, AIC, LR and SLR tests, and LM) in terms of the accuracy of the response estimator (difference between the mean squared error (MSE) using the true lag order and the MSE using the selected lag order). The small sample correction to LR tests (SLR) was proposed by Sims (1980) and Lagrange multiplier tests (LM) refer to a sequential Portmanteau test. Ivanov and Kilian (2005) conclude that there is no one single criterion that would be appropriate for all sample sizes and processes. They nevertheless provide some guidance on which criterion to use in each case. They also show that if the appropriate criterion is used, the accuracy of the impulse response estimates is significantly improved. For instance, the AIC is appropriate for all sample sizes in the case of a monthly VAR model while the SBC provides better estimates if the model is a VECM.

Ozcicek and McMillin (1999) compared lag selection criteria in terms of forecasting performance and impulse response functions accuracy for both symmetric and asymmetric lag VAR models. They focused their analysis on the AIC, SBC, Posterior Information Criterion (PIC) and the AIC and SBC for asymmetric models (KAIC and KSBC). They generated ten bivariate VAR models (differing by their lag length and degree of asymmetry) based on actual economic data. They computed the

lag length frequency distributions for each selection criterion. For symmetric models, they found that the AIC selected the correct lag length more often while for asymmetric models, the KAIC is the preferred criterion. The SBC and PIC tend to underestimate the true lag order. Regarding the forecasting performance, for models with short lag length, Ozcicek and McMillin (1999) found that there was not much difference between all criteria while for models with long lag length, the AIC performed better. For the impulse response functions accuracy, the AIC outperformed the other criteria for models with long length while the SBC, PIC and KSBC gave better estimates in the case of asymmetric VAR models with short lag length. Finally, the authors did not find significant differences in the case of symmetric short lag VAR models.

Lütkepohl (2005) implemented Monte Carlo simulations to compare the lag order frequency distribution and forecasting performance (MSE) in small samples of four different lag selection methods: AIC, FPE, SBC and LR tests. Lütkepohl (2005) explains that if the objective of the research is forecasting, the AIC and FPE are generally preferred as they use the minimum MSE as criterion. On the other hand, if the objective is to find the correct lag order, consistent criteria (SBC and HQC) are preferred. In his simulations, Lütkepohl (2005) chose a bivariate VAR(2) as the general model. The exercise is carried out for two sample sizes (T=30 and 100). Lütkepohl (2005) first concluded that none of the criteria accurately estimated the true lag order. The AIC and FPE lag order distributions as well as forecasting performance are very similar, especially when T=100. The SBC tends to underestimate the true lag order. However, SBC forecasts are the best for T=30

suggesting that underestimation should not be a serious concern in small samples when the purpose of the study is forecasting. For T=100, all criteria lead to similar forecasts. LR tests tend to overestimate the true lag order and as a result they produced the worse forecasts.

The common conclusion to all these studies is that the choice of the lag selection method has important consequences on the dynamic properties of the VAR model and might lead to spurious results regardless of the objective of the study. Also, it appears difficult to generalize about the best selection method to use across processes and sample sizes. Despite this abundant literature, it is particularly not clear which method to choose in small samples (Lütkepohl, 2005). Another important conclusion is that the simulation findings only hold for the context in which they were designed. Therefore, reassessing the impact of lag order selection on causality tests using the TYDL procedure appears of practical importance. Moreover, if authors have tried to cover most DGPs, the case of a VAR model with residuals with a moving average structure is seldom analyzed. Indeed, Lütkepohl (2005) concludes his Monte Carlo study explaining that if in practice it is often assumed that the underlying DGP is a finite order VAR model, it might not be always the case. He added that if the true DGP is an infinite order VAR model the AIC should perform better as it tends to select less parsimonious models.

In this spirit, some literature suggests that inappropriate lag selection in the particular case of moving average errors can lead to tests with poor properties. Following the work of Schwert (1989), Ng and Perron (1995) investigated the impact of lag order selection in the context of unit-root tests. Via Monte Carlo simulations

they compared deterministic rules with data-based rules. Deterministic rules refer to the case where the practitioner fixes the lag order independently of the sample size. Ng and Perron (1995) evaluated the effect of using deterministic rules on size and power properties of augmented Dickey-Fuller unit-root tests (ADF) for moving-average and autoregressive DGPs. The authors observed that unit-root tests present serious size distortions in the moving average case especially when the moving average coefficient is negative and large. Size distortions increase with sample size. As the fixed lag order increases, size distortions seem to vanish while the power decreases. In the autoregressive case, size distortions are minimal. Ng and Perron (1995) conclude that the issue with deterministic rules is that they don't take into account the underlying DGP. The authors also proceeded to a comparison of three data-based criteria (AIC, SBC and sequential tests) when T=100. They set up lower and higher bounds for the lag length. In the moving average case, the AIC and SBC select too parsimonious models which lead to unit-root tests with large size distortions when the moving average coefficient is large and negative. Again, they observed that size distortions do not disappear in large samples. In the autoregressive case, both information criteria select the true lag order most of the time and, as a consequence, the exact size of the unit-root tests is close to the nominal size. Because sequential tests tend to be less conservative than information criteria, size distortions are minimal but over-parameterization can lead to tests with low power. Ng and Perron (1995) conclude on the importance of appropriately choosing the lower and upper bounds of the lag order to avoid, depending on the rule, over-parameterization or under-parameterization.

Lütkepohl and Saikkonen (1997) re-investigated Ng and Perron (1995) study but in the context of cointegration tests. Lütkepohl and Saikkonen (1997) proved that, asymptotically, the choice of the lag order (*k*) has no effect on the properties of LR tests for the cointegration rank as long as *k* is selected as a function of *T* such that $k \to \infty$ and $k^3/T \to 0$ as $T \to \infty$ (Said and Dickey, 1984; Ng and Perron, 1995; Lütkepohl and Saikkonen, 1997). However, they found via simulations that in small samples the choice of the lag length matters. In the case of a VAR model with true cointegration rank *r=0* and true lag order *k=1*, the authors found that if the lag order is underspecified, the LR tests present large size distortions. Although less severe, an overspecified lag order also leads to size distortions. In fact rejection rates increase as the overspecified lag order increases. Regardless if the lag order is well specified, the exact size of the tests is always higher than the nominal size when *r>0*. Information criteria such as the AIC, HQ and SBC tend to select the true lag order more often that the deterministic rule ($T^{1/3}$). Consequently, the use of these criteria leads to LR tests with better properties. In the case of a VARMA, LR tests perform poorly when a small lag order is selected. Moreover, for increasing lag order, the size of the tests deteriorates. Again, the size of the tests is closer to the nominal size when using a model selection criterion rather than a deterministic rule. However, the SBC leads to LR tests with the worse size properties as it tends to select too parsimonious models. In conclusion, Lütkepohl and Saikkonen (1997) recommend the use of selection criteria in small samples.

All these studies as well as the works of DeJong et al. (1992) and Perron and Ng (1998) motivated some authors (e.g., Ng and Perron, 2001 and Qu and Perron, 2007) to develop a new type of information criterion (modified information criterion) that significantly improves the size of unit-root tests (Ng and Perron, 2001) and cointegration tests (Qu and Perron, 2007). Tests can either suffer from power loss in the case of a nearly unit-root autoregressive process or size distortions in the presence of residuals with a moving average root close to -1 (Ng and Perron, 2001). In practice, the true DGP is unknown but it is generally assumed that the process has a finite order AR or VAR representation. The truncation lag *k* is determined by some data-based procedure such as an information criterion or LR tests. If indeed the true DGP is an infinite order AR or VAR, conventional lag selection procedures may choose a lag length that is smaller than the true one, therefore leading to size distortions. This is an important matter to address as processes with errors with a large negative moving average root are common in economics. Ng and Perron (2001) give the example of inflation rate series and omitted outliers.

4.3 Monte Carlo Experiment

4.3.1 Experimental Design

The goal of this Monte Carlo experiment is to compare LR tests and the SBC in terms of their selected lag length frequency distribution and, most importantly, in terms of the finite sample properties of the resulting non-causality tests using the TYDL procedure as presented in the previous section. We chose to compare these two criteria because they are the most often used in econometric works (Ng and

Perron, 1995). Moreover it allows comparing estimator-type (SBC) with test statistic-type (LR tests) selection methods. Our general process is a VARMA(k,1):

$$Y_t = \Phi_{t-1}^1 * Y_{t-1} + \cdots + \Phi_{t-k}^k * Y_{t-k} + \varepsilon_t + \Theta_{t-1}^1 * \varepsilon_{t-1}. \quad (6)$$

For instance, the following equation depicts a bivariate VARMA(2,1):

$$\begin{pmatrix} Y_{1,t} \\ Y_{2,t} \end{pmatrix} = \begin{pmatrix} \emptyset_{11,t-1}{}^1 & \emptyset_{12,t-1}{}^1 \\ \emptyset_{21,t-1}{}^1 & \emptyset_{22,t-1}{}^1 \end{pmatrix} * \begin{pmatrix} Y_{1,t-1} \\ Y_{2,t-1} \end{pmatrix} + \begin{pmatrix} \emptyset_{11,t-2}{}^2 & \emptyset_{12,t-2}{}^2 \\ \emptyset_{21,t-2}{}^2 & \emptyset_{22,t-2}{}^2 \end{pmatrix} * \begin{pmatrix} Y_{1,t-2} \\ Y_{2,t-2} \end{pmatrix} +$$

$$\begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix} + \begin{pmatrix} \theta_{11,t-1} & \theta_{12,t-1} \\ \theta_{21,t-1} & \theta_{22,t-1} \end{pmatrix} * \begin{pmatrix} \varepsilon_{1,t-1} \\ \varepsilon_{2,t-1} \end{pmatrix}, \quad (7)$$

where $\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \sim N(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 100 & 0 \\ 0 & 100 \end{bmatrix})$.

Lütkepohl (1985) explains that a central concern in Monte Carlo experiments is to simulate processes that allow generalizing the conclusions. Hence, in this research, four different VAR models have been simulated. They differ by the number of variables in the system N={2,3} and the lag length k={1,2}. Trivariate VAR models are very common in the empirical literature that is why we chose to include this case. For each VAR model, twelve processes have been simulated. The DGP vary in terms of the degree of integration of the variables (I(0) or I(1)), cointegration (CI(0) or CI(1)), the presence of causality[15] from Y_2 to Y_1 or not ($\emptyset_{12}{}^1 and\ \emptyset_{12}{}^2 \neq 0\ or\ \emptyset_{12}{}^1 = \emptyset_{12}{}^2 = 0$) and the presence of moving average terms. While VARMA processes can be represented by an infinite lag order VAR, in practice, because samples are small, a VAR model is estimated with truncation lag *k* is estimated instead. The motivation of including MA in the DGP was to observe the implications

[15] Short-run causality

of this approximation. Tables 4-1 to 4-4 present those processes for a bivariate VAR(1), a bivariate VAR(2), a trivariate VAR(1) and a trivariate VAR(2) respectively. Processes 7 to 12 (tables 4-1 to 4-4) were generated so as to satisfy the null hypothesis (H_0) of non-causality from Y_2 to Y_1 while processes 1 to 6 satisfy the alternative hypothesis (H_1).

Simulations were performed at three different sample sizes T = {50,100,200}. We generated T+100 observations and discarded the first 100 observations. After generating the data and for each process, we estimated alternative VAR(k) models in levels for *k* varying from 1 to k_{max} where $k_{max} = int(12 * \left(\frac{T}{100}\right)^{\frac{1}{4}})$ (Schwert, 1989; Ng and Perron, 2001). Therefore, k_{max}=10 for T=50, k_{max}=12 for T=100 and k_{max}=14 for T=200. The frequency distribution of the lag length as selected by each method (i.e., SBC and LR tests) is then computed over NSAM=500 samples. Although the ultimate objective of this research is to produce accurate non-causality tests results it is important to look at the entire distribution of the lag length. It allows linking the non-causality tests performance to lag order selection and concluding if eventual issues are caused by an overfitting or an underfitting of the true process.

Next, following the TYDL procedure, for each sample, a finite order VAR(k+d) is estimated in levels with *k* being selected by one of the two methods and *d* being the maximum order of integration (*d=1* in all cases). The estimation is carried out in a SUR framework (Rambaldi and Doran, 1996) and the null hypothesis that Y_2 does not cause Y_1 is tested using MWALD tests. We then computed the rejection frequencies over the 500 samples. Computing rejection frequencies allows studying

the finite sample properties of the MWALD tests. For processes for which the null hypothesis is false (processes 1 to 6), the MWALD tests would perform well if rejection frequencies are close to 100%. For processes for which the null hypothesis is true (processes 7 to 12), the simulation results shed light on the size properties of the tests. The MWALD tests have good size if their exact size is close to 5%, the nominal size.

4.3.2 Lag Order Selection Methods

4.3.2.1 Likelihood Ratio Tests

One of the most popular methods to select the lag order in the case of vector autoregressive models are likelihood ratio (LR) tests. If we want to determine if a VAR model with $k=r$ lags (restricted model) is more appropriate than a VAR model with $k=u$ lags (unrestricted model) where $r<u$ we construct the following LR statistics:

$$LR = t * (log[\Sigma_r] - log[\Sigma_u]), \quad (8)$$

where $\Sigma_u$and $\Sigma_r$are the estimated error covariance matrices for the unrestricted VAR and the restricted VAR model respectively and *t* is the number of effective observations. Note that each VAR model is estimated with the same number of observations $t = T - k_{max}$. The LR statistic has a χ^2 distribution with $(k_u - k_r) * N^2$ degrees of freedom. Large values of the LR statistic leads to a rejection of the null hypothesis that the appropriate lag order is *r*. Because only the asymptotic distribution of LR tests is known, this lag selection method is more useful in large

samples. However, Sims (1980) proposed a modification of the LR tests that corrects the small sample bias:

$$LR = (t - c)(log\lceil\Sigma_r\rceil - log\lceil\Sigma_u\rceil), \quad (9)$$

where c is the number of parameters in each equation of the unrestricted system. For a VAR model without intercept, $c = k_u * N$. We chose to use this modified version for this research. The selection of the optimal lag length implies carrying out several pairwise comparisons. Testing for a large number of restrictions may lead to significant power losses and it is recommended to compare VAR models with close lag structure. Therefore, we chose to implement the following algorithm where LR tests are carried out sequentially (Lütkepohl, 2005). Starting with the maximum possible lag order k_{max}, we test if a VAR(k-1) is more appropriate than a VAR(k) using LR tests. If the null is not rejected, the second step is to test a VAR(k-2) against a VAR(k-1). This process continues until rejecting the null and the lag length of the unrestricted model corresponds to the optimal lag length (Lütkepohl, 2005). The significance level of individual tests is 5%.

4.3.2.2 Schwarz Bayesian Criterion

Information criteria are by far the most popular methods to determine the lag order of a model as they are automatically computed in statistical softwares. These criteria select the model that minimizes the sum of squares of the residuals while obeying to the principle of parsimony. For a system of equations such as a VAR model, those criteria are merely a generalization of their univariate form. The Schwarz Bayesian Criterion (SBC) (Schwarz, 1978) is computed as follows:

$$SBC = t * log\lceil\Sigma\rceil + N\log(t), \quad (10)$$

where $\lceil\Sigma\rceil$ is the determinant of the covariance-variance matrix of the residuals of the estimated VAR model, *t* is the number of effective observations and *N* is the total number of parameters in the system. *N* is the penalty to overfitting while the weight to overfitting is $\log(t)$. The model with the smallest SBC is chosen and its lag length corresponds to the optimal lag order.

4.4 Results

4.4.1 Lag Order Frequency Distributions

The frequency distribution results are reported in figures 4-1 to 4-24. Each figure corresponds to a panel of the lag order frequency distributions for the twelve DGPs (tables 4-1 to 4-4) and for a particular type of VAR model (N=2 or 3, k=1 or 2), sample size (T=50, 100 and 200) and lag selection method (SBC or LR tests). Figures 4-1 to 4-6 are panels of the lag order distributions for a bivariate VAR with one lag. Figures 4-1 and 4-2 represent the lag distribution at T=50 for the LR tests and SBC respectively. As processes 1 to 3 and 7 to 9 are finite lag order processes (table 4-1), we expect the selection methods to choose k=1 most of the time. The SBC selects k=1 with a high probability (figure 4-2). The LR tests also choose k=1 more frequently than any other lag lengths although the distributions are more spread than those of the SBC (figure 4-1). In fact, lags are selected over the entire allowed range (1 to 10 lags, figure 4-1) and the LR tests overestimate the true lag length about 40% of the time for those processes. As the sample size increases, the frequency of selecting the true lag order (k=1) does not increase for the LR tests while for the SBC, at T=200, we would select the correct lag length 100% of the time (figure 4-2).

Table 4-1: Description of the data generating processes – Bivariate VAR (1).

Process	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	CAUSALITY Y2 -> Y1						**NO CAUSALITY Y2 -> Y1**					
	CI(1,1)	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**
k=1												
$\emptyset_{11,t-1}$	0.5	0.8	1.2	0.5	0.8	1.2	1	1	0.4	1	1	0.4
$\emptyset_{12,t-1}$	-1	0.5	-0.5	-1	0.5	-0.5	0	0	0	0	0	0
$\emptyset_{21,t-1}$	-0.25	0.4	0.6	-0.25	0.4	0.6	-0.25	0	0.2	-0.25	0	0.2
$\emptyset_{22,t-1}$	0.5	-0.2	0.3	0.5	-0.2	0.3	0.5	1	-0.2	0.5	1	-0.2
q=1												
$\boldsymbol{\theta}_{11,t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
$\boldsymbol{\theta}_{12,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{21,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{22,t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
NSAM	500	500	500	500	500	500	500	500	500	500	500	500
T	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200
var1	100	100	100	100	100	100	100	100	100	100	100	100
var2	100	100	100	100	100	100	100	100	100	100	100	100
cov12	0	0	0	0	0	0	0	0	0	0	0	0

Table 4-2: Description of the data generating processes - Bivariate VAR (2).

Process	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	CAUSALITY Y2 -> Y1						**NO CAUSALITY Y2 -> Y1**					
	CI(1,1)	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**
k=2												
$\emptyset_{11,t-1}$	-0.2	0.2	0.2	-0.2	0.2	-0.2	0.8	0.2	0.2	0.8	0.2	0.2
$\emptyset_{12,t-1}$	0.1	-0.7	0.7	0.1	-0.7	0.7	0	0	0	0	0	0
$\emptyset_{21,t-1}$	0.5	0.4	-0.4	0.5	0.4	-0.4	0.5	0.4	-0.4	0.5	0.4	-0.4
$\emptyset_{22,t-1}$	0.2	0.4	0.2	0.2	0.4	0.2	0.6	0.4	0.2	0.6	0.4	0.2
$\emptyset_{11,t-2}$	0.8	0.8	0.3	0.8	0.8	0.3	0.2	0.8	0.3	0.2	0.8	0.3
$\emptyset_{12,t-2}$	0.7	0.7	0.7	0.7	0.7	0.7	0	0	0	0	0	0
$\emptyset_{21,t-2}$	-0.4	-0.4	0.4	-0.4	-0.4	0.4	0.4	-0.4	0.4	0.4	-0.4	0.4
$\emptyset_{22,t-2}$	0.6	0.6	0.3	0.6	0.6	0.3	-0.2	0.6	0.3	-0.2	0.6	0.3
q=1												
$\boldsymbol{\theta}_{11,t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
$\boldsymbol{\theta}_{12,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{21,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{22,t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
NSAM	500	500	500	500	500	500	500	500	500	500	500	500
T	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200
var1	100	100	100	100	100	100	100	100	100	100	100	100
var2	100	100	100	100	100	100	100	100	100	100	100	100
cov12	0	0	0	0	0	0	0	0	0	0	0	0

Table 4-3: Description of the data generating processes – Trivariate VAR(1).

Process	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	CAUSALITY Y2 -> Y1						**NO CAUSALITY Y2 -> Y1**					
	CI(1,1)	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**
k=1												
$\emptyset_{11,t-1}$	0.5	0.1	0.2	0.5	0.1	0.2	0.8	1	-0.2	0.8	1	-0.2
$\emptyset_{12,t-1}$	-0.5	0.15	0.4	-0.5	0.15	0.4	0	0	0	0	0	0
$\emptyset_{13,t-1}$	0.5	-0.3	-0.1	0.5	-0.3	-0.1	0.2	0	0.3	0.2	0	0.3
$\emptyset_{21,t-1}$	-0.05	0.01	-0.2	-0.05	0.01	-0.2	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
$\emptyset_{22,t-1}$	0.95	0.7	-0.1	0.95	0.7	-0.1	0.95	0.3	0.3	0.95	0.3	0.3
$\emptyset_{23,t-1}$	0.05	-0.03	0.3	0.05	-0.03	0.3	0.05	0.2	0.2	0.05	0.2	0.2
$\emptyset_{31,t-1}$	0.06	0.006	-0.1	0.06	0.006	-0.1	0.06	0	-0.4	0.06	0	-0.4
$\emptyset_{32,t-1}$	0.06	-0.18	0.3	0.06	-0.18	0.3	0.06	0.2	0.2	0.06	0.2	0.2
$\emptyset_{33,t-1}$	0.94	0.982	0.4	0.94	0.982	0.4	0.94	0.1	0.1	0.94	0.1	0.1
q=1												
$\boldsymbol{\theta}_{11,t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
$\boldsymbol{\theta}_{12,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{13,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{21,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{22,t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
$\boldsymbol{\theta}_{23,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{31,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{32,t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{33,t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
NSAM	500	500	500	500	500	500	500	500	500	500	500	500
T	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200

(Table 4-3 continued)

Process	1	2	3	4	5	6	7	8	9	10	11	12
var1	100	100	100	100	100	100	100	100	100	100	100	100
var2	100	100	100	100	100	100	100	100	100	100	100	100
var3	100	100	100	100	100	100	100	100	100	100	100	100
cov12	0	0	0	0	0	0	0	0	0	0	0	0
cov13	0	0	0	0	0	0	0	0	0	0	0	0
cov23	0	0	0	0	0	0	0	0	0	0	0	0

Table 4-4: Description of the data generating processes – Trivariate VAR(2).

Process	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	CAUSALITY Y2 -> Y1						**NO CAUSALITY Y2 -> Y1**					
	CI(1,1)	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**	**CI(1,1)**	**CI(1,0)**	**CI(0,0)**
k=2	0.7	1.2	0.2	0.7	1.2	0.2	1.2	1.2	0.2	1.2	1.2	0.2
$\emptyset_{\mathbf{11},t-1}$	-0.2	0.3	0.7	-0.2	0.3	0.7	0	0	0	0	0	0
$\emptyset_{\mathbf{12},t-1}$	0.1	-0.4	-0.1	0.1	-0.4	-0.1	-0.4	-0.4	-0.1	-0.4	-0.4	-0.1
$\emptyset_{\mathbf{13},t-1}$	0.09	0.14	-0.4	0.09	0.14	-0.4	0.09	0.14	-0.4	0.09	0.14	-0.4
$\emptyset_{\mathbf{21},t-1}$	1.2	1.25	-0.5	1.2	1.25	-0.5	1.2	1.25	-0.5	1.2	1.25	-0.5
$\emptyset_{\mathbf{22},t-1}$	-0.25	-0.3	-0.6	-0.25	-0.3	-0.6	-0.25	-0.3	-0.6	-0.25	-0.3	-0.6
$\emptyset_{\mathbf{23},t-1}$	0.22	0.16	-0.1	0.22	0.16	-0.1	0.18	0.16	-0.1	0.18	0.16	-0.1
$\emptyset_{\mathbf{31},t-1}$	0.36	0.3	0.3	0.36	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.3
$\emptyset_{\mathbf{32},t-1}$	0.54	0.6	0.4	0.54	0.6	0.4	0.5	0.6	0.4	0.5	0.6	0.4
$\emptyset_{\mathbf{33},t-1}$	-0.2	-0.2	0.3	-0.2	-0.2	0.3	-0.2	-0.2	0.3	-0.2	-0.2	0.3
$\emptyset_{\mathbf{11},t-2}$	-0.3	-0.3	0.7	-0.3	-0.3	0.7	0	0	0	0	0	0
$\emptyset_{\mathbf{12},t-2}$	0.4	0.4	0.1	0.4	0.4	0.1	0.4	0.4	0.1	0.4	0.4	0.1
$\emptyset_{\mathbf{13},t-2}$	-0.14	-0.14	0.4	-0.14	-0.14	0.4	-0.14	-0.14	0.4	-0.14	-0.14	0.4
$\emptyset_{\mathbf{21},t-2}$	-0.25	-0.25	0.1	-0.25	-0.25	0.1	-0.25	-0.25	0.1	-0.25	-0.25	0.1
$\emptyset_{\mathbf{22},t-2}$	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.4
$\emptyset_{\mathbf{23},t-2}$	-0.16	-0.16	0.5	-0.16	-0.16	0.5	-0.16	-0.16	0.5	-0.16	-0.16	0.5
$\emptyset_{\mathbf{31},t-2}$	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
$\emptyset_{\mathbf{32},t-2}$	0.4	0.4	0.1	0.4	0.4	0.1	0.4	0.4	0.1	0.4	0.4	0.1
$\emptyset_{\mathbf{33},t-2}$												
q=1	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
$\boldsymbol{\theta}_{\mathbf{11},t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{\mathbf{12},t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{\mathbf{13},t-1}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta}_{\mathbf{21},t-1}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
$\boldsymbol{\theta}_{\mathbf{22},t-1}$	0	0	0	0	0	0	0	0	0	0	0	0

(Table 4-4 continued)

Process	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
$\boldsymbol{\theta_{23,t-1}}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta_{31,t-1}}$	0	0	0	0	0	0	0	0	0	0	0	0
$\boldsymbol{\theta_{32,t-1}}$	0	0	0	-0.8	-0.8	-0.8	0	0	0	-0.8	-0.8	-0.8
$\boldsymbol{\theta_{33,t-1}}$												
	500	500	500	500	500	500	500	500	500	500	500	500
NSAM	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200	50, 100, 200
T	100	100	100	100	100	100	100	100	100	100	100	100
var1	100	100	100	100	100	100	100	100	100	100	100	100
var2	100	100	100	100	100	100	100	100	100	100	100	100
var3	0	0	0	0	0	0	0	0	0	0	0	0
cov12	0	0	0	0	0	0	0	0	0	0	0	0
cov13	0	0	0	0	0	0	0	0	0	0	0	0
cov23	0	0	0	0	0	0	0	0	0	0	0	0

For processes including moving average terms (4 to 6 and 10 to 12 – see table 4-1), both criteria have distributions that present more dispersion and their center is k>1. This result was expected as VARMA processes are approximated by infinite order VAR processes. LR tests distributions present more dispersion than those of the SBC. For T=100 and T=200, the mode of the LR tests lag distributions is also systematically higher than SBC's. For both selection methods, as the sample size increases, the center of the distribution shifts to the right. For instance, for the LR tests and in the particular case of process 10 (table 4-1) the mode is k=2 at T=50, k=4 at T=100 and k=5 at T=200 (figures 4-1, 4-3 and 4-5). Note also that for process 12 (table 4-1), at T=50, the percentage of selected k=1 is high (figures 4-1 and 4-2). Thus both selection methods and the SBC in particular, clearly underestimate the true lag order.

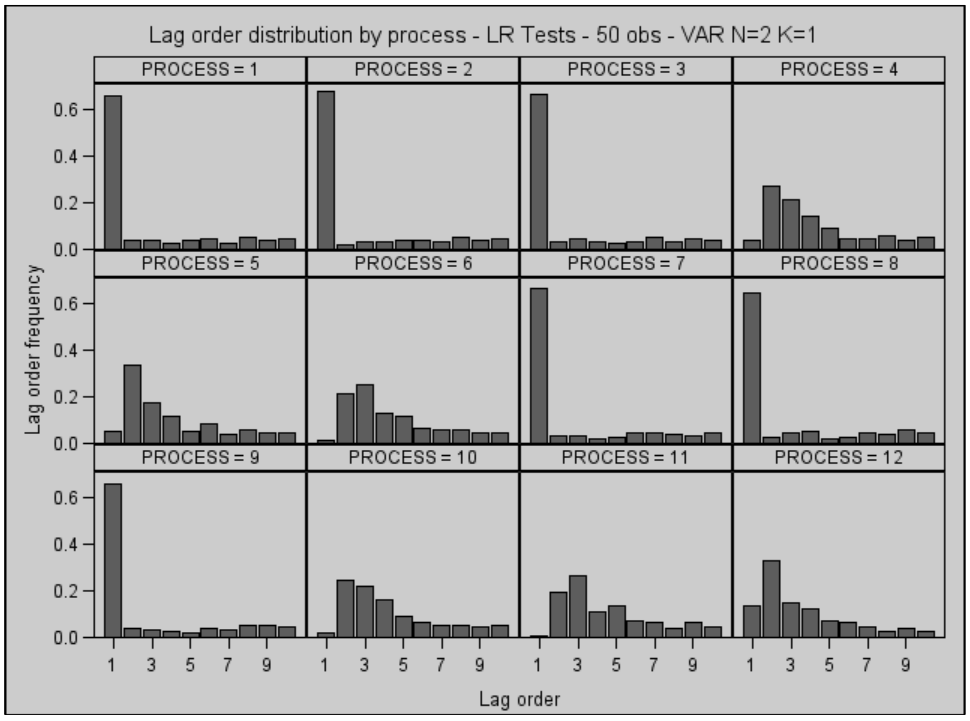

Figure 4-1: Lag order distribution – LR Tests – T=50 – Bivariate VAR(1).

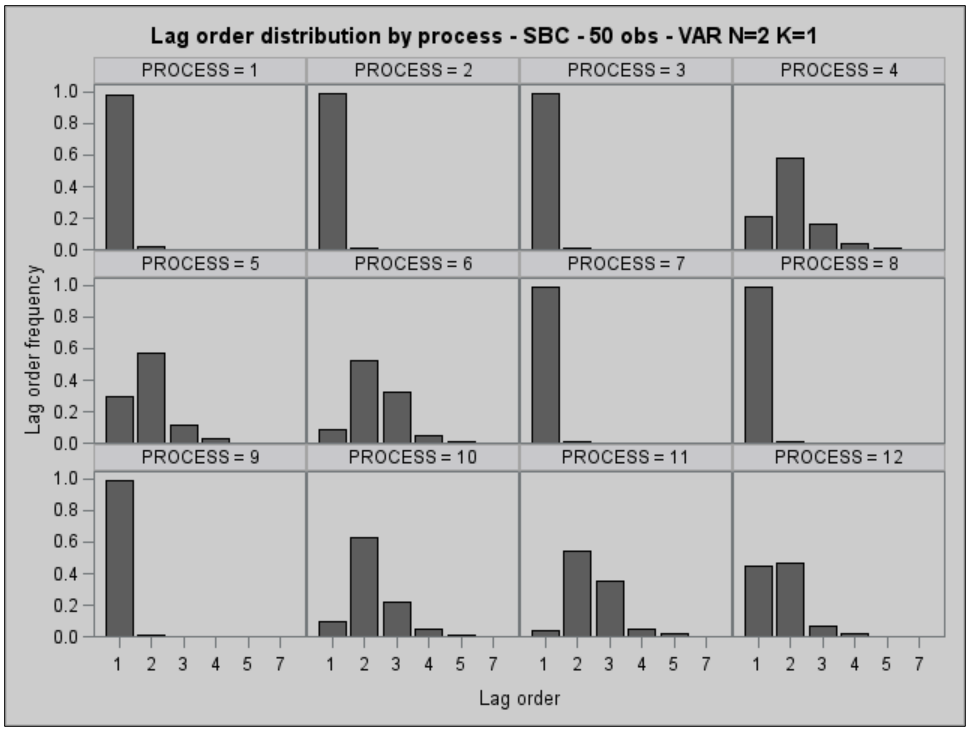

Figure 4-2: Lag order distribution – SBC – T=50 – Bivariate VAR(1).

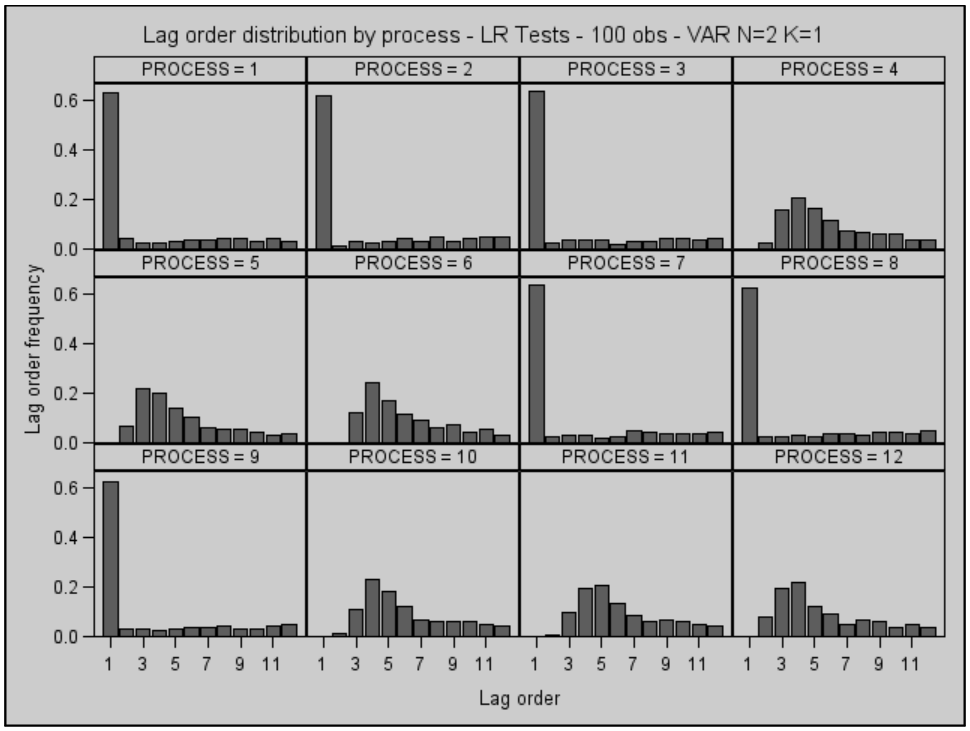

Figure 4-3: Lag order distribution – LR Tests – T=100 – Bivariate VAR(1).

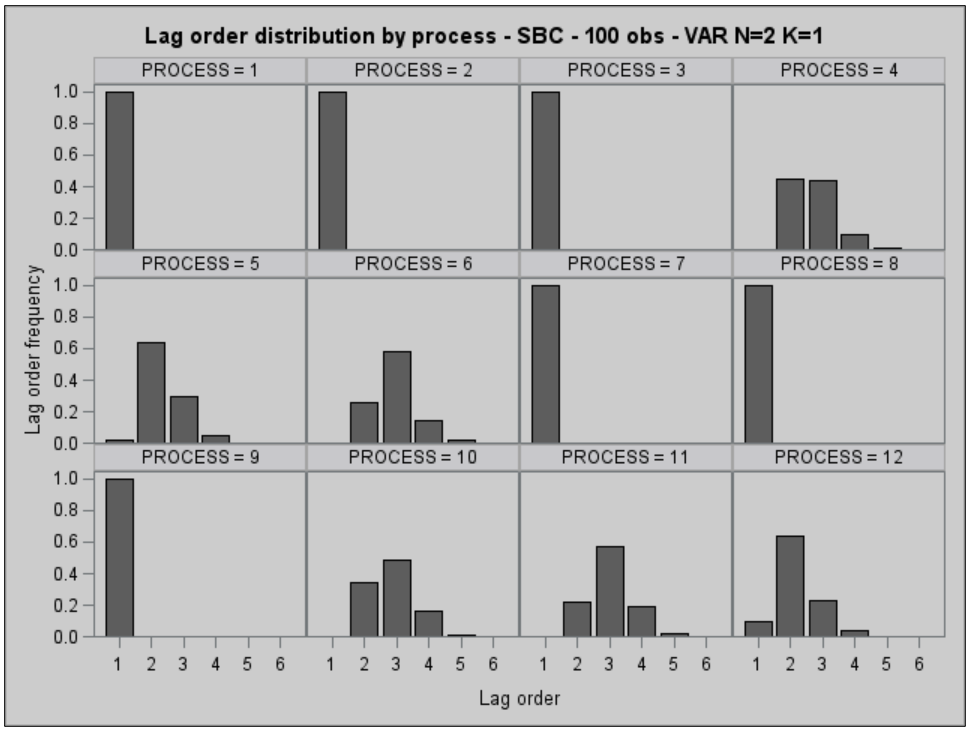

Figure 4-4: Lag order distribution – SBC – T=100 – Bivariate VAR(1).

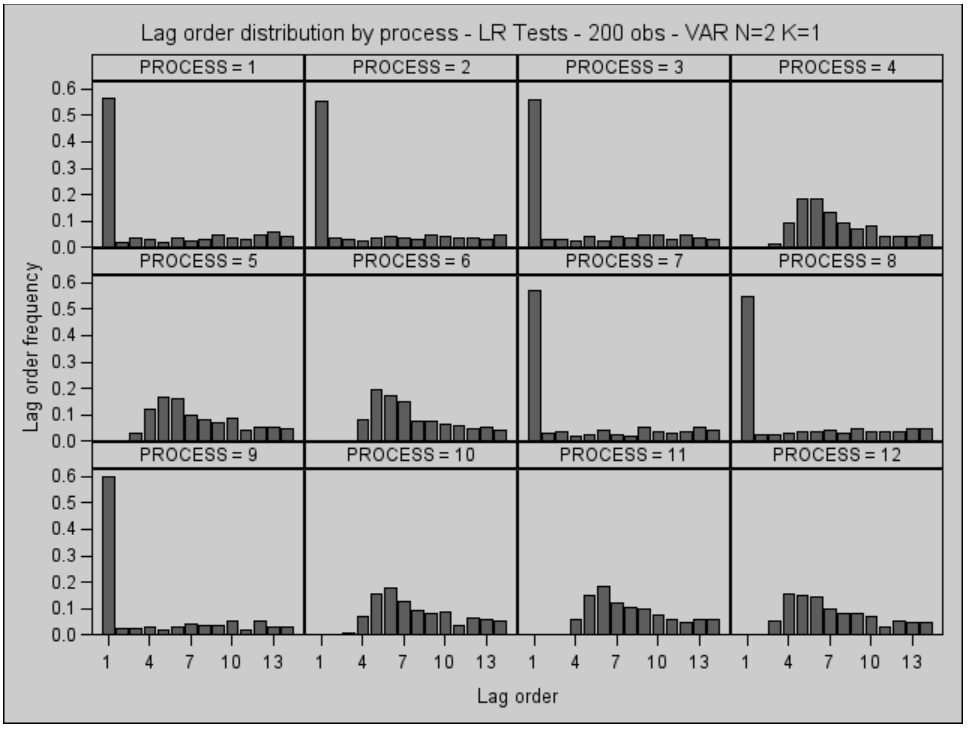

Figure 4-5: Lag order distribution – LR Tests – T=200 – Bivariate VAR(1).

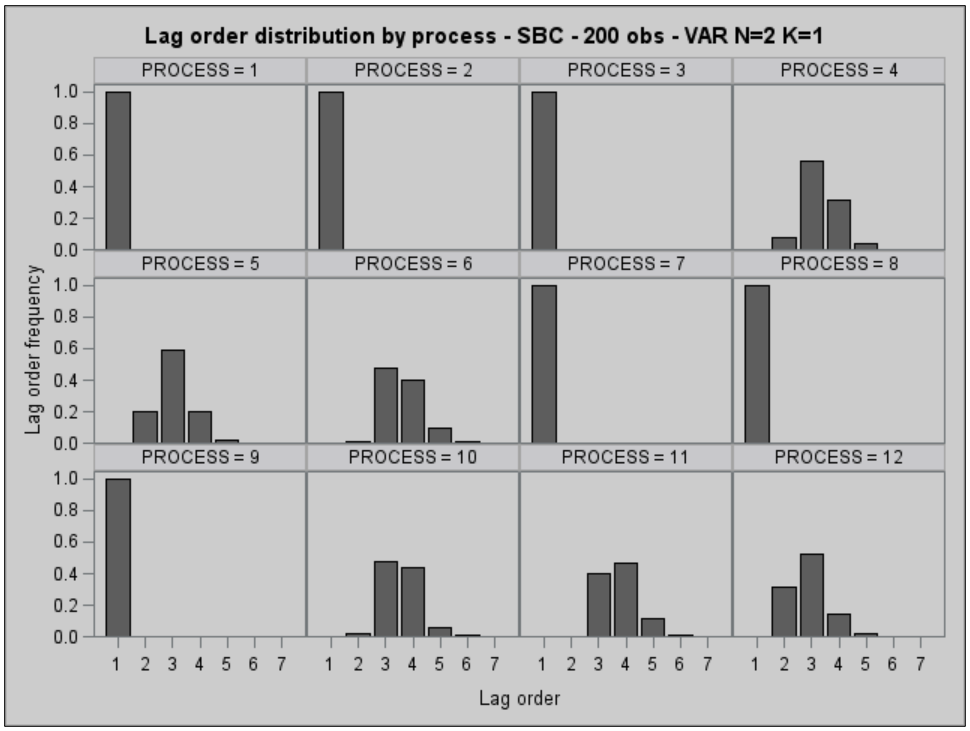

Figure 4-6: Lag order distribution – SBC – T=200 – Bivariate VAR(1).

Figures 4-7 to 4-12 are panels of the lag distributions for a bivariate VAR with two lags. As in the previous case, for finite order VAR model (processes 1 to 3 and 7 to 9 – see table 4-2), the true lag order (k=2) is selected most of the time by both lag selection methods. LR tests distributions are more spread and the true lag order is overestimated around 40% of the time while the probability of choosing the correct lag is close to one in the case of the SBC. Surprisingly, at T=50, both methods present a high proportion of k=1 selected for processes 7 and 9 (figures 4-7 and 4-8). The probability of underestimating the true lag order decreases for both lag selection methods as the sample size increases. However, only in the case of the SBC the probability of selecting the correct lag length increases with the sample size. For infinite order VAR processes (4 to 6 and 10 to 12 – see table 4-2) lag order distributions are more spread and their center shifts to higher lags as the sample size

increases. For instance, for the LR tests and process 10, the mode is k=2 at T=50, k=4 at T=100 and k=6 at T=200. For process 12, the mode is k=2 at T=50, k=3 at T=100 and k=4 at T=200 (figures 4-7, 4-9 and 4-11). In the case of the SBC and for process 10 the mode is k=2 at T=50, k=3 at T=100 and k=4 at T=200 while for process 12, the mode is k=1 at T=50 and k=2 at T=100 and 200 (figures 4-8, 4-10 and 4-12). Note also that both lag selection methods tend to underestimate the true lag order for processes 11 and 12. At T=50, the LR tests pick k=1 36% of the time (process 11) and 18% of the time (process 12). Likewise, the SBC selects k=1 with a probability of 74% and 60% for processes 11 and 12 respectively. As the sample size increase, the proportion of k=1 decreases for both criteria.

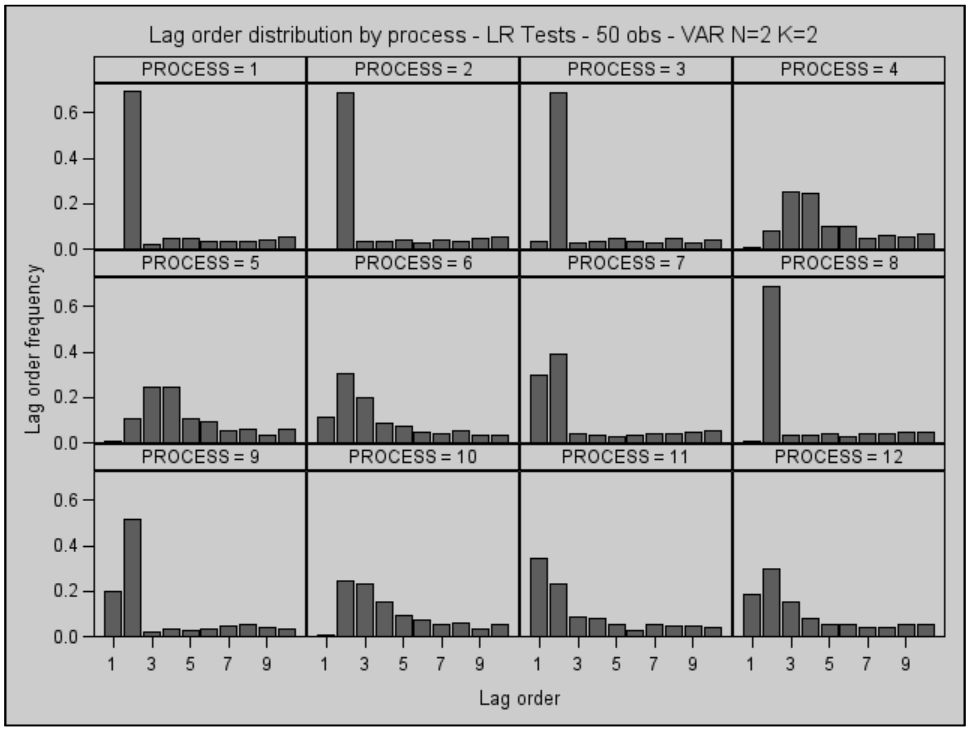

Figure 4-7: Lag order distribution –LR Tests– T=50 – Bivariate VAR(2).

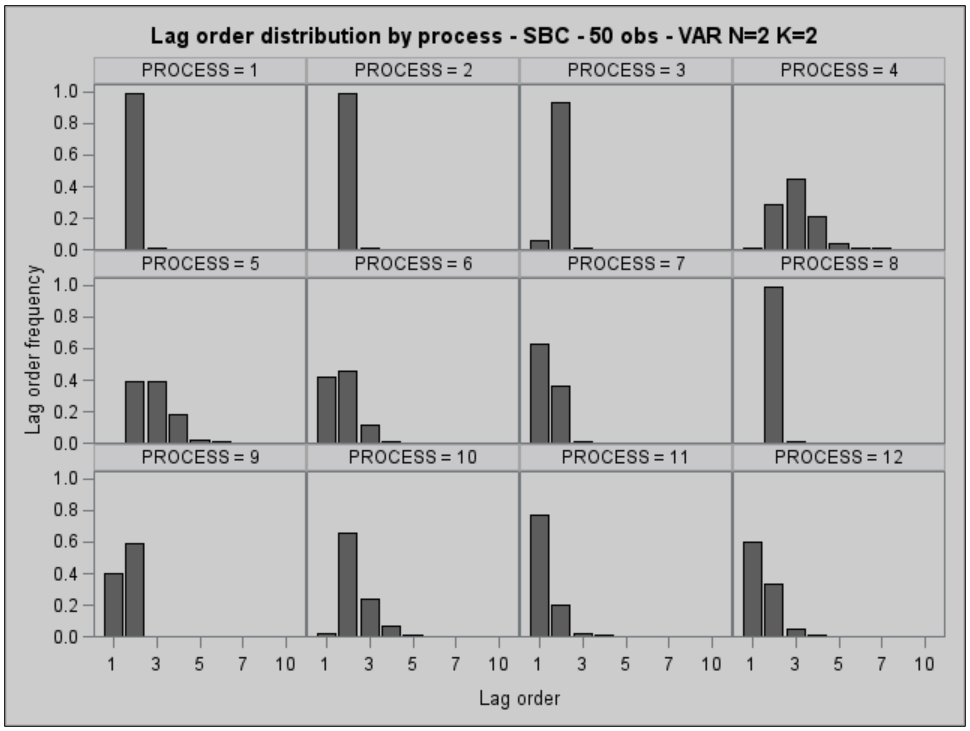

Figure 4-8: Lag order distribution –SBC– T=50 – Bivariate VAR(2).

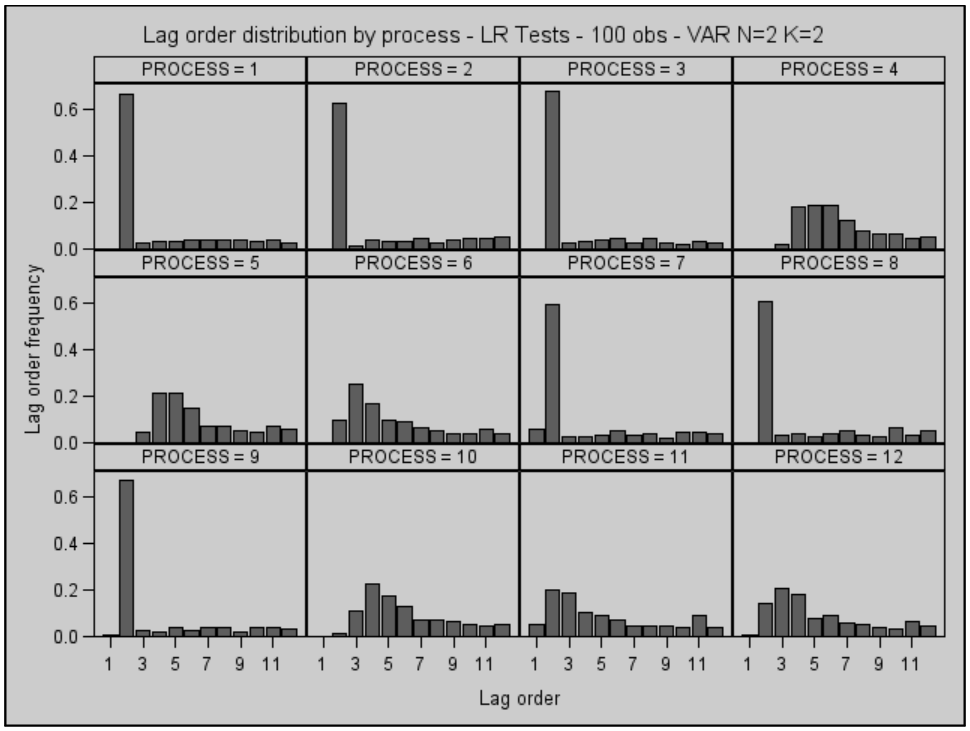

Figure 4-9: Lag order distribution –LR Tests– T=100 – Bivariate VAR(2).

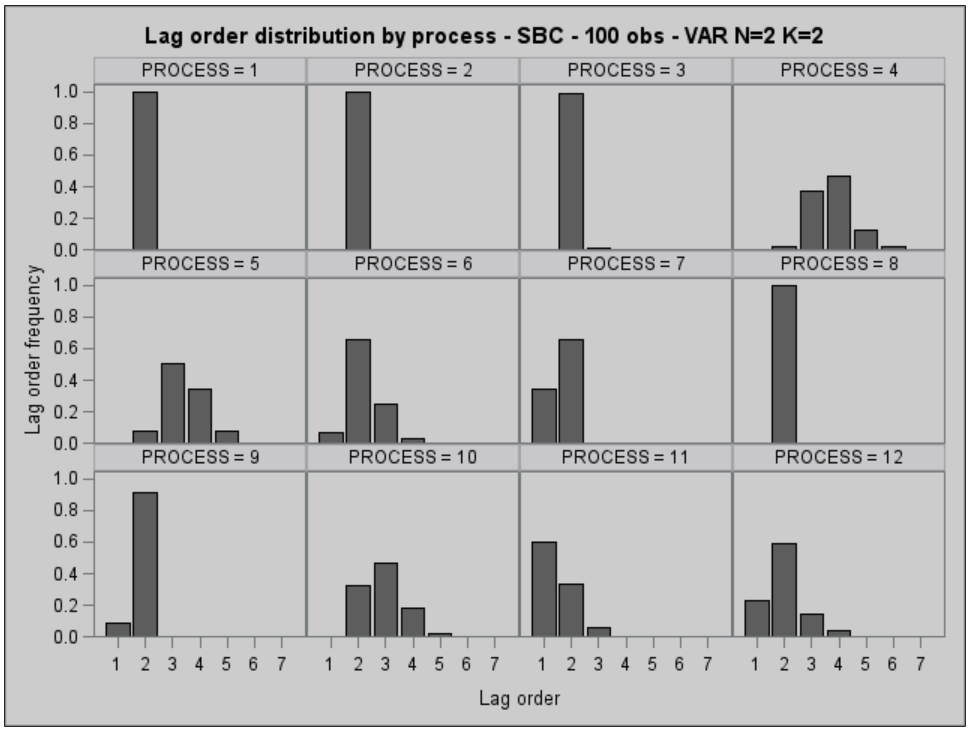

Figure 4-10: Lag order distribution –SBC– T=100 – Bivariate VAR(2).

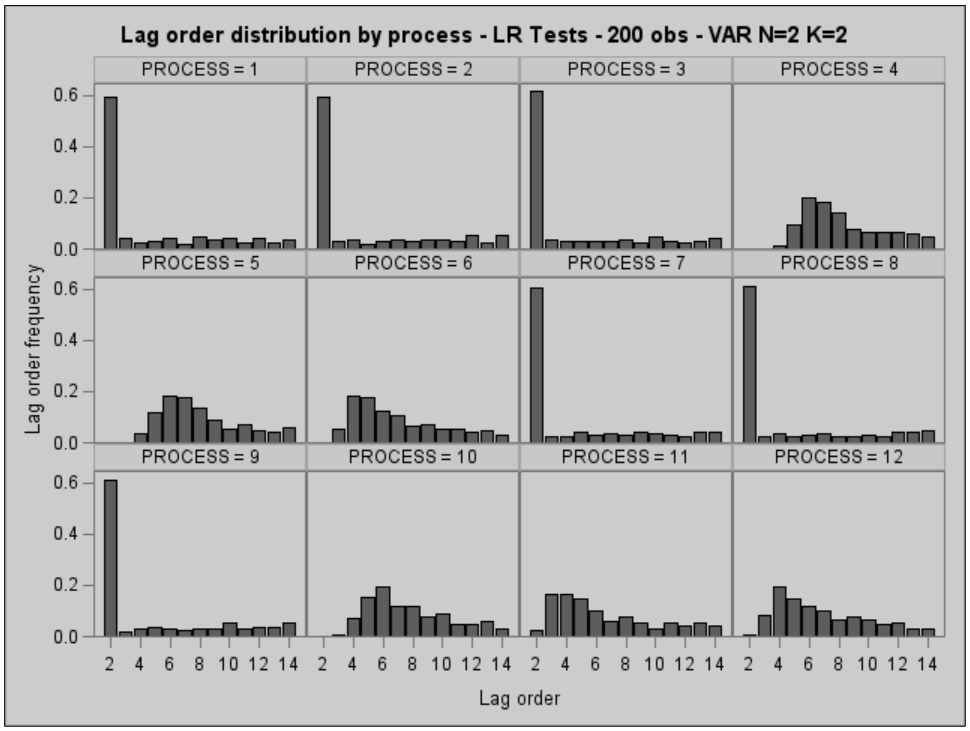

Figure 4-11: Lag Order Distribution –LR Tests– T=200 – Bivariate VAR(2).

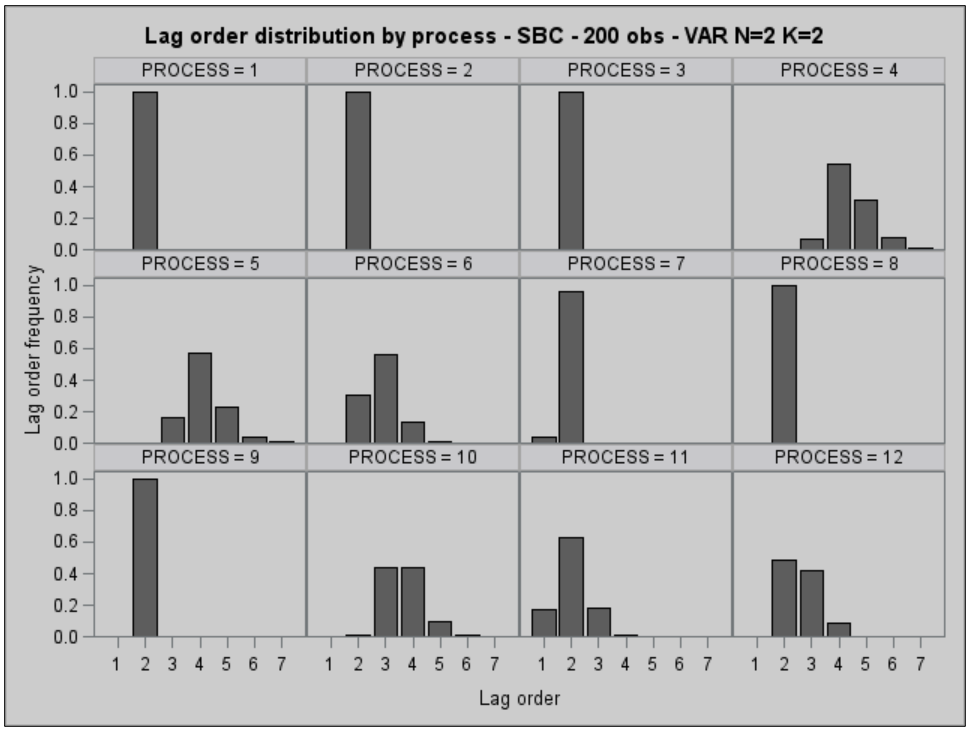

Figure 4-12: Lag order distribution –SBC– T=200 – Bivariate VAR(2).

Figures 4-13 to 4-18 are panels of the lag order distributions of the LR tests and SBC for a trivariate VAR with one lag. For processes 1 to 3 and 7 to 9 (table 4-3), the results are similar to those found for the two previous VAR models (i.e., bivariate VARs). At T=50, the LR tests select the correct lag length about 60% of the time while the SBC chooses the true lag order with a probability close to 1. For processes 4 to 6 and 10 to 12 (table 4-3), the mode increases for both lag selection methods as the sample size increases. The mode of the LR tests distributions is systematically higher than that of the SBC's. Also, compared to the SBC, as the sample size increases, the mode of the LR tests distributions seems to increase at a faster rate. For instance, for the LR tests and process 11, the mode is k=2 at T=50, k=4 at T=100 and k=6 at T=200 (figures 4-13, 4-15 and 4-17). For the same process, the mode of the SBC distributions is k=2 at T=50, k=2 at T=100 and k=3 at T=200

(figures 4-14, 4-16 and 4-18). Finally, as for the two previous VAR models, in the presence of moving average terms, the dispersion of the distributions increases for both lag selection methods.

Figures 4-19 to 4-24 present panels of the lag order distributions of the LR tests and SBC for a trivariate VAR with two lags. Starting with finite order processes (table 4-4), as previously, the LR tests select the true lag length about 60% of the time and overestimate it the rest of the time. The probability of selecting the true lag length slightly decreases in larger samples. On the other hand, at T=50, the SBC underestimates the true lag length for processes 1, 2, 7 and 8 in particular. For instance, for process 1, the SBC selects k=1 51% of the time (figure 4-20). As the sample size increases, the probability of choosing the correct lag order increases and at T=200, the SBC selects k=2 100% of the time (figure 4-24).

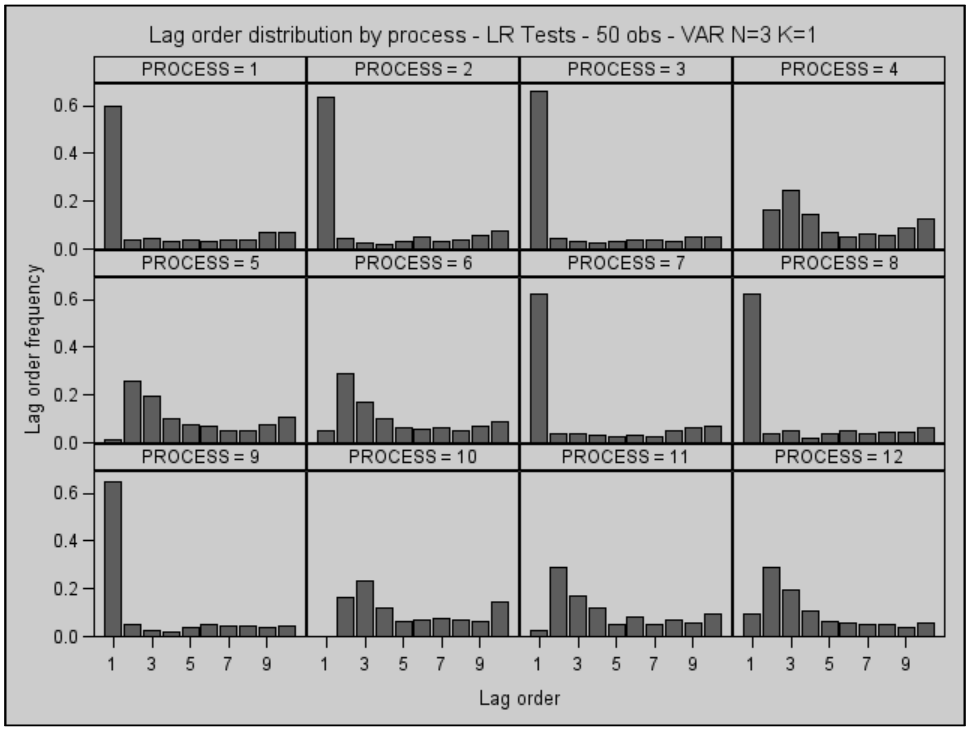

Figure 4-13: Lag Order Distribution –LR Tests– T=50 – Trivariate VAR(1).

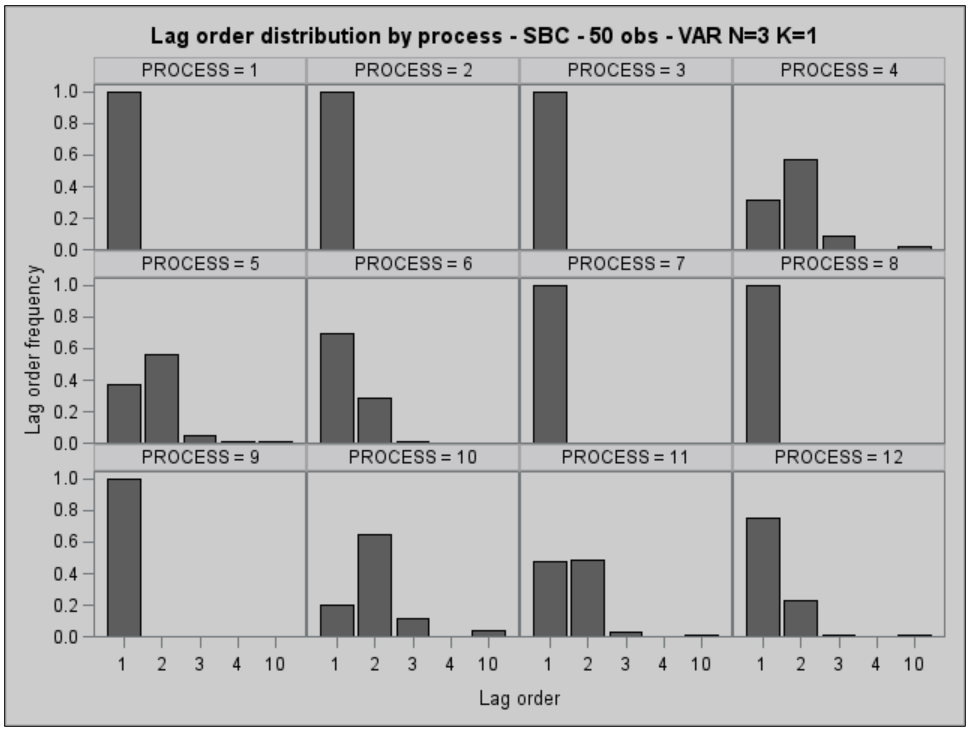

Figure 4-14: lag order distribution –SBC– T=50 – Trivariate VAR(1).

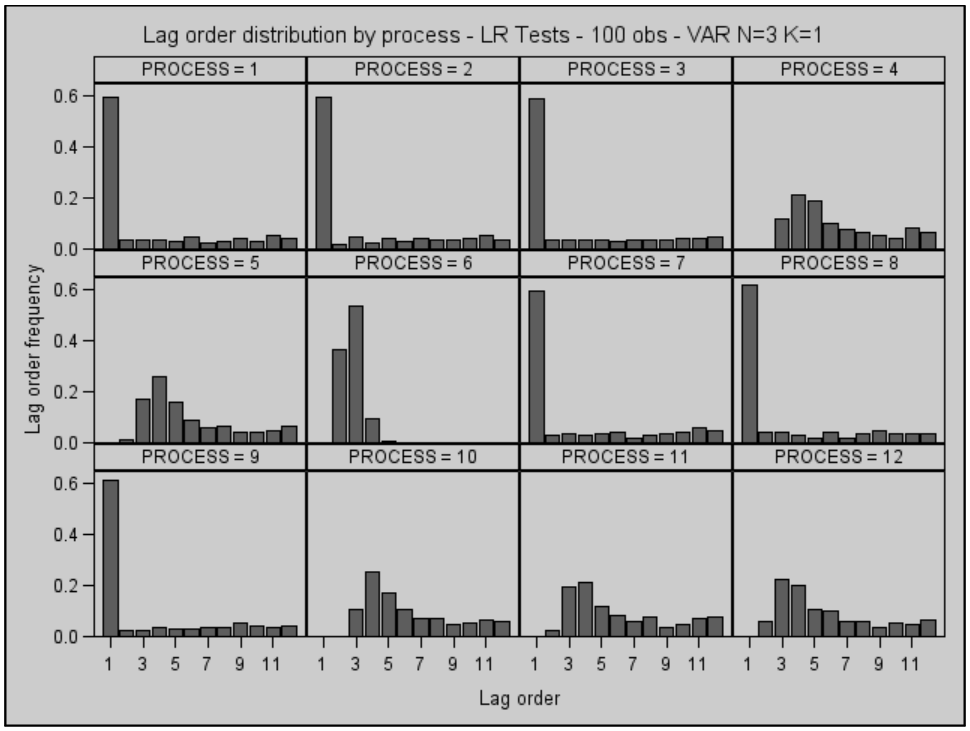

Figure 4-15: Lag order distribution –LR Tests– T=100 – Trivariate VAR(1).

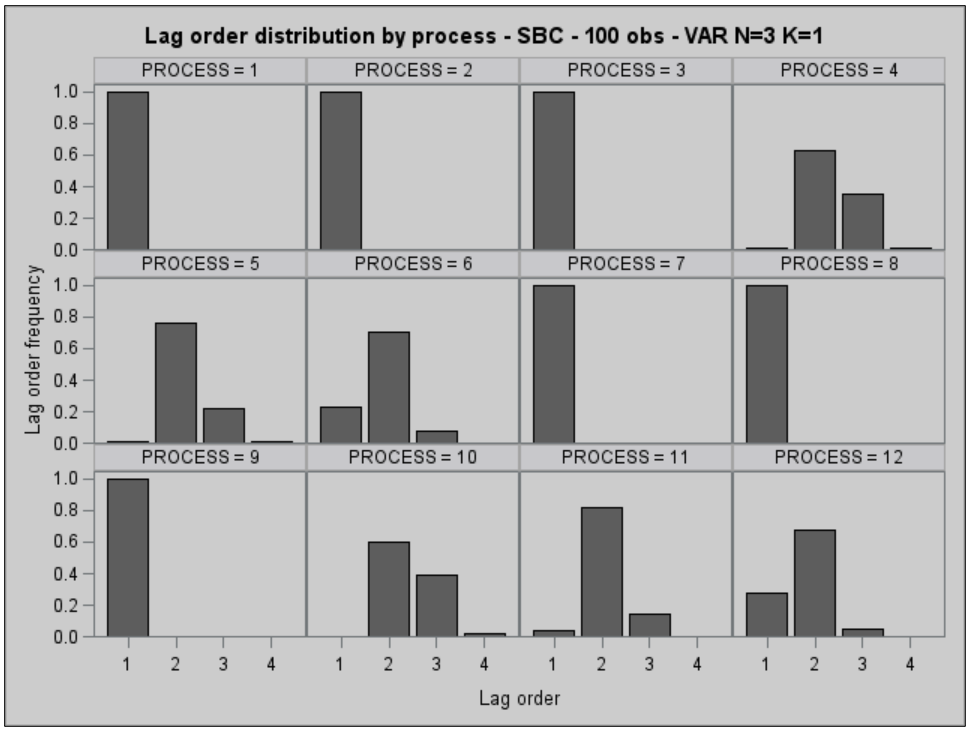

Figure 4-16: Lag order distribution –SBC– T=100 – Trivariate VAR(1).

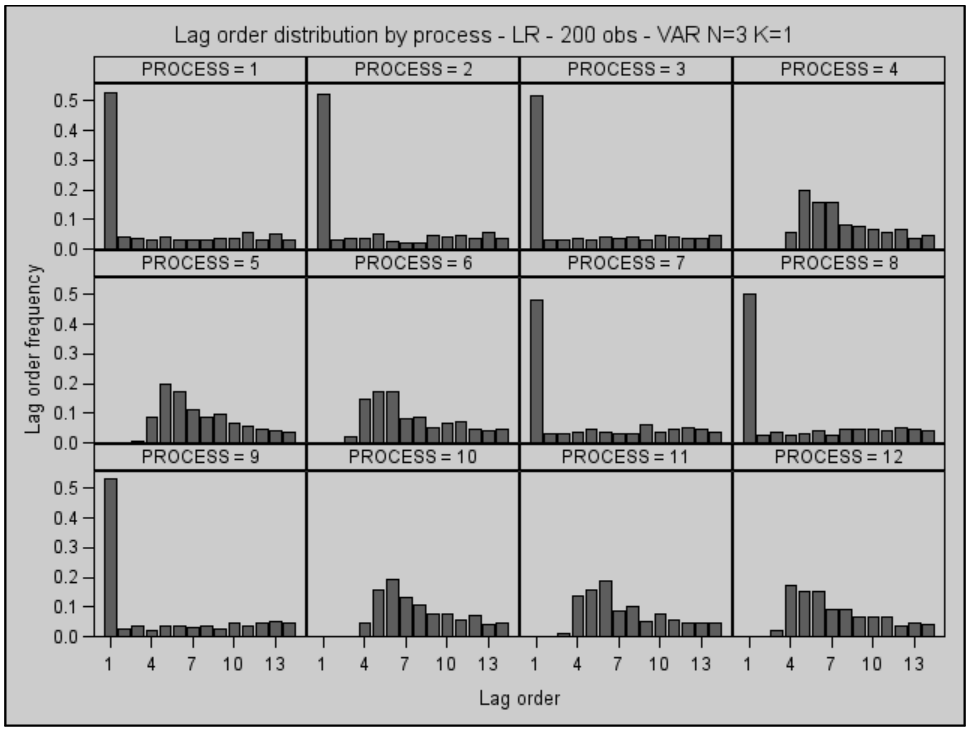

Figure 4-17: Lag order distribution –LR Tests– T=200 – Trivariate VAR(1).

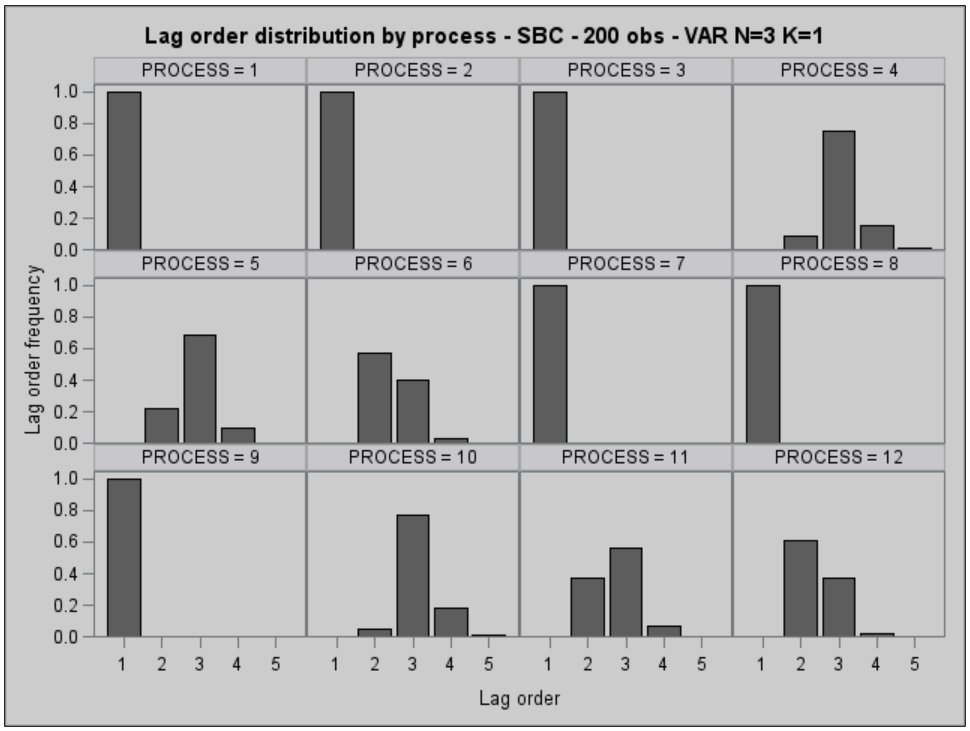

Figure 4-18: Lag Order Distribution –SBC– T=200 – Trivariate VAR(1).

For processes 4 to 6 and 10 to 12 (table 4-4), the SBC seems to underestimates the true lag order. Indeed, at T=50, the SBC would select k=2 with a high probability (figure 4-20) when, because of the presence of moving average terms, it was expected that longer lag length would be selected. As the sample size increases, the mode of the SBC distributions increases and, at T=200, the SBC would select k=3 most often (figure 4-24). For the same processes (i.e., 4 to 6 and 10 to 12), the LR tests select k=3 most often at T=50 (figure 4-19) but a large proportion of selected lag orders is larger than 3. At T=100 (figure 4-21), the mode shifts to k=4 and at T=200 (figure 4-23), k=6 is selected with the highest probability. Finally, remark that for infinite order processes the mode of LR distributions is the same for a trivariate VAR with two lags than for a trivariate VAR with one lag.

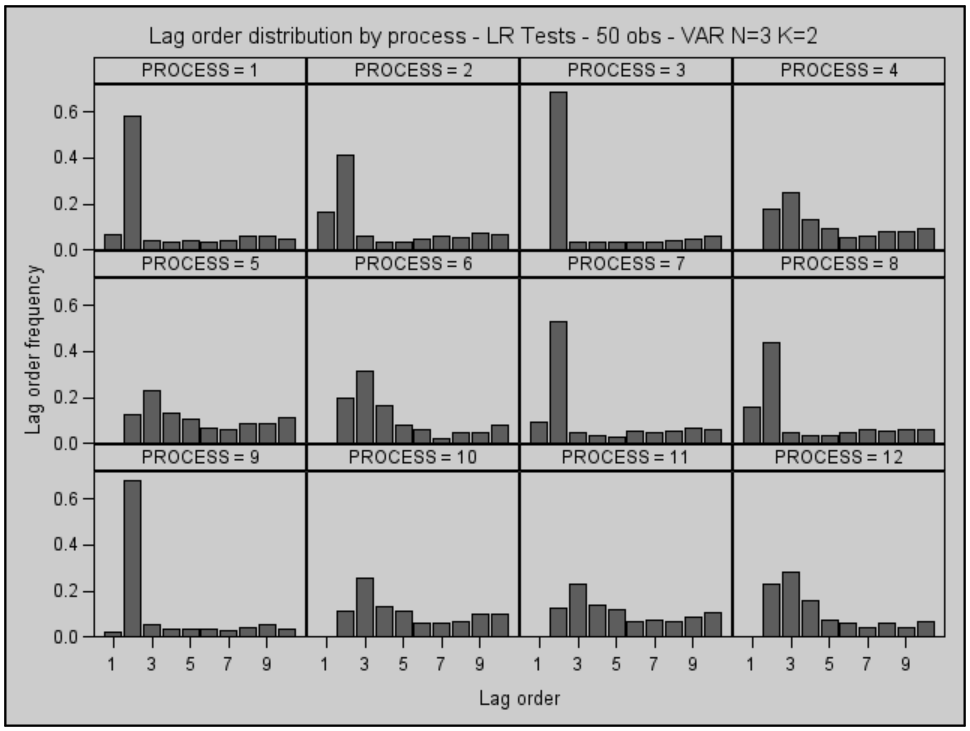

Figure 4-19: Lag order distribution –LR Tests– T=50 – Trivariate VAR(2).

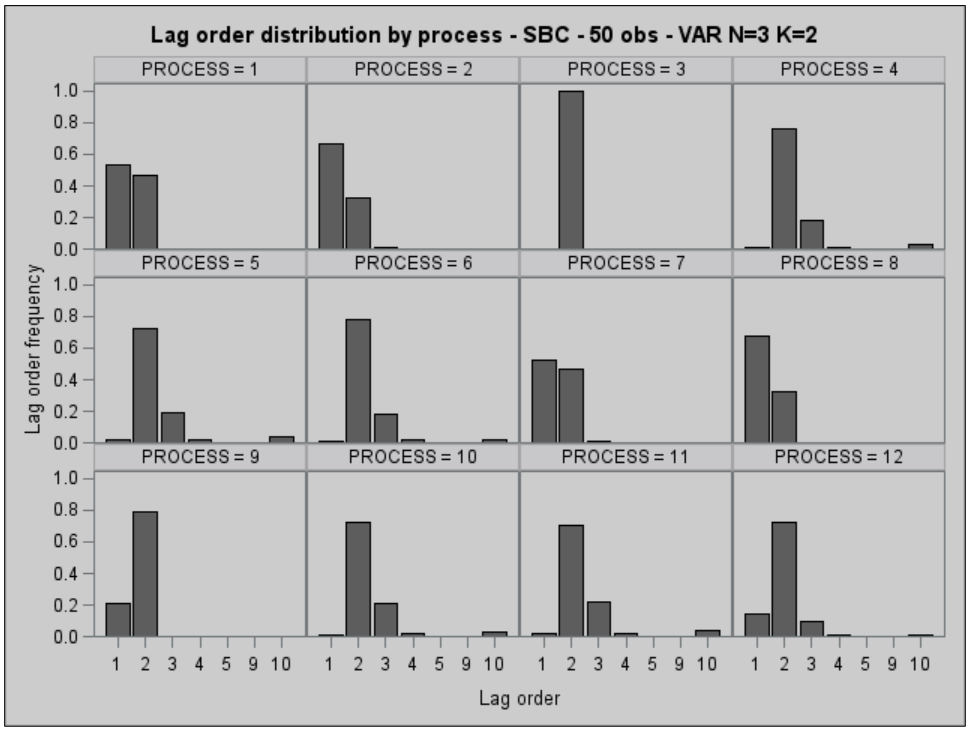

Figure 4-20: Lag order distribution –SBC– T=50 – Trivariate VAR(2).

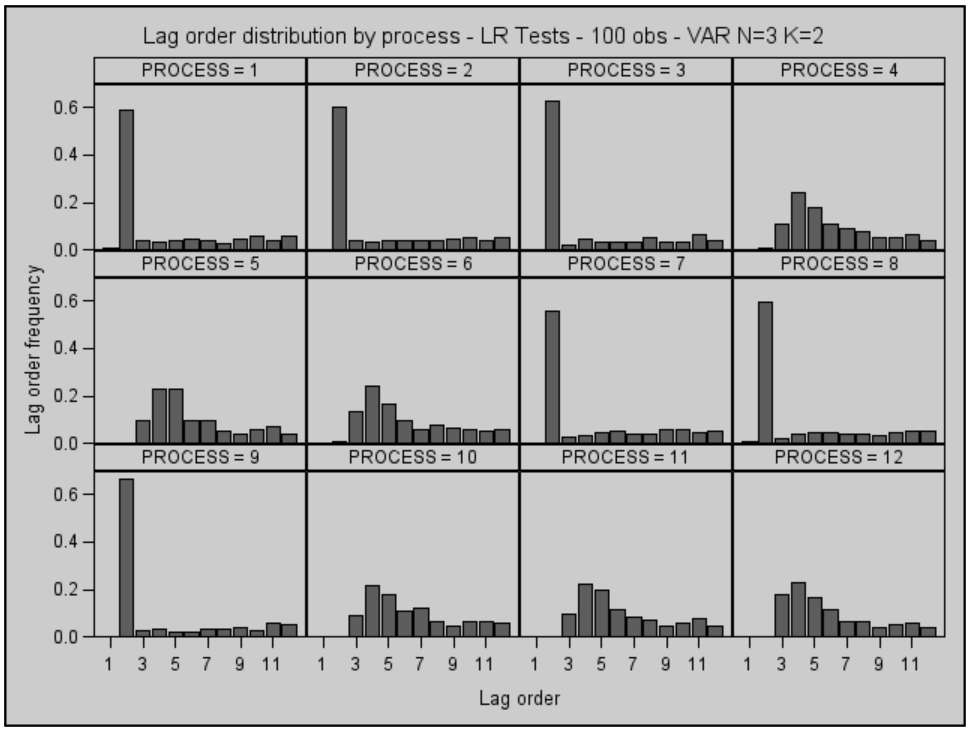

Figure 4-21: Lag order distribution –LR Tests– T=100 – Trivariate VAR(2).

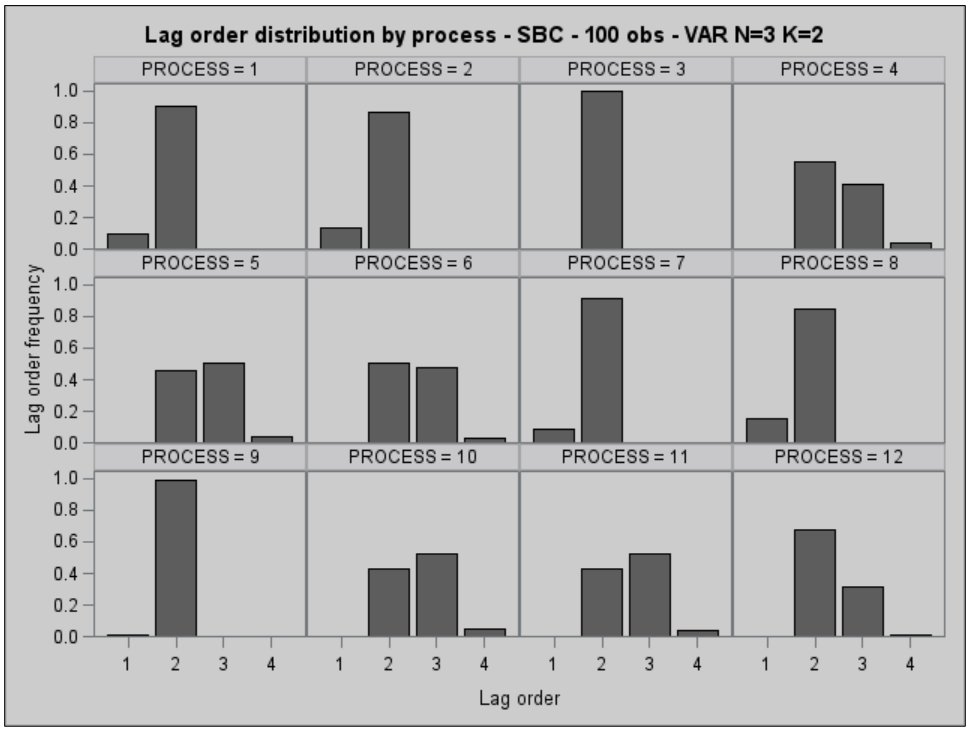

Figure 4-22: Lag order distribution –SBC– T=100 – Trivariate VAR(2).

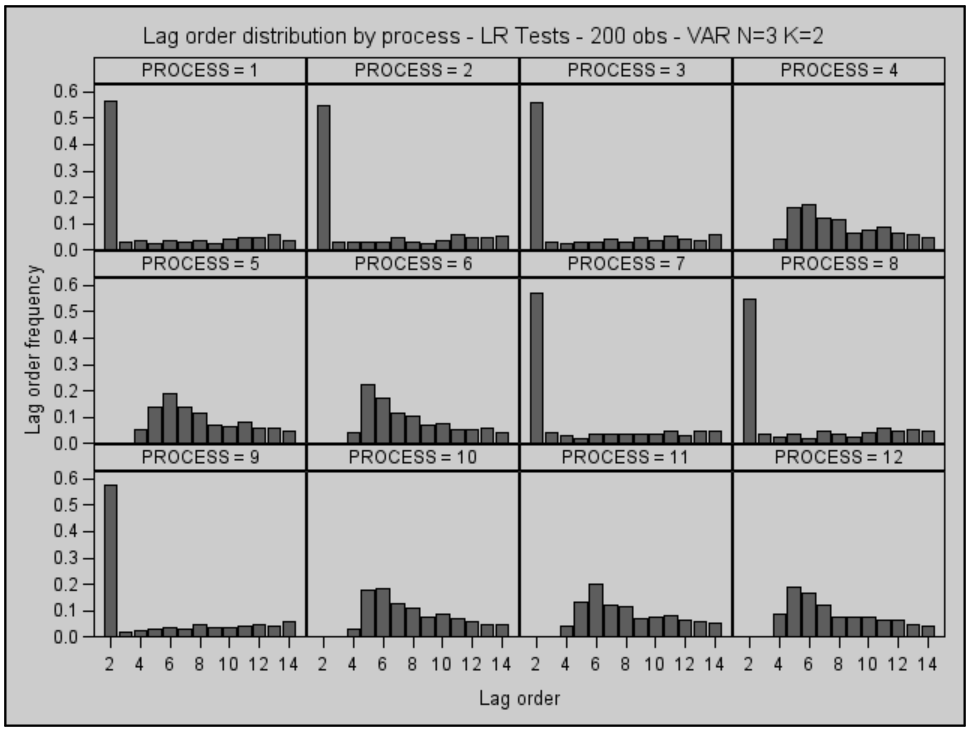

Figure 4-23: Lag order distribution –LR Tests– T=200 – Trivariate VAR(2).

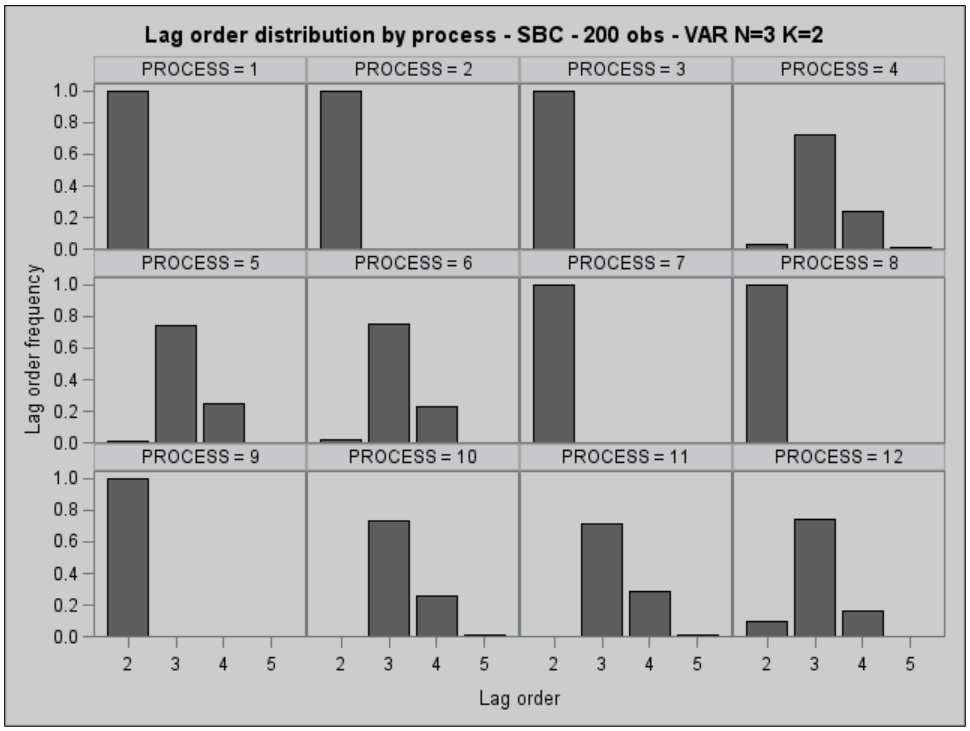

Figure 4-24: Lag order distribution –SBC– T=200 – Trivariate VAR(2).

4.4.2 Rejection Frequencies

Tables 4-5 to 4-12 summarize the rejection frequencies for the null hypothesis that Y_2 does not cause Y_1. The nominal size is 5% and processes 1 to 6 satisfy the alternative hypothesis while processes 7 to 12 satisfy the null. For a bivariate VAR with one lag, tables 4-5 and 4-6 show that, regardless of which lag selection method is used, the probability of correctly rejecting the null hypothesis is high. Indeed, at T=200, we would correctly reject the null of non-causality 100% of the time. Note however that at smaller sample sizes (T=50 and T=100), if the LR tests are used the rejection frequencies are lower that if the SBC is employed (tables 4-5 and 4-6).

Table 4-5: Rejection frequencies for the Y_2 does not cause Y_1 – LR Tests – All sample sizes and processes – Bivariate VAR(1).

Process	T=50	T=100	T=200
Process 1	99.0	100.0	100.0
Process 2	80.8	96.0	99.8
Process 3	85.0	97.8	100.0
Process 4	98.4	100.0	100.0
Process 5	67.4	93.0	100.0
Process 6	73.8	95.0	100.0
Process 7	10.8	8.2	7.4
Process 8	8.6	9.0	7.4
Process 9	9.0	9.2	7.2
Process 10	11.2	8.0	6.4
Process 11	12.6	10.6	7.0
Process 12	11.0	10.8	8.6

For both lag selection methods, rejection frequencies are low for processes 2, 6 and, to a greater extent, 5 (tables 4-5 and 4-6). Looking now at processes 7 to 12, table 4-6 suggests that if the SBC is employed, the exact size of the tests is close to the nominal size (5%). This statement is especially true at T=200.

Table 4-6: Rejection frequencies for the Y_2 does not cause Y_1 – SBC – All sample sizes and processes – Bivariate VAR(1).

Process	T=50	T=100	T=200
Process 1	100.0	100.0	100.0
Process 2	87.8	99.4	100.0
Process 3	91.2	99.8	100.0
Process 4	100.0	100.0	100.0
Process 5	75.2	96.2	100.0
Process 6	82.0	98.8	100.0
Process 7	5.8	6.4	4.8
Process 8	6.0	6.6	4.4
Process 9	5.4	6.4	4.6
Process 10	8.0	7.6	6.0
Process 11	8.0	6.2	4.8
Process 12	9.2	10.2	6.6

More serious size distortions appear if the LR tests are used instead. At T=50, the exact size can be as high as 12.6% (table 4-5). Although size distortions decrease as the sample size increases, at T=200, the exact size remains larger than 5% for processes 7 to 12 (table 4-5). For both lag selection methods, the exact size of the tests is systematically higher for processes 10 to 12 compared to processes 7 to 9 (tables 4-5 and 4-6). Note that these two sets of processes only differ by the presence of moving average terms (table 4-1). Tables 4-7 and 4-8 summarize the results for a bivariate VAR with two lags.

Table 4-7: Rejection frequencies for the Y_2 does not cause Y_1 – LR Tests – All sample sizes and processes – Bivariate VAR(2).

Process	T=50	T=100	T=200
Process 1	96.4	100.0	100.0
Process 2	97.2	100.0	100.0
Process 3	99.2	100.0	100.0
Process 4	96.6	100.0	100.0
Process 5	95.8	100.0	100.0
Process 6	99.2	100.0	100.0
Process 7	8.2	7.6	6.6
Process 8	11.0	9.6	8.6

(Table 4-7 continued)

Process	T=50	T=100	T=200
Process 9	8.8	9.8	6.0
Process 10	8.8	8.8	7.0
Process 11	8.4	9.8	8.4
Process 12	9.8	10.0	8.6

For both lag selection methods the rejection frequencies are higher than in the case of a bivariate VAR with only one lag (processes 1 to 6). This is somewhat surprising as the number of extra parameters in the case of a VAR with two lags should decrease the rejection frequencies. At T=100 and T=200, we would reject a false null hypothesis 100% of the time regardless of the lag selection method (tables 4-7 and 4-8). At T=50, rejection frequencies are lower if the LR tests are used but the MWALD tests conserve a high performance as we would correctly reject the null more than 95% of the time (table 4-7). The difference in rejection frequencies for processes 2, 5 and 6 compared to other processes is not as significant as previously (tables 4-5, 4-6, 4-7 and 4-8). Likewise, size distortions are not more important for processes including moving average terms (processes 10 to 12 compared to 7 to 9). In fact, we found less size distortions for all processes (7 to 12) compared to the case of a bivariate VAR(1). Note however that if the SBC is employed, size distortions actually increase with the sample size for processes 10 and 12 (table 4-8). For the LR tests (table 4-7), size distortions generally vanish as the sample size increases.

Table 4-8: Rejection frequencies for the Y_2 does not cause Y_1 –SBC– All sample sizes and processes – Bivariate VAR(2).

Process	T=50	T=100	T=200
Process 1	100.0	100.0	100.0
Process 2	99.6	100.0	100.0
Process 3	100.0	100.0	100.0

(Table 4-8 continued)

Process	T=50	T=100	T=200
Process 4	98.4	100.0	100.0
Process 5	99.4	100.0	100.0
Process 6	100.0	100.0	100.0
Process 7	4.2	5.8	3.4
Process 8	8.4	7.0	5.6
Process 9	4.4	6.8	3.8
Process 10	5.0	5.4	7.0
Process 11	6.0	5.2	4.4
Process 12	8.0	10.8	11.8

Tables 4-9 and 4-10 present the rejection frequencies for a trivariate VAR with one lag using the LR tests and SBC respectively. Regardless of the lag selection method, rejection frequencies are very low (processes 1 to 6). However, as the sample size increases, rejection frequencies converge to 100%. It is not the case for processes 2 and 5. At T=50 those two processes present the lowest rejection frequencies and at T=200 we would correctly confirm the presence of causality around 50% of the time (tables 4-9 and 4-10).

Table 4-9: Rejection frequencies for the Y_2 does not cause Y_1 – LR Tests – All Sample Sizes and Processes – Trivariate VAR(1).

Process	T=50	T=100	T=200
Process 1	80.8	99.2	100.0
Process 2	20.2	31.6	47.8
Process 3	63.4	86.4	99.2
Process 4	83.0	99.2	100.0
Process 5	20.2	26.6	43.6
Process 6	50.0	100.0	97.8
Process 7	12.0	8.8	6.0
Process 8	10.0	9.0	7.2
Process 9	9.0	7.4	7.4
Process 10	17.6	7.6	6.2
Process 11	13.2	8.2	7.2
Process 12	10.0	7.2	5.6

For both lag selection methods, there are serious size distortions (processes 7 to 12, tables 4-9 and 4-10) especially when the LR tests are used and when processes include moving average terms (processes 10 to 12). For instance, for process 10, the exact size of the MWALD tests is 17.6% (table 4-9).

Table 4-10: Rejection frequencies for the Y_2 does not cause Y_1 – SBC – All Sample Sizes and Processes – Trivariate VAR(1).

Process	T=50	T=100	T=200
Process 1	85.0	99.6	100.0
Process 2	18.8	32.4	52.0
Process 3	73.2	96.2	100.0
Process 4	90.8	100.0	100.0
Process 5	16.6	33.0	59.0
Process 6	69.2	94.2	100.0
Process 7	5.6	5.4	5.0
Process 8	4.6	5.4	4.8
Process 9	5.0	6.0	5.0
Process 10	9.2	6.6	6.4
Process 11	10.2	6.8	6.6
Process 12	8.2	6.6	6.0

Nevertheless, size distortions vanish as the sample size increases and at T=200, the size of MWALD tests is not larger than 7.4% (table 4-9). If the SBC is employed, the exact size of the test is generally close to the nominal size even at small sample sizes (table 4-10). As previously, we remarked that for processes including moving average terms, size distortions are larger. Finally, tables 4-11 and 4-12 summarize the results for a trivariate VAR with two lags. At T=50, rejection frequencies (processes 1 to 6) are low regardless of the lag selection method. As noted before, it is particularly the case for processes 2 and 5. Note that as the sample size increases, so do the rejection frequencies. At T=200, we would correctly reject the null more than 80% of the time regardless of the process and the lag selection

method. However, rejection frequencies are systematically lower if the LR tests are used; save for process 1.

Table 4-11: Rejection frequencies for the Y_2 does not cause Y_1 – LR Tests – All Sample Sizes and Processes – Trivariate VAR(2).

Process	T=50	T=100	T=200
Process 1	76.2	99.6	100.0
Process 2	38.2	61.8	87.6
Process 3	91.8	99.8	100.0
Process 4	83.0	99.8	100.0
Process 5	38.6	53.0	81.6
Process 6	89.6	99.6	100.0
Process 7	11.8	10.2	6.4
Process 8	11.8	8.8	7.6
Process 9	7.6	9.4	7.8
Process 10	16.4	9.2	5.4
Process 11	19.2	9.0	5.6
Process 12	13.2	8.0	6.4

At T=50, there are severe size distortions if the selection method is LR tests especially if the process contains moving average terms (processes 10 to 12). For instance, for process 11, the exact size is close to 20%. For both lag selection methods, size distortions vanish as the sample size increases (tables 4-11 and 4-12).

Table 4-12: Rejection frequencies for the Y_2 does not cause Y_1 –SBC– All Sample Sizes and Processes – Trivariate VAR(2).

Process	T=50	T=100	T=200
Process 1	53.8	96.0	100.0
Process 2	48.0	72.2	96.8
Process 3	99.2	100.0	100.0
Process 4	84.0	100.0	100.0
Process 5	37.2	64.8	93.2
Process 6	98.2	100.0	100.0
Process 7	6.4	7.2	5.4
Process 8	4.8	7.0	5.4
Process 9	4.0	5.2	4.4
Process 10	11.2	9.6	5.8
Process 11	10.4	10.2	6.0
Process 12	7.4	7.0	6.4

4.5 Discussion

Two main facts have motivated this research. First, the TYDL procedure has been increasingly used in applied economics to analyze causal relationships. Second, this procedure relies on lag order selection. While empirical studies somewhat oversees this important step, there is theoretical and empirical evidence that lag order selection has a significant impact on forecasts, impulse response functions, unit-root and cointegration tests. The recent work of Ng and Perron (2001) and Qu and Perron (2007) have revealed the scope of the problem when the processes include moving average terms with a root close to -1. Nonetheless, to date, there was no study on the impact of lag order selection in the context of non-causality tests when using the TYDL procedure.

Using Monte Carlo simulations, this study compares the lag order frequency distributions of two common lag order selection methods (SBC and LR tests) as well as their impact on finite sample properties of non-causality tests (MWALD tests). Twelve DGPs (VAR models) have been simulated. They vary in terms of the presence of unit roots, cointegration, causality and moving average terms as well as the number of variables and lags.

4.5.1 Lag Order Frequency Distributions

When the process corresponds to a finite order VAR, both methods select the true lag order model with a high probability although the LR tests tends to overfit at all sample sizes. In general, the SBC selects the true lag length 100% of the time while the LR tests point the true lag length 60% of the time. This latter result coincides with the findings of Gonzalo and Pitarakis (2002). However, we found that

for a trivariate VAR with two lags, the SBC tends to underestimate the true lag length. This result also coincides to Gonzalo and Pitarakis (2002) findings. Indeed, these authors showed that in small samples, information criteria such as the SBC tend to underfit the true model in high dimension systems.

The distributions of the LR tests are always more spread than those of the SBC. In fact, lag orders are selected over the entire allowed range ($k = 1 \rightarrow k_{max}$) when using the LR tests. Gonzalo and Pitarakis (2002) also found that the LR tests tend to select lag order close to k_{max}. For the SBC only, as the sample size increases, the probability of selecting the true lag order increases. Hence, our results confirm that the SBC is consistent (e.g., Lütkepohl, 2005). For finite order VAR models, when there is no causality in one direction, both criteria underestimate the true lag order. We did not observe this issue when there are causal feedbacks in the processes. It is possible that the absence of causality might create a case of asymmetric lags in VAR models and the use of the Keating's (1995) version of the AIC or SBC (e.g., Ozcicek and McMillin, 1999) could reduce this bias. In the case of infinite order VAR models, we found that the LR tests generally select a higher lag order than the SBC does. Also, we observed that both criteria tend to select a longer lag length as the sample size increases. Some theoretical facts described in Lütkepohl (2005) can help understand this trend. An infinite order VAR model can be approximated by a finite order VAR model and estimated with a least squares estimator if the VAR lag order goes to infinity as the sample size increases. However, the lag order has to increase at a slower rate than the sample size. Lütkepohl (2005) further derives the lower and upper bounds of the rate at which the lag order has to increase. Our results

showed that although we observed this behavior for both lag selection methods, the lag order seems to increase at a faster rate for the LR tests than for the SBC. Processes 10 and 12 for a bivariate VAR(2) are good illustrations of this tendency. Both processes satisfy the null of non-causality from Y_2 to Y_1. For process 10 both variables are I(1) and cointegrated while for process 12, the variables are stationary. For process 10, at T=50, both lag selection methods select k=2. At T=100, the LR tests select k=4 while the SBC selects k=3. At T=200, the LR tests select k=6 and the SBC selects k=4. The results are even more striking for process 12.

As a final comment, we observed that, in the case of mixed unit-root processes, lag order frequency distributions are closer to the distributions when all the variables are all I(1) than to the distributions when the variables are all I(0).

4.5.2 Rejection Frequencies of the Null Hypothesis That Y_2 Does Not Cause Y_1 When the Null Is False

Despite different lag order frequency distributions, we found that, in general, the choice of the lag order selection method does not affect the performance of non-causality tests although, in small samples (T=50), the LR tests always lead to tests with the lowest performance. This can be explained by the tendency of this criterion to overfit the model as mentioned before. In large samples (T=200), both criteria lead to tests with maximum rejection frequencies (100%). However, for trivariate VARs with one or two lags, we found that MWALD tests do not perform well for processes 2 and 5 regardless of the selection criterion. Rejection frequencies remain low at T=200. Although less important, we also found low rejection frequencies for a bivariate VAR(1). To this issue, we tried to identify some possible explanations. First,

as low rejection frequencies are found when either the SBC or the LR tests are used, we conclude that these results are independent from lag order selection. Second, the common denominator of these DGPs is the presence of I(1) variables but the absence of cointegration. In the case of a trivariate VAR with one lag the dependent variable in the equation of interest (Y_1) is I(0) and one or more of the regressors are I(1). In our simulations the trivariate VAR(2) only contains I(1) variables and for the bivariate VAR(1) the dependent variable in the equation of interest is I(1). Pagan and Wickens (1989) explain that "the disturbance will also be I(1) if the dependent variable is I(0) and there is only one I(1) regressor; to achieve an I(0) disturbance there must be at least two I(1) regressors" (Pagan and Wickens, 1989, p. 1002). Unit-root tests led us to conclude that residuals were stationary in that particular case. Therefore, poor performance cannot be linked to the non-stationarity of the residuals, thus showing that the augmented-lag methodology of Toda and Yamamoto (1995) effectively ensures the stationarity of the residuals even in the case described by Pagan and Wickens (1989). A second possible explanation is that the VAR model is a non-stationary or explosive process. Computing the eigenvalues of the companion matrix allows determining if the VAR model is stable or not. If the eigenvalues are inside the unit circle the process is stationary; if one or more of the eigenvalues are on the unit circle the process is non-stationary and finally if one or more of the eigenvalues are outside the unit circle, we conclude that the process is explosive. The latter case has actually not been studied by Toda and Yamamoto (1995) but they proved that the Wald statistic has an asymptotic chi-square distribution in the two other cases. We thus proceeded to the computation of the eigenvalues for process 2

for the four VAR types (the results can be extended to process 5 which only differs by the presence of moving average terms). We found that the three VARs for which we observed low rejection frequencies present eigenvalues both inside and on the unit circle. For instance, figure 4-25 shows that there is one eigenvalue on the unit circle and two inside for a trivariate VAR with one lag (process 2). However, the bivariate VAR with two lags presents only eigenvalues on the unit circle. Hence, the presence of eigenvalues both inside and on the unit circle might explain the observed low rejection frequencies.

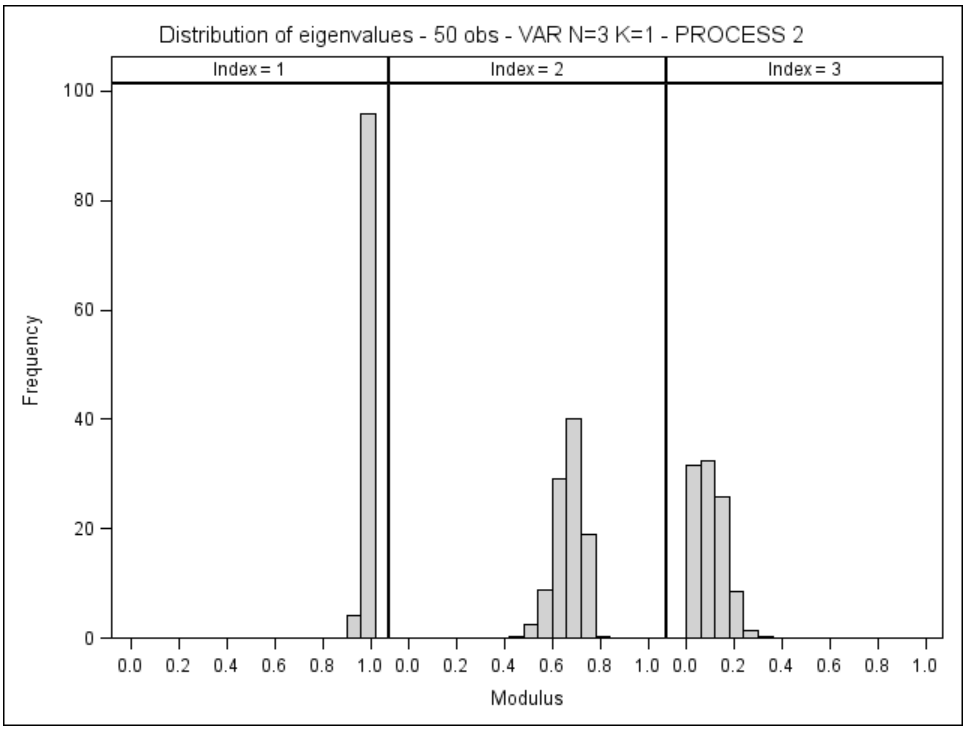

Figure 4-25: Distribution of the eigenvalues of a trivariate VAR(1) – Process 2 - T=50.

Further, we found lower rejection frequencies for the trivariate VAR models than for the bivariate VAR(1). Also, among the two trivariate VAR models, the VAR(1) presented the lowest rejection frequencies. One observation is that for the

trivariate VAR(1), the dependent variable is I(0) while for the two other cases the dependent variable is I(1). In order to corroborate that this observation can be an issue, we re-carried non-causality tests for this particular DGP with Y_1~I(1) and Y_2 and Y_3~I(0). Maintaining causality between Y_1 and Y_2, we used the same parameters as in table 4-3 for process 2 but switched the coefficients. We found that although still low, rejection frequencies increased when the dependent variable is I(1). Another observation is that for the two DGPs with the lowest rejection frequencies (trivariate VARs) there were less eigenvalues on the unit circle than within. Finally, we observed that for the trivariate VAR with one lag, there are large differences in the distributions of the eigenvalues (figure 4-25). Indeed, the mode is 0.1 for one of the three eigenvalues and 1.0 for another. Thus, it is possible that the presence of a "dominant" eigenvalue might lead to tests with low performance when testing for non-causality using the TYDL procedure.

4.5.3 Rejection Frequencies of the Null Hypothesis that Y_2 Does Not Cause Y_1 When the Null Is True

Size distortions are generally minimal although we found systematic size distortions in small samples (T=50) except for processes 7 and 9 (finite order VAR models) when the SBC is used. The LR tests lead to larger size distortions than if the SBC is used. At T=200, for both lag order selection methods, the size of the tests is close to the nominal size (5%). For VARMA processes, although the maximum lag order selected by the SBC is always shorter than in the case of the LR tests, we could not link this result to the observed size distortions in general. Indeed, we would have expected that as the SBC selects more parsimonious models, size distortions would be more severe than in the case of the LR tests when processes include moving average

terms. For both lag selection methods, we found that the presence of moving average terms systematically increases the exact size of the MWALD tests at T=50. This result confirms the findings of many authors such as Qu and Perron (2007). This issue could be avoided fixing a higher lower bound. For a VARMA process and at T=200, we found that as the selected lag order approaches the upper bound, size distortions vanish. However, for the particular case of a bivariate VAR(2), for processes 10 and 12 and using the SBC, the size of non-causality tests increases with the sample size. In relation to the discussion in 4.5.1, these findings might suggest that the rate at which the lag order as selected by the SBC increases is not fast enough.

Comparing a bivariate VAR(2) with a bivariate VAR(1), the results show that the LR tests perform better when the true lag length is longer. A possible explanation is that the LR tests tend to select larger lag length than the lower bound. Thus, the probability of capturing the true lag order increases for DGPs with a true lag length larger than the lower bound. Finally, in small samples, for a trivariate VAR, MWALD tests present severe size distortions regardless of the true lag length. This might be due to the poor performance of LR tests in small samples. For instance, when using the LR tests we would incorrectly reject the null of non-causality 20% of the time in the case of a trivariate VAR with moving average terms.

4.5.4 Future Research

All these results lead us to several recommendations for future research. First, the experiment shall be carried out looking at the impact of lag order selection on size-adjusted power. The second recommendation is to provide theoretical evidence to these findings. Third, it would be interesting to redo the experiment but for VAR

models of higher degree (N>3 and k>2). Fourth, other criteria should be considered such as the Keating's (1995) AIC and SBC. Fifth, the issues encountered when using a usual lag order selection method in the presence of moving average terms with a root close to -1 could call for a modified information criterion like in Ng and Perron (2001) for unit root tests and Qu and Perron (2007) for cointegration tests. The idea is to construct a criterion that takes into account the information contained in the null hypothesis. Such a research certainly needs both theoretical and empirical evidences. Fifth, theoretical evidence is also required to shed light on the performance of MWALD tests in the case of VAR models with some unit-roots. Indeed, in the TYDL procedure the lag order selection is performed estimating a VAR model in levels independently from the time series properties of the data. Some lag order selection methods might perform better when the VAR model is non-stationary and it would be interesting to evaluate their performance in different scenarios (all I(0), I(1) or I(2) variables and mixed unit-roots processes). A comparison of the TYDL procedure with other causality testing frameworks in the particular case of mixed unit-root processes might be interesting. Finally, future research that would derive the lower and upper bounds of the rate at which the lag order goes to infinity for each lag order selection method and in different conditions would also be highly valuable.

4.5.5 Recommendations to Practitioners

As a final point, this research definitely highlighted some useful results for a practitioner. First, in small samples, it is better to use the SBC as it generally leads to MWALD tests with better finite sample properties compared to the LR tests. Also, the LR tests require some programming while the SBC is directly computed by most

statistical packages. In large samples (T=200), both lag order selection methods can be used. In the case of processes with some unit roots and no cointegration non-causality tests perform poorly regardless of the lag selection method. Thus, unit-root and cointegration tests may still be required when testing for causality in small samples. As a final advice, special attention should be given to the default maximum lag in statistical softwares procedures. For instance, the default in SAS® is k=5.

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5 SUMMARY

5.1 Overview of the Main Findings, Conclusions and Recommendations

A large array of literature has revealed that the analysis of export performance is a complex task. In this context, this dissertation, divided into three essays, sought to provide methodological guidance, empirical and simulation evidence to analyze a country's export performance. Ghana, a West-African country, was selected as a case study. This choice was motivated by the remarkable economic development experienced by this country. Indeed, if today Ghana is one of the fastest growing countries in Africa, thirty years ago its economy was close to collapse. At that time (1983), Ghana decided to embark in the economic recovery program (ERP) supported by the International Monetary Fund (IMF), the World Bank and other multilateral and bilateral donors. At the heart of this program were market-oriented reforms that included inflation control and the transition to a floating exchange rate regime; two indicators of price competitiveness. In addition, the IMF and the Government of Ghana identified the agricultural sector and agricultural exports in particular, as the main levers of economic growth. Seemingly related to the implemented reforms and programs, exports have grown steadily in Ghana for the past thirty years. However, at the agricultural sector level, exports have not experienced a continuous upward trend suggesting that other factors might have affected the country's export performance.

In chapter 2, we identified potential factors of export performance. An intensive literature review on trade theories has revealed that export price competitiveness is the most important factor in a country's export performance. However, in order to correctly appreciate Ghana's export price competitiveness we

needed a trade-weighted Ghana Cedi index that depicts some of the most relevant patterns of Ghana's trade. We constructed the real effective exchange rate (REER) annually and quarterly. The REER measures the export price competitiveness of a country compared to its main trading partners. Our index takes into account several important methodological points that were excluded in available indices. First the currencies included in the index represent Ghana's top-fifteen trading partners. Second, following the Federal Reserve's methodology (e.g., Leahy, 1998 and Loretan, 2005), our index captures all types of competition. Indeed, the weights are actually made of three types of weights. Import weights take into account the competition between imported and domestically produced goods; export weights capture the competition between Ghana's exports and goods produced in country *j* and finally, third competition weights measure the competition between Ghana's exports and country *j*'s exports in a third-market country. Third, weights are time-dependent meaning that weights were calculated annually (quarterly) for the computation of the annual (quarterly) REER. Lastly, our index takes into account geopolitical changes that occurred during the studied period (e.g., reunification of Germany and introduction of the Euro). The computation of the weights has revealed important changes in Ghana's trading patterns. Although Europe remains the main export market, its importance has decreased. This tendency masks some important trends at the country level. Once the main trading partner of Ghana, the U.K. represents today less than 8% of Ghana's total exports. The Netherlands is the first European market and its share remained around 13% since 1960. France is a growing export market for Ghana as well as India and Malaysia. Indeed, if in 1960 the share of

those three countries was negligible; today, their export shares are 5%, 4% and 3.5% respectively. The plots of both annual and quarterly REER showed that Ghana's export price competitiveness has first decreased from 1960 to 1983 and then increased since the inception of the ERP. Major break points in the indices have been linked to several macroeconomic reforms implemented since 1983 and reviewed in the second chapter. Further, we found that for the past ten years Ghana's export price competitiveness has remained stable mainly because of the absence of major changes in financial policies.

In the second part of this chapter, we considered additional factors of export performance and competitiveness. Some of those factors are the object of well-known trade theories (e.g., Helpman and Krugman, 1985) as emphasized in the literature review. In order to identify the factors that applied to the case of Ghana, and its agricultural sector in particular, this research primarily relied on grounded theory and qualitative analysis. Via focus groups and personal interviews, the perspectives of Ghana's agricultural export sector stakeholders were collected in Ghana in 2011. In an attempt to analyze Ghana's agricultural export sector as a whole, views were collected in five regions of Ghana (Ashanti, Central, Eastern, Greater Accra and Volta) from seven different types of stakeholders namely, farmers and extensionists, agro-processing companies, exporters, donors and other developments partners, ministries, governmental agencies as well as research and academic institutions. We also tried to select participants across sectors (e.g., fruits, vegetables, cocoa). The analysis of the data led to seventeen categories of factors of export performance.

Many of them are non-price factors and help to understand what the strengths of the sector are and what is still needed to develop exports further.

The third chapter sought to provide empirical evidence that export price competitiveness (REER) and foreign GDP have been the main drivers of Ghana's export performance. This analysis relied on export demand theory. Using annual data from 1970 to 2009 we tested causality from the REER and foreign GDP to both agricultural and total exports. After thoroughly determining the time series properties of the variables with the latest available unit-root tests (e.g., Qu and Perron, 2007) we decided to employ the TYDL procedure (Toda and Yamamoto, 1995; Dolado and Lüktepohl, 1996) to establish causal relationships. This procedure consists in estimating a lag-augmented vector autoregressive (VAR) model and to carry modified Wald (MWALD) tests. We found that only the REER has caused Ghana's exports while neither the REER nor foreign GDP have caused agricultural exports. Three important points were discussed in this chapter based on these results. First, as argued by Goldstein and Khan (1978) and Mullor-Sebastian (1990), the non-causality between exports and foreign GDP may be due to the fact that Ghana, like most developing countries, is a residual supplier. Second, the insignificance of both the REER and foreign GDP in Ghana's agricultural exports performance suggests that other factors have caused agricultural exports. Those factors were identified in chapter two. Third, the results showed that IMF-recommended policies have been effective at improving Ghana's export performance. Nevertheless, neo-liberal criticisms to IMF actions in developing countries have led us to measure the effect of exchange rate volatility on Ghana's exports. This analysis relies on decision theory

and the risk-aversion assumption. We estimated two bivariate GARCH-in-mean models to analyze the effect of both "own-country" exchange rate volatility (GHS/US$) and "third-country" exchange rate volatility (€/US$) on monthly total exports. The decision to include "third-country" exchange rates was supported by Cushman (1986)'s findings. We first found that GHS/US$ exchange rate volatility did not affect Ghana's export growth. This might confirm the views of some Ghanaian agro-exporters that the Ghana Cedi is still pegged to the US$. We also found that €/US$ exchange rate volatility has deeply depressed Ghana's export growth. We provided some intuition to this result that can be the object of future research. Considering first that the European Union is Ghana's main export market to which it sells raw products such as cocoa beans. Ghana's exported raw products are processed in European countries and then exported to the rest of the world. Considering further that international transactions are mainly in US$ and assuming risk-aversion and profit maximization, if €/US$ exchange rates uncertainty increases, European exporters will reduce their production. Consequently, they will import fewer raw materials and Ghana's exports will fall. Although in practice exporters can offset this risk using financial instruments we assume, as suggested by Hooper and Kohlhagen (1978), that there is always a part that remains uncovered.

Finally, chapter four sought to determine the impact of lag order selection on non-causality tests in a Monte Carlo experiment. This study rose from methodological needs and lack of simulation evidence in the existing literature. Indeed, in the TYDL procedure used in chapter three, lag order selection is a crucial step and an incorrect lag structure of the VAR model may lead to biased MWALD tests results. We

compared two lag order selection methods namely, the Schwarz Bayesian criterion (SBC) and likelihood ratio (LR) tests, in terms of their lag length frequency distributions and the finite sample properties of the resulting non-causality tests. In order to capture most of the situations encountered in applied economics, we simulated twelve data generating processes (DGPs) that differ by the stationarity properties of the variables, the presence of cointegration, causality and moving average terms. We also varied the number of variables (N={2,3}), lags (k={1,2}) and the sample size (T={50,100,200}). Similarly to other simulation studies found in the literature, we concluded that the SBC generally selects smaller lag lengths than do the LR tests. In finite order VAR models, the SBC selects the true lag order 100% of the time while the LR tests overestimate it with a probability around 40%. In high dimension VAR models, the SBC tends to underestimate the true lag length. Likewise, we found that when there is no causality in the true DGP, both lag selection methods underfit the VAR model. In infinite order VARs, we also found that the lag length selected by the SBC is smaller than that selected by LR tests. Interestingly, we observed that as the sample size increases, the lag order selected by the SBC increases at a slower rate compared to LR tests.

When the null hypothesis of non-causality is false, the LR tests lead to non-causality tests with the lowest rejection frequencies. However in large samples, the MWALD tests present high performance regardless of the lag order selection method. In the case of mixed unit-root processes and when the dependent variable is I(0) in particular, rejection frequencies are very low. When the null hypothesis of non-causality is true, size distortions are present at T=50 regardless of the lag order

selection method. In larger samples, the exact size of the non-causality tests is close to the nominal size (5%). For processes with moving average terms, the MWALD tests present large size distortions that generally vanish in large samples. We also found that in some circumstances, the rate at which the lag order as selected by the SBC increases leads to increasing size distortions. Finally the LR tests seem to perform better when the true lag length is greater. All these results led to suggestions for future research.

Overall, this dissertation supports the idea that the macroeconomic reforms (i.e., inflation control and exchange rate realignment) implemented since the inception of the ERP have been successful at increasing Ghana's export performance. However, we provided some evidence that market-oriented reforms such as the transition to a floating exchange rate regime may have adversely affected Ghana's export growth. Also, there are many other factors than economic and financial policies that will have to be addressed in order to develop further the agricultural export sector. From a methodological point of view, we proved that qualitative methods can successfully complement an econometric analysis on export performance. We also showed that the analysis of exchange rate volatility on exports calls for elaborated models borrowed from financial econometrics. A drawback of these models is that only a limited number of variables can be included in the analysis as they require large samples. Further, the TYDL procedure appears to be an appropriate methodological framework to analyze a country's export performance. However, we provided simulation evidence that lag order selection has to be thoroughly thought in order to avoid misleading conclusions. The combination of all

these methods allows producing a complete analysis of a country's export

performance.

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APPENDICES

Appendices 1 and 2 present the lag length selected by various methods for a model containing a trend and a constant and a model containing a constant only respectively. The ADF_{10} and ADF_5 are based on a sequential t-test for the significance of the last lag in the ADF regression in levels at the 10% and 5% significance levels respectively. The DF-GLS_{10} and DF-GLS_5 are based on a sequential t-test for the significance of the last lag in the ADF regression = of GLS-detrended series at the 5% and 10% significance levels respectively. $MAIC^{GLS}$ and $MAIC^{OLS}$ are the modified AIC using GLS-detrended data (Ng and Perron, 2001) and OLS-detrended data (Perron and Qu, 2007) respectively.

Appendix 1: Lags selected by various methods (model with constant and trend).

Variable	LNTX	LNAX	LNREER	LNTWFGDP
ADF_{10}	7	0	1	2
ADF_5	0	0	1	1
DF-GLS_{10}	7	0	1	2
DF-GLS_5	7	0	1	2
$MAIC^{GLS}$	7	0	1	2
$MAIC^{OLS}$	7	0	1	2

Appendix 2: Lags selected by various methods (model with a constant).

Variable	LNTX	LNAX	LNREER	LNTWFGDP
ADF_{10}	7	0	1	2
ADF_5	0	0	1	1
DF-GLS_{10}	7	0	1	2
DF-GLS_5	7	0	1	2
$MAIC^{GLS}$	0	1	1	2
$MAIC^{OLS}$	0	1	1	2

Appendices 3 and 4 summarize the results from different unit-root tests, assuming a model with a constant and a trend (appendix 3) or a model with a constant only (appendix 4). The ADF_{10}, $ADF_{5,}$ $DF\text{-}GLS_{10}$ and $DF\text{-}GLS_5$ tests use the lags reported in appendices 1 and 2. ADF statistics are for H_0: $\gamma=0$. The DF-OLS-GLS tests use GLS-detrended data in the autoregression but are constructed with the number of lags suggested by the $MAIC^{OLS}$ criterion. We did not report the unit root tests DF-GLS-GLS as the number of lags selected by the $MAIC^{GLS}$ was systematically the same than with the $DF\text{-}GLS_{10}$ and $DF\text{-}GLS_5$ (appendices 1 and 2). The $MZ_{\alpha}^{GLS\text{-}GLS}$, $MSB^{GLS\text{-}GLS}$, $MZ_t^{GLS\text{-}GLS}$ and $MP_T^{GLS\text{-}GLS}$ are the $\overline{M^{GLS}}$ tests proposed by Ng and Perron (2001). Their "OLS version" (e.g., $MZ_{\alpha}^{OLS\text{-}GLS}$) use the $MAIC^{OLS}$ criterion to select the lag length.

Appendix 3: Unit-root tests at selected lags (model with constant and trend).[16]

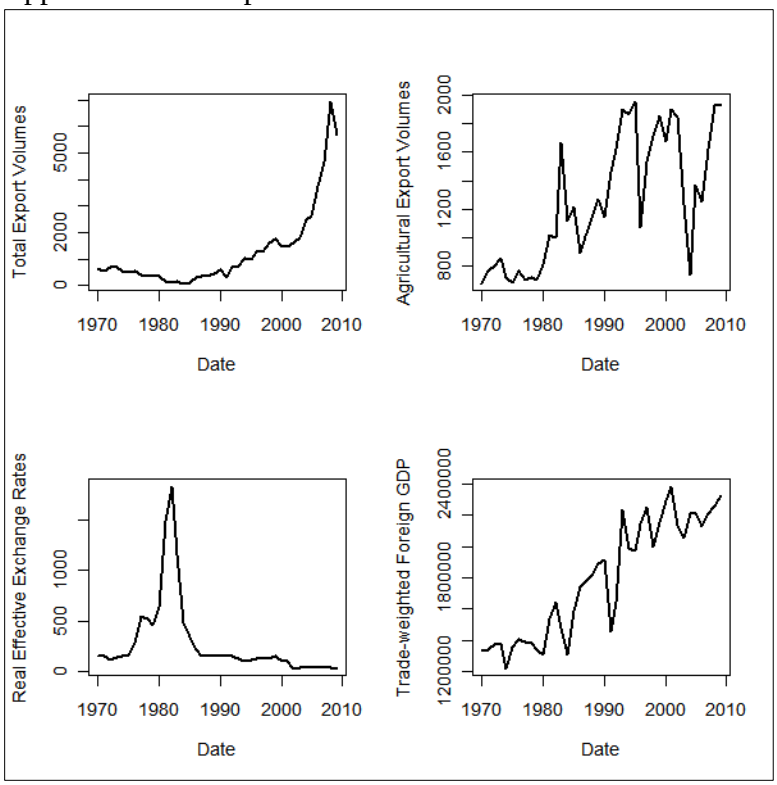
Variable	**LNTX**	**LNAX**	**LNREER**	**LNTWFGDP**
ADF_{10}	-2.9231***	-3.4645**	-2.4385***	-2.6818***
ADF_5	-1.6471***	-3.4645**	-2.4385***	-4.9264
$DFGLS_{10}$	-1.7362***	-3.5413	-2.1024 ***	-2.5572***
$DF\text{-}GLS_5$	-1.7362***	-3.5413	-2.1024 ***	-2.5572***
DF-OLS-GLS	-1.3222***	-1.1879***	-1.5042***	-1.2648***
$MZ_{\alpha}^{GLS\text{-}GLS}$	-10.9441***	-8.3153***	-5.6461***	-19.967
$MSB^{GLS\text{-}GLS}$	0.2080***	0.2452***	0.2928***	0.158
$MZ_t^{GLS\text{-}GLS}$	-2.2765***	-2.0388***	-1.6531***	-3.1546
$MP_T^{GLS\text{-}GLS}$	8.6533***	10.9594***	16.0871***	4.5954
$MZ_{\alpha}^{OLS\text{-}GLS}$	-10.9441***	-8.3153***	-5.6461***	-19.967
$MSB^{OLS\text{-}GLS}$	0.2080***	0.2452***	0.2928***	0.158
$MZ_t^{OLS\text{-}GLS}$	-2.2765***	-2.0388***	-1.6531***	-3.1546
$MP_T^{OLS\text{-}GLS}$	8.6533***	10.9594***	16.0871***	4.5954

16 *** If unit-root at 10% and ** at 5%.

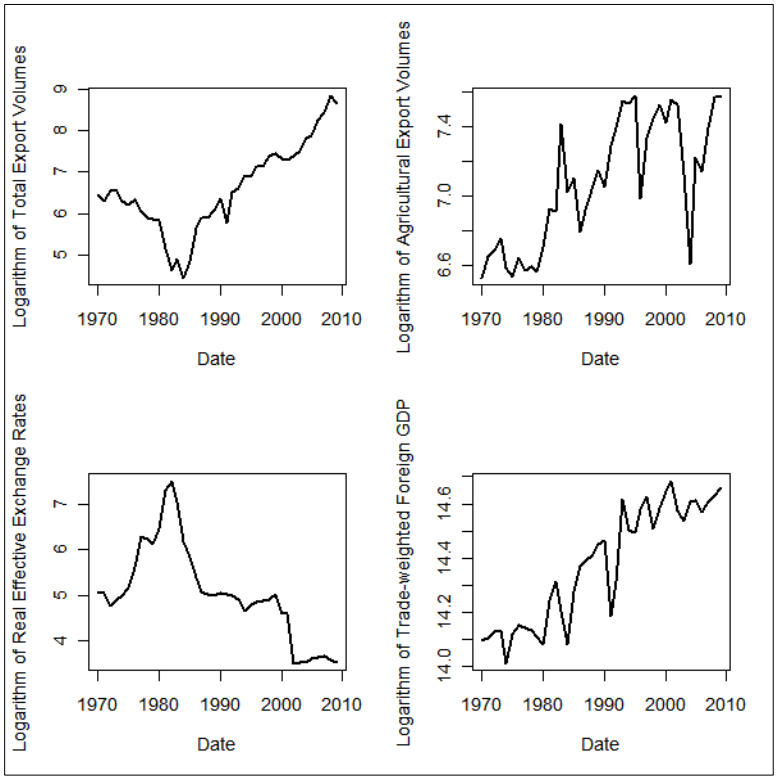
Appendix 4: Unit-root tests at selected lags (model with a constant).[16]

Variable	LNTX	LNAX	LNREER	LNTWFGDP
$\mathbf{ADF_{10}}$	-0.5265***	-2.2007***	-1.101 ***	-0.6508***
$\mathbf{ADF_{5}}$	0.1207***	-2.2007***	-1.101 ***	-0.6508***
$\mathbf{DF\text{-}GLS_{10}}$	-0.8956***	-1.6871**	-1.1832 ***	0.0456***
$\mathbf{DF\text{-}GLS_{5}}$	-0.8956***	-1.6871**	-1.1832 ***	0.0456***
DF-OLS-GLS	-0.0292***	-1.0796***	-0.5866***	0.0456***
$\mathbf{MZ_{\alpha}^{GLS\text{-}GLS}}$	-0.2961***	-2.5506***	-3.5032***	-0.7521***
$\mathbf{MSB^{GLS\text{-}GLS}}$	0.4779***	0.3519***	0.3324***	0.4832***
$\mathbf{MZ_{t}^{GLS\text{-}GLS}}$	-0.1415***	-0.8976***	-1.1646***	-0.3634***
$\mathbf{MP_{T}^{GLS\text{-}GLS}}$	18.1071***	9.0144***	7.2208***	16.6311***
$\mathbf{MZ_{\alpha}^{OLS\text{-}GLS}}$	-0.2962***	-2.5506***	-3.5032***	-0.7521***
$\mathbf{MSB^{OLS\text{-}GLS}}$	0.4779***	0.3519***	0.3324***	0.4832***
$\mathbf{MZ_{t}^{OLS\text{-}GLS}}$	-0.1415***	-0.8976***	-1.1646***	-0.3634***
$\mathbf{MP_{T}^{OLS\text{-}GLS}}$	18.1071***	9.0144***	7.2208***	16.6311***

Appendix 5: Time plots of the series in levels.



Appendix 6: Time plots of the logarithms of the series.



VITA

Aude L. Pujula was born in Perpignan, France, to Antoine-Robert and Anne-Marie Pujula. From 1996 to 2000 she pursued sport studies (downhill ski) at the Lycée climatique et sportif Pierre de Coubertin (Font-Romeu, France) where she graduated with honors. She was then admitted to ESAP (now EIP); an agricultural engineering school located in Toulouse, France. In 2005, during the last year of the program she decided to transfer to CNEARC (now IRC, Montpellier, France) to specialize in tropical agriculture. In 2007, she was awarded the degree Master of Science in agricultural engineering from both schools. In January 2008 she started a PhD in agricultural economics at Louisiana State University and specialized in econometrics. She will graduate from this program in August 2013. Upon completion, she will start working at DuPont (Geneva, Switzerland).