Food and Agriculture Organization
of the United Nations

Economic importance of cotton in Burkina Faso

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Economic importance of cotton in Burkina Faso

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Contents

Acronyms

ACC	Colonial Cotton Association
APROCOB	Cotton Companies of Burkina
CFDT	French Company for the Development of Textile Fibers
CIF	Cost, Insurance and Freight
CIRAD	French Agricultural Research Centre for International Development
COPACO	Cotton Company
ECOWAS	Economic Community of West African States
FAO	Food and Agricultural Organization
FASR	Strengthened Structural Adjustment Facilitating Programme
FCFA	Central African franc
FOB	Free on Board
GDP	Gross Domestic Product
GM	Genetically modified
HDI	United Nations Human Development Index
IBRD	International Bank for Reconstruction and Development
ICAC	International Cotton Advisory Committee
INERA	Environment and Agricultural Research Institute
ISIC	International Standard Industrial Communication
NCC	National Cotton Council
NRA	Nominal Rates of Assistance
OECD	Organisation for Economic Co-operation and Development
SA	Structural adjustment
SAS	Statistical Analysis Software
SOCOMA	Cotton Company of Gourma
SOFITEX	Burkina Faso Textile Company
SSA	Sub–Saharan Africa
UNPCB	National Union of Cotton Producers of Burkina Faso
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WTO	World Trade Organization

Abstract

This report investigated the role that cotton production has played in the economic development and poverty reduction in Burkina Faso, with a principal focus on how cotton prices, as a proxy to agricultural income, affects economic growth. Findings suggest that while cotton contributes to modest rates of economic growth, the lack of profitable investment opportunities in the industrial and service sectors limit agriculture's growth potential. The artificially low prices paid to Burkinabe cotton producers suppress farm income and constrain the long–term buildup of investment capital needed to adopt more modern and productive technology and management practices. Moreover, the low pricing has aggravated household's ability to make any meaningful movement out of poverty. One of the major points drawn from this report is that Burkina Faso's cotton sector has emerged as a model sector that other countries in the region should consider emulating. Burkina Faso has been forward looking and open to innovation as evidenced by its proactive stance in adopting Genetically Modified (GM) cotton and its inclusion of the smallholder farming community as an equal partner in the ginning industry. While cotton sectors in developing countries will continue to face challenges from declining world markets and sustaining productivity, Burkina Faso provides a viable path for cotton's continued presence in West African agriculture.

Introduction

Cotton production has been a major economic component and driver of economic growth in several West African countries over the past few decades. For landlocked countries such as Burkina Faso, Mali, and Chad, cotton has served as a vital source of export earnings. Being highly dependent on agriculture, those economies are subject to the uncertainties that surround crop and livestock enterprises, such as weather and diseases. Additionally, because cotton is an export–driven crop, global commodity prices can also have a significant influence on profitability. The frequent price collapses in world cotton markets over the past decade brought international attention to the plight of the West African farmer and the economic peril of low commodity prices. While the impacts are immediately evident at the producer level, agricultural planners must also be aware of how commodity prices affect regional and national level economic outcomes. Specifically, it is questioned if swings in commodity prices, and/or shocks to production, above or below their average trends affect economic growth.

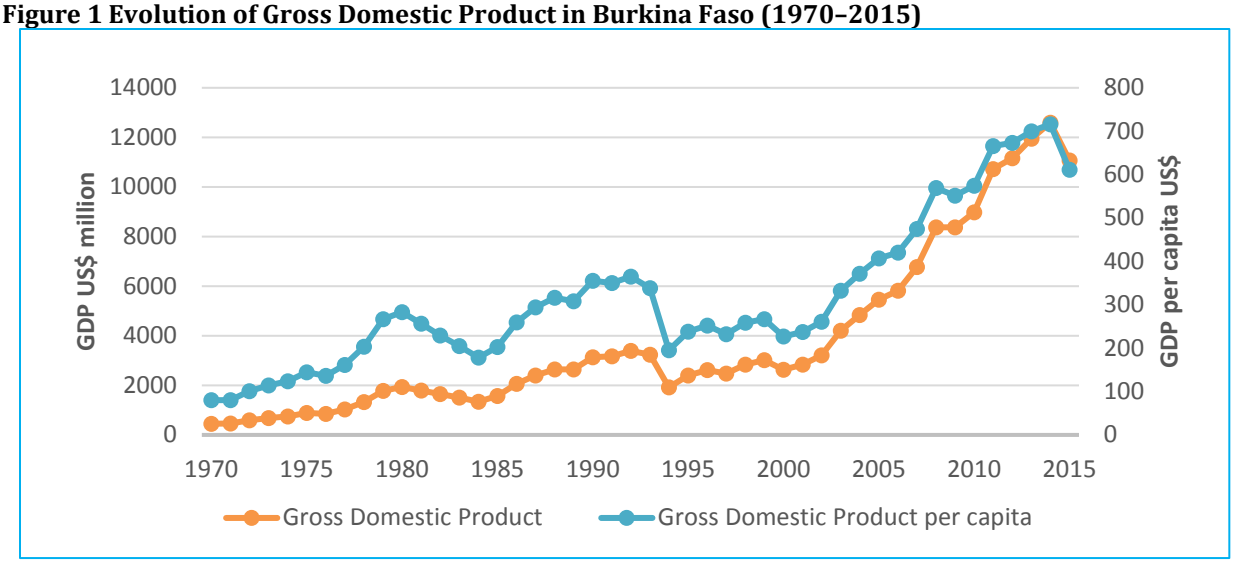
For Burkina Faso, the relationship between cotton prices and growth in Burkina Faso has been complicated. Cotton production is one of the few formal economic sectors making a substantial contribution to both economic output and overall employment. At the same time, the structure of the industry – with its parastatal control of ginning and, for much of the sector's history, exports – has meant that the country's cotton producers have historically received lower prices than the global average.

The purpose of this report is to investigate the mechanisms through which cotton production has contributed to economic growth in Burkina Faso over the past few decades, and whether this relationship is likely to continue given the sector's ongoing problems of volatile world cotton markets, low farm productivity, and institutional structure, or whether recent efforts to address these issues may improve the sector's contribution to growth and poverty reduction. This report begins with a background section on Burkina Faso to familiarize readers with the history of cotton production there over the past few decades. This is followed by a section describing Burkina Faso's cotton industry, with emphasis on the production, marketing, and policy aspects. The subsequent section explores the relationship between cotton prices and overall economic growth, including through multipliers and spillover effects into other sectors of the economy. Resultant impacts on food security and poverty are also considered. The report then concludes by exploring the policy implications of the findings, focusing on the policies and technological alternatives that could maintain cotton production as a leading enterprise in the country's agricultural landscape.

I. Background and context

Burkina Faso has generated impressive economic growth over the past couple of decades (Figure 1). Gross domestic product (GDP) has expanded at an average growth rate of 10.4 percent per year since 1994, rivaling the earlier economic performance of the Asian Tigers in the 1960s and 1970s, and more recent economic powerhouses like China, Brazil, and India. Burkina Faso's economic growth has been inclusive by Sub Saharan African standards, as prosperity it has been accompanied by a marked improvement in social welfare measures. Based on the United Nations Human Development Index (HDI), Burkina Faso's development has advanced as rapidly as any country over the past fifteen years[1]. Although Burkina Faso remains near the bottom of the global rankings, the country's HDI scores have steadily improved from an average of 0.21 in the 1980s to a value of 0.38 in 2010–13, an increase of 80.1 percent.

Figure 1 Evolution of Gross Domestic Product in Burkina Faso (1970–2015)



Source: FAOSTAT (2017).

Agriculture has been one of the key drivers of economic growth in Burkina Faso. A majority of the Burkinabe population is employed within the agricultural sector (around 80 percent of the population), and the sector continues to account for a significant share of economic output even as the economy has modernized. Over the past decade, the agricultural sector averaged a 25 percent share of national GDP (World Bank Development, 2015). The growth rate of agricultural output, though subject to weather and various other uncertainties, has been one of the major contributors to the economic upturn over the past decade, surpassing growth in the manufacturing sector and falling only slightly behind the industrial sector[2] (World Bank Development, 2015). The manufacturing and industrial

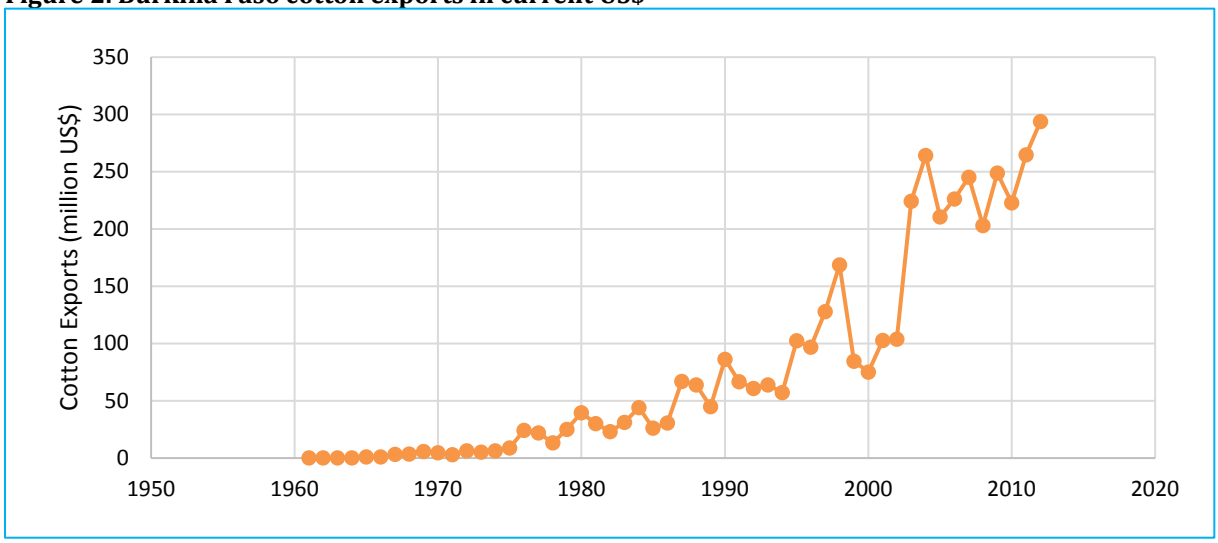
[1] UNDP's HDI is based on education (years of schooling), life expectancy, and per-capita income levels.

[2] World Bank classification designates the industrial sector through the ISIC (International Standard Industrial Classification) Divisions 10-45, food, beverages, clothing, etc. The manufacturing sector is as subgroup of the industrial sector, comprising ISIC divisions 15-37, chemicals, pharmaceuticals, rubber products, etc.

sectors remain underdeveloped and continue to lag behind regional trendsetters such as Ghana and Nigeria; over the past decade, the manufacturing and industrial shares of Burkinabe GDP averaged 23.2 and 9.3 percent, respectively. The largest segment of the Burkinabe economy is the services sector (42.5 percent of GDP), which is based primarily on informal, lower–valued employment in urban areas (World Bank Development, 2015).

Within the agricultural sector, cotton has historically been Burkina Faso's most economically important crop, as illustrated by the sector's role as the largest generator of Burkina Faso's export earnings over the past several decades. Since 2000, cotton exports have averaged US$207 million per year, including the handful of years at the beginning of the decade when the world cotton market collapsed (Figure 2). Over the past few years, following the world cotton market recovery (2005–2012), Burkinabe cotton exports climbed to an average of US$239 million per year. While accounting for only a modest portion of GDP (an average of 2.5 percent over the past decade), cotton export revenues have provided Burkina Faso with a stable source of foreign currency that has catalyzed economic development in other sectors. Globally, Burkina Faso is a top–10 exporter of cotton, accounting for an average share of 3 percent of global exports since 2000. Domestically, the production and ginning of cotton is of prime importance to the Burkinabe economy. Cotton is a major source of employment, and has created substantial economic multipliers through the development of the sector's value chain and the physical infrastructure it requires (Kaminski, 2011). In the following section, the development of Burkina Faso's cotton industry is examined, including its historical context, structure, and current issues facing the industry.

Figure 2. Burkina Faso cotton exports in current US$



Source: FAOSTAT.

Recently the industry has undertaken two initiatives designed to modernize Burkina Faso's cotton sector, with the intent of both raising producer incomes and improving the competitiveness of the country's cotton production on the world market: reform of the parastatal structure and the commercialization of genetically modified biotech (Bt) cotton. These two actions have the potential to positively impact actors throughout the cotton value

chain, reduce rural poverty, and improve food security outcomes. Given their progressive response to ills that have affected cotton sectors throughout the region, Burkina Faso is the logical focal point of this report since lessons learned from Burkina Faso are transferable to neighboring countries, such as Mali, which share similar institutions and agroecology. Moreover, Burkina Faso has emerged as the largest cotton producer in West Africa, while Mali and other countries in the region are facing serious challenges in sustaining cotton production given the decline in global prices, production constraints, and competition from food crops.

a. Development of Burkina Faso's cotton sector

Cotton has played a historically important role in West African life (Bassett, 2001; Schwartz, 1996). Prior to the French colonial period, circa 1900, cotton (*Gossypium arboretum*) was introduced into West Africa from either India or East Africa. Cotton was initially grown in association with food crops, but it never held a dominant role in farming. During this time, cotton was produced as a perennial crop rather than on an annual basis as it is today (Belem, 1985). Yields were low during this period, rarely reaching 150 kilogram (kg) per hectare (ha) of raw cotton (Schwartz, 1996). Despite the low productivity, cotton was used to manufacture clothes, where it was ginned, spun, and woven into fabric by local means. Cotton was also an important source of barter with Saharan traders to the north, where cotton was exchanged for either rock salt; or to the south, where cotton was traded for kola.

During the French colonial period, cotton was produced under a top–down technocratic system where the smallholder cotton producer was poorly treated (Bassett, 2001; Schwartz, 1996; Roberts, 1997). French efforts to increase cotton production in West Africa were motivated by a desire to obtain a reliable and low–cost supply of cotton for their domestic textile industry, which was crippled in 1902 by a supply crisis on world markets (Schwartz, 1996). Soon after this crisis, the French established the Colonial Cotton Association (*Association Cotonière Coloniale*, or ACC) to promote cotton production in the French Sudanese colonies. In 1949, the notion of the ACC was transformed into the CFDT, which lasted until the end of the colonial period in the early 1960s. For the most part, the development of cotton was a failure during the French colonial period, due to the harsh treatment of the smallholder producer, the failure to modernize traditional production systems, and the poor commercial infrastructure (Bassett, 2001; Speirs, 1991). The abuses of the ACC peaked in the 1920s when cotton producers were nearly enslaved by the French system. Monitors were sent into villages, compelling West African producers to meet production quotas by coercion and direct force. Producers failing to meet quotas were at times executed (Bassett, 2001).

Towards the end of the French colonial period in the early 1960s, several governments in Francophone West Africa, including that of Burkina Faso, focused their agricultural development programs on cotton (Sanders *et al.* 1996). Cotton quickly "took off": between 1961 and 1978, cotton yields increased eightfold in Burkina Faso, from 103 to 836 kg per ha, and cotton acreage tripled from 23 000 to 72 000 ha (Vitale *et al.* 2011). Although the French colonial period had ended, France remained the largest bilateral donor

and continued its investments in the cotton sector. A key contribution was the agricultural development efforts of the French Agricultural Research Centre for International Development, known by its French acronym, CIRAD (*Centre de coopération internationale en recherche agronomique pour le développement*), which specializes in tropical agriculture. During the 1960s and 1970s, CIRAD, in conjunction with the national cotton companies, extended the use of modern inputs that boosted productivity, including chemical fertilizers, insecticides, herbicides, and improved cotton seeds (Sanders *et al.* 1996). The substantial increase in cotton area was achieved primarily through the introduction of animal traction in the traditional cotton growing areas and eventually, beginning in the early 1980s, through the agricultural expansion into the sub–humid frontier (McMillian *et al.* 1998). Animal traction greatly increased labor efficiency in plowing, planting, and weeding operations, and eased seasonal bottlenecks in labor that had previously occurred during the critical early months of the growing calendar when only manual farming was available[3]. As yields and planted area increased in Burkina Faso (as well as neighboring countries such as Mali and Benin), the West African cotton sector quickly gained a foothold in world markets.

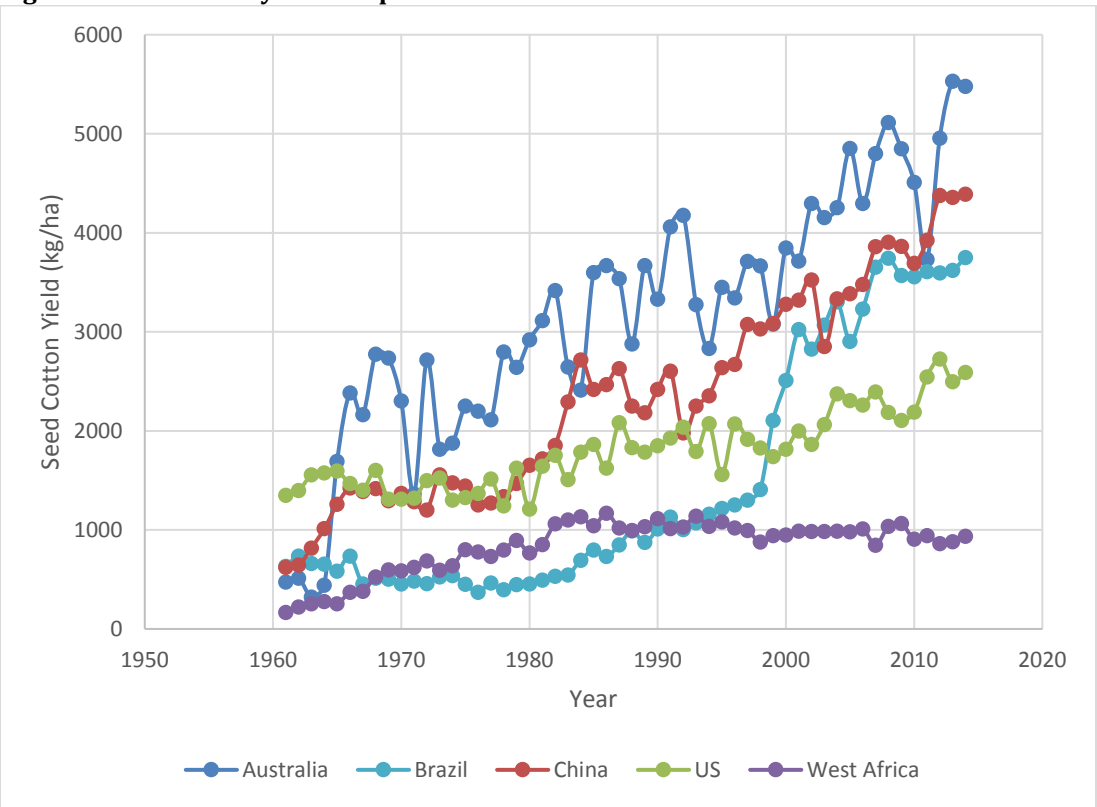
The initial success achieved in the 1960s and 1970s began to erode in the mid–1980s when world cotton prices plummeted sharply. Since then, several weaknesses in the West African cotton sectors have surfaced, often caused by the highly centralized, parastatal ownership of the ginning industries. The well–intentioned social mandates to establish equity among producers (including pan territorial and guaranteed pricing mechanisms) are too rigid to cope with the world price declines and volatility that are characteristic of the global cotton market. Like many major agricultural commodities such as maize, wheat, and soybeans, global cotton supply continues to outpace demand, and the effect of excess supply on global cotton prices has been more of an issue in cotton than for the more perishable food crops. On the demand side, competition from synthetics (e.g. polyester) has eroded cotton's share of global fiber markets, placing further downward pressure on cotton prices. The depression in world cotton prices has been further aggravated by subsidies in developed countries that incentivize producers to expand production based on artificially high price levels established by domestic policy measures. Brazil along with the C4 countries[4] have been active in rallying support against United States cotton subsidies, which they argue were a major cause of the crisis by artificially depressing world cotton prices (Liebhardt, 2005). In 2004, Brazil won a landmark case (DS267 – United States – Subsidies on upland cotton) with the World Trade Organization (WTO) that found the United States in violation of its international obligations to the WTO (Schnepf, 2005). Estimates of the effects of subsidies on cotton prices are wide–ranging and contentious, ranging between US$26 and US$504 million depending on the study (FAO, 2004). As noted by Shepherd and Delpeuch (2007), the results were particularly sensitive to the supply elasticity used in the analysis, which took on different values in each of the studies. Many of the supply elasticities were derived from ad hoc procedures, presumably since adequate data was not available to conduct a formal estimation.

[3] Post-independence development efforts were successful in increasing the adoption of animal traction. By 1990, Burkina Faso had 100 000 working draft animals and currently about 90 percent of cotton producers in Burkina Faso farmed with animal traction.

[4] C4 refers to the four major cotton producing countries in West Africa: Burkina Faso, Mali, Chad, and Benin.

Although productivity gains were impressive in the first couple of decades of the sector's development, yield growth slowed in the early 1990s throughout most of West Africa, including in Burkina Faso. By the mid–1990s, cotton yields in Burkina Faso and neighboring countries, such as Mali, leveled off at about 1 100 kg per ha. Pest pressure, soil degradation, and seed quality have been the principal factors limiting productivity growth and increasing production costs. West African cotton yields continue to lag the new yield frontiers achieved in other regions, such as United States, China, and Australia, resulting in substantial yield gaps (Figure 3).

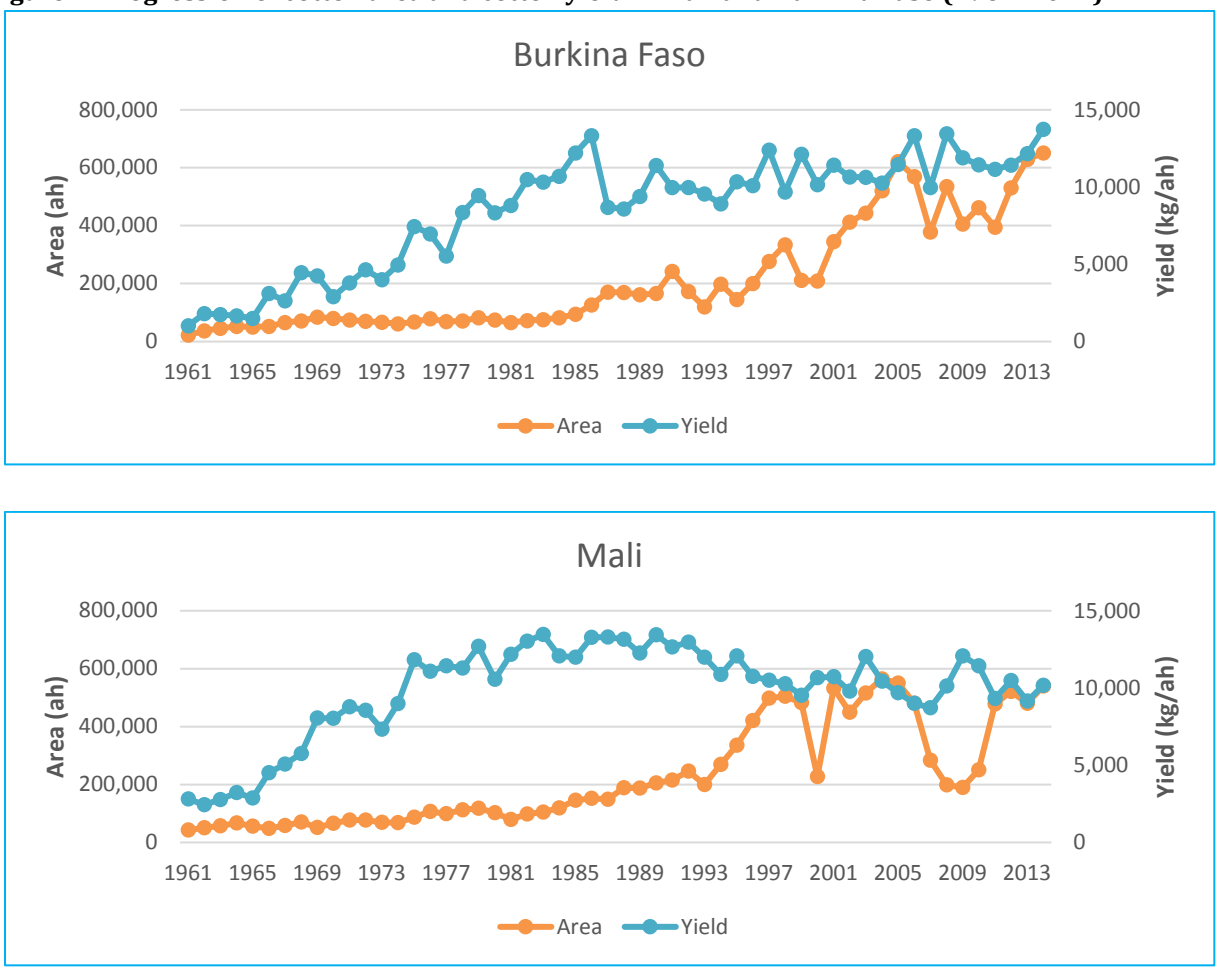
Figure 3. Seed cotton yield comparisons between West Africa and other countries



Source: FAO (2009).

West Africa's yield stagnation, as illustrated in Burkina Faso and Mali, has been unfortunate since, globally speaking, cotton yields have increased by an average of over 2 percent annually since the mid–1980s, which enabled producers in other regions (particularly the United States and Australia) to better cope with falling global prices by raising output (Figure 4).

Figure 4. Progression of cotton area and cotton yield in Mali and Burkina Faso (1961–2014)

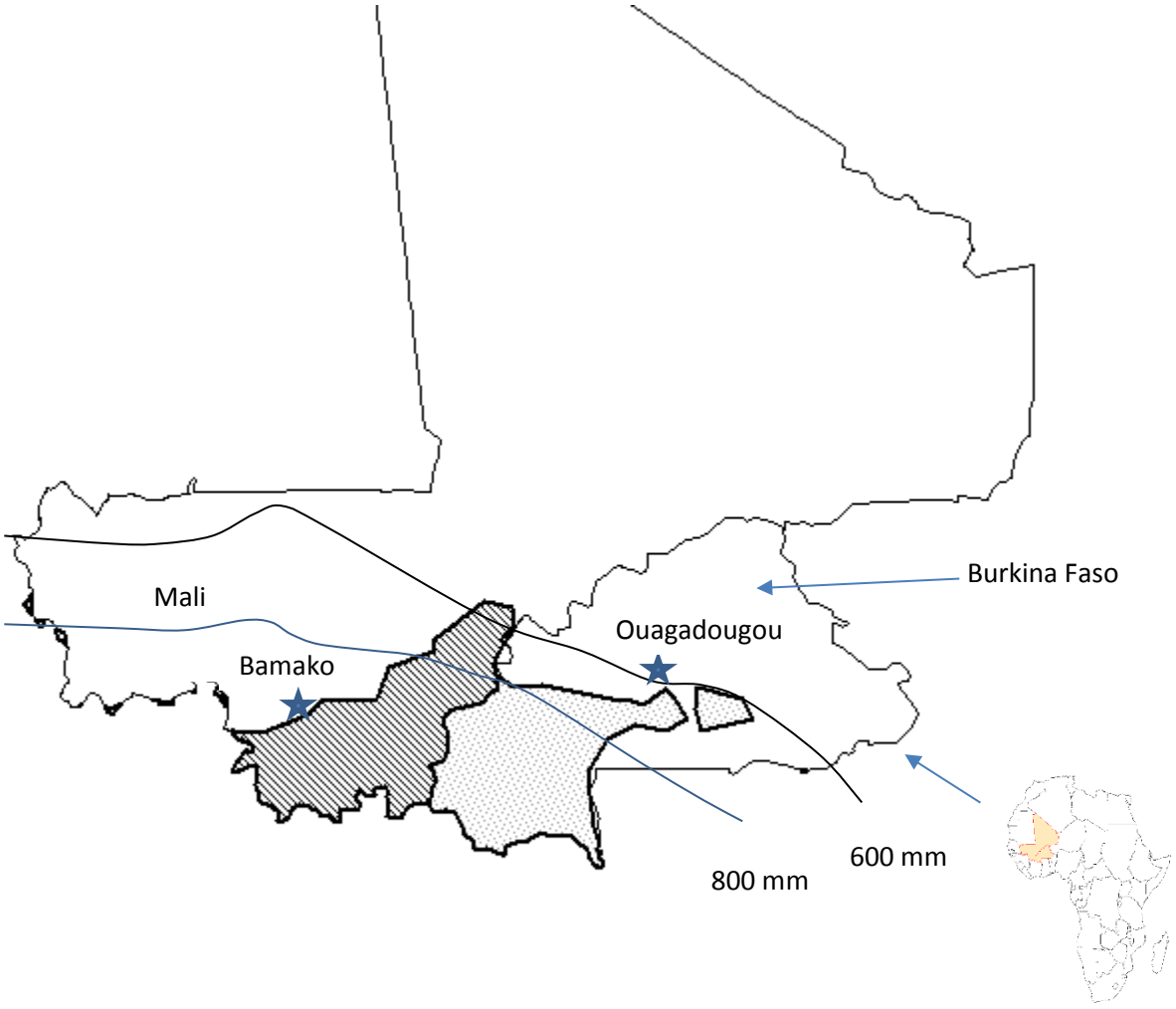


Source: FAO, (FAOSTAT 2017).

Recurrent price collapses in world cotton markets beginning in 1999, coupled with increased production costs, have created a crisis in many parts of the West African cotton sector. Three of the larger producers in the region – Mali, Benin, and Cote D'Ivoire – became temporarily insolvent in 2000 when world cotton prices went into a free fall. Since then, prices have recovered somewhat, but well–founded concerns are growing among all major stakeholders (producers, ginners, policymakers, and donors) that West Africa could lose part, or all, of its cotton sector. The tenuous nature of cotton production is a reality experienced elsewhere, as well. In many parts of the world, cotton has been a difficult crop to sustain over the long term, as its production faces particular agronomic, institutional, and environmental challenges (water shortages, for example). The history of the United States Southern Plains, where cotton production went from boom to bust in a mere 20 years (1920–1940), is a reminder of the potential fragility of cotton. In Mali, for instance, producers have already begun to shift cotton acres into maize and other cereal crops in order to better generate higher and more stable farm income (Baquedano *et al.* 2010; Sanders *et al.* 2015). In East Africa and Southern Africa, cotton production has had mixed success, with success often lasting only a decade or so followed by swift declines in sector performance despite substantial government and donor intervention (Tumusiime *et al.* 2014).

Today, cotton production in Burkina Faso occurs primarily in the Sudanian and Sudano–Guinean agro–ecological zones, similar to the pattern of cotton production in neighboring Mali (Figure 5). The slightly drier Sudanian cotton zone was the traditional base of cotton production in the region during the French colonial period, but over the past three decades the eradication of the tsetse fly and river blindness (*onchocerciasis*) expanded production into the more fertile river valleys of the Sudano–Guinean zone to the south (Bassett, 2001). Both zones support rain–fed cotton production, with average annual rainfall of 600–800 millimeters (mm) in the Sudanian zone and 800–1 100 mm in the Sudano–Guinean zone. Virtually all of the cotton produced in Burkina Faso is grown by smallholder farmers, with an average field size of 3.8 ha of cotton (Baquedano *et al.* 2010). Cotton is produced in a three year rotation with cotton grown in the first year, followed by successive years of a cereal crop such as maize, sorghum, or millet.

Figure 5. Cotton production zones in Mali and Burkina



Source: Foreign Agricultural Service, 2005.

b. Institutional structure: parastatal ownership and partial reform

Beginning with the French colonial period, the West African cotton sector has been vertically owned and operated by a combination of French foreign investors and African governments, comprising a quasi–parastatal organization (Speirs, 1991; World Bank, 2000; Teft, 2004; Schwartz, 1996; Baffes *et al.* 2004). Burkina Faso is the typical example of a C4 cotton sector. Since independence, the Burkinabe cotton processing and marketing segment had been owned and operated by SOFITEX, a government parastatal, in joint cooperation with a privately–owned French company, CFDT. Until recently, SOFITEX–CFDT had complete control and ownership of the cotton processing and marketing segments. This was a "one–stop" cotton farming system in which SOFITEX provided all of the production inputs to growers, on credit, and maintained exclusive rights to purchase the seed cotton from the farmers (Schwartz, 1996). Once ginned, SOFITEX marketed its cotton lint in association with the Cotton Company (*Compagnie Cotonnière*, or COPACO), a CFDT subsidiary (Baffes, 2007). For cotton producers, the vertically integrated system has had both positive and negative aspects. Cotton producers have benefited from the input supply chain, which provides them with modern inputs (seeds, fertilizers, insecticides, and animal draft power), credit, extension services, and a guaranteed pricing system that shields them from risk (OECD, 2006). Producers also benefitted from research carried out by CIRAD. The benefits were often eroded, however, by the monopsony control of SOFITEX, which left the cotton producer with only a meager share of the world cotton price, as will be discussed in the following section (Speirs, 1991; World Bank, 2004; Baffes *et al.* 2004).

This parastatal structure put the cotton sectors of Burkina Faso and other West African cotton producers under the microscope of donor organizations in the early 1990s, after government bailouts were required to keep the national ginning companies solvent. A plethora of sector reform measures have been put forth by development agencies, but have been met with strong resistance from host governments and foreign investors–principally those attached to the French Company for the Development of Textile Fibers (*Compagnie Française pour le Développement des Fibres Textiles*, or CFDT) and offshoot companies. To date, while only modest reforms have taken place, Burkina Faso has emerged as the most progressive country in the region. In 2002, the Burkinabe government partially divested itself of the cotton sector. Under the new institutional arrangement, the cotton sector is now jointly owned by the government (35 percent), Dagris (a French privately–owned textile company) (35 percent), and the National Union of Cotton Producers of Burkina Faso (*Union Nationale des Producteurs de Cotton du Burkina Faso*, or UNPCB) (30 percent) (Hanson, 2007). Three cotton companies now operate in Burkina Faso–SOFITEX, Faso Coton, and Cotton Company of Gourma (*Societe Cotoniere de Gourma*, or SOCOMA) – with each company operating in a different region of the country. All three companies purchase cotton at the same price and follow a pan–territorial pricing scheme. Although each company maintains the same type of "one–stop" cotton farming system, cotton prices are now negotiated among the principal stakeholders within the cotton sector, with Burkinabe producers having contributed to the negotiation of price levels since 1999 through the UNPCB (OECD, 2006; World Bank, 2004). Other notable reforms have included the establishment of a price setting

mechanism that includes a stabilization fund and the creation of a profit–sharing mechanism that includes the Burkinabe government, Dagris, and UNPCB.

c. Policy and pricing environment

Cotton policy is dictated primarily by the national ginning company, SOFITEX, and the government, although recently producer groups have gained more influence in the sector (see above). One of the distinguishing policy features of the Burkinabe industry is the guaranteed cotton price. This has insulated smallholder producers from price risk and was likely a major factor in the widespread adoption of cotton production following independence. Forecasting cotton price movements has often been difficult, providing periods of either substantial windfall profits for ginning companies when markets turned up in the short run, or, alternatively, years of severe financial distress when government and donor bailouts were necessary to make good on the guaranteed price (see next section).

d. The role of technology in Burkinabe cotton production

In West Africa, cotton production is more technologically advanced compared to cereal and other subsistence crops, but still modest by developed country standards (OECD, 2006). Cotton is one of the few crops grown intensively in West Africa, a region primarily characterized by low–input, extensive farming. Cotton utilizes more inputs in its production than any other crop grown in the region, including rice and maize. The input intensiveness of cotton is primarily due to pest pressure on cotton production. Crop damage caused by insect pests has become a major issue confronting the West African cotton sector, and has been a contributing factor to the stagnation and recent cotton yield declines in the region (Banwo and Adamu 2003; Oerke, 2002). In Sub–Saharan Africa, high temperatures that persist throughout the year enable multiple pest generations per year, fostering heavier pest densities (Abate *et al.* 2000). The larva of the cotton bollworm is the main cotton pest in Burkina Faso and throughout West Africa (Vaissayre and Cauquil 2000). On unprotected fields, Burkinabe researchers have found that insect pests can damage up to 90 percent of the cotton crop (Traoré *et al.*, 1998). In severe infestations, pests leave so little behind that the most cost–effective alternative is often for farmers to abandon their fields (Traoré *et al.*, 1998).

Pests compete directly with the farmer for yields, reduce profits, and make it harder for a grower to maintain a solvent household economy. Associated losses from pests are even more problematic in smallholder production because households have few safety nets to fall back on in years of severe pest infestation when incomes fall too low to satisfy basic needs (De Janvry *et al.*, 1991; Baquedano *et al.*, 2010). The insect pest problem is expected to worsen over the long–term throughout the West Africa region. All of the major global climate change models forecast higher temperatures that will potentially promote higher pest populations within the region (Hulme, 2005; Pimentel, 1993).

In the face of this continued pest pressure, conventional pest control measures have been losing effectiveness as pest populations have developed resistance to pyrethroid insecticides (the major agents used in Burkina Faso from 1985 through 2000) (Coton, 1999;

Goldberger *et al.* 2005; Martin *et al.* 2002). Nevertheless, Burkinabe farmers have continued to use conventional insecticides intensively, especially as cotton production has expanded into more marginal agricultural lands along the frontier where pest populations are often greatest (McMillian *et al.* 1998). In addition to becoming increasingly ineffective and costly, conventional pest control has also become more hazardous, as the use of more broadly toxic endosulfans has increased since 2000 throughout many parts of West Africa, including Burkina Faso, due to pyrethroid resistance (Vognan *et al.* 2002). The increased use of pyrethroids has elevated concerns over human health and the environment. Furthermore, the spraying methods currently used by farmers (typically back–pack sprayers) often present significant health hazards (Ajayi and Waibel 2003; Drafor, 2003; Maumbe and Swinton, 2003).

In a typical year, Burkinabe farmers spend roughly US$60 million on protecting their fields from bollworms and other insects using conventional spray–based approaches (Vognan *et al.* 2002; Toe, 2003). Recommended sprayings (about six per season) will protect only about 11 percent of the cotton yield from insect pests; about 23 percent of the cotton yield will still be lost. As many as ten sprayings can be required. Farmers in this region face potential losses between 20 to 65 percent of their cotton yield to pests and insects (Teft, 2004; Oerke *et al.* 1999). In Burkina Faso, cotton yield losses often surpass 30 percent even on fields treated with recommended insecticide applications.[5]

It was the growing discontent with conventional pest control methods that prompted Burkina Faso's initial interest in Bt cotton – a genetically modified cotton variety that contains the Bt gene, which kills the larva of the primary cotton pest (the cotton bollworm) without the need for insecticide application (see Box 1). By 2000, the magnitude of crop damage caused by insect pests had reached staggering proportions, contributing significantly to the stagnation and decline in cotton yields (Banwo and Adamu, 2003; Oerke, 2002). Stakeholders in the Burkinabe cotton sector began to explore new pest control options to increase productivity, improve the competitiveness of Burkina Faso's cotton growers on international markets, and reduce the environmental and health consequences of chemical sprays. Bt cotton surfaced as a possibility that would address all of these issues. International donors (USAID) and regional organizations such as the Economic Community of West African States (ECOWAS) were successful in making the country's cotton stakeholders (cotton companies and producers) and national research institutes (INERA) aware of BT cotton at conferences and workshops, fueling stakeholders' interest in the technology.

[5] This compares to a global average of about 15 percent of world cotton production lost to insects annually (Oerke *et al.* 2006).

BOX 1: MECHANICS OF PEST CONTROL USING BT COTTON

The Bollgard II (BG II) cotton variety introduced into Burkina Faso is a genetically modified variety that targets one of the region's primary cotton pests without the need for insecticide application. Genetic engineering techniques were used to insert genes into cotton that encode and promote the production, within the plant, of proteins toxic to certain caterpillar pests of cotton (Perlak *et al.*, 1990). In Bollgard II, these proteins, Cry1Ac and Cry2Ab, are encoded by genes originating from the common soil bacterium Bacillus thuringiensis (Bt). These Cry proteins are both highly effective in killing certain *lepidopteran larvae* (caterpillars) (Greenplate *et al.*, 2003). Once ingested, the Cry proteins bind to specific molecular receptors on the lining of the caterpillar's gut, create holes in the gut, and quickly cause death. Individual Bt Cry proteins are highly specific to certain caterpillars and do not target other insects (MacIntosh *et al.*, 1990), unlike conventional pesticides, many of which kill across a wide spectrum of both targeted and non-targeted (sometimes beneficial) insects.

Formulations of microbial Bt fermentation products, containing Cry proteins, have been used for more than 60 years as natural insecticides in spraying programs in agriculture and forestry pest control, including niche markets such as organic cotton (Aronson *et al*., 1986). While these Bt formulations can be quite effective under certain conditions, the products have never been widely adopted in crops such as cotton because they have short half-lives in the field (the Cry proteins are degraded by UV light); many insect larvae may escape control by these products if spray coverage is not optimal; and they are relatively expensive due to their method of production (fermentation).

From this initial interest, the process of bringing BT cotton into the marketplace lasted nearly a decade, but the effects have already been large (see Box 2). Vitale *et al.* (2011) report that after the first six years of commercial BT cotton production in Burkina Faso, yields on BT cotton averaged 22 percent higher than conventional varieties. Factoring in the production costs savings, the average producer earned an additional US$66 per ha. The significantly higher returns explain the high adoption rate of close to 80 percent.

BOX 2: THE ROAD TO BT COTTON ADOPTION IN BURKINA FASO

In May 2000, the first biotechnology meeting took place in Ouagadougou, Burkina Faso, where the cotton growers union (UNPCB) and Cotton Companies of Burkina (APROCOB) were briefed on experiences from other parts of the world describing the benefits of Bt cotton. The meeting led to a request on behalf of the cotton sector stakeholders to meet with the seed industry representatives, including Monsanto and Syngenta. A presidential decree granted approval for conducting confined field trials under supervision of a newly formed Biosafety Committee. Burkina Faso's national agricultural research centre, INERA, conducted the three years of field trials from 2003 to 2005 as part of an umbrella research agreement with Monsanto. By 2007, on-farm field trials of two local germplasm varieties, STAM 59 and STAM 103, were conducted. In June 2008 the National Biosafety Agency authorized the commercial planting of BG II in Burkina Faso.

Higher cotton yields–such as the gains made due to the recent adoption of Bt cotton–are crucial for the continued competiveness of Burkina Faso's cotton sector. At the same time, it is important to note that sustained yield gains will require continuous research and development efforts and likely target various aspects of the production process. On this front, both the United States and Brazil can provide instructive examples of countries that overcame cotton yield stagnation. United States yield gains beginning in the 1980s were made possible by several factors, including expansion into the western part of the country where the development of irrigated cotton generated substantial increases in cotton yields. Increased productivity was also achieved through higher fertilizer input levels, enhanced varietal research and improved seed quality, farm support programs, boll weevil eradication, and most recently the introduction of Bt cotton (Baquedano *et al.* 2010). In Brazil a concerted effort by the government and cotton stakeholders to increase investments in research and development (including the adoption of Bt varieties) led the country's cotton yields to increase steadily since the 1990s, and they are now nearly three times higher than yields observed in West Africa (Figure 3).

e. Summary and opportunities

The Burkinabe cotton sector remains one of the most prominent in the country's economy. Despite its importance, stagnant productivity growth over the past few decades hindered the ability of producers to compete in the world market. The industry's structure (principally the parastatal ownership of the ginning companies) and pricing mechanisms were also problematic, as discussed in the next section. But in response to these issues, Burkina Faso has embarked on two major policy initiatives in the hopes of sustaining its cotton sector into the 21st century. On the production side, Burkina Faso has become one of Africa's leaders in biotechnology, and has been growing GM cotton on a large–scale commercial basis since 2009. The cotton sector reform, although less successful, is an on–going process that should make Burkina Faso's cotton sector more efficient and responsive to world markets.

II. Cotton prices: relation to economic growth and development in Burkina Faso

Export earnings and the cotton surplus generated in the rural areas are expected to play an important role in fueling economic growth. Experience from many parts of the developing world, over the past few decades, reveals that investments from the agricultural sector have not always translated into a thriving industrial sector. The investment mechanisms become dependent on global commodity prices and domestic production, both of which are highly variable, with significant downside risk due to poor weather, pests, and downturns in markets. Even when economic growth occurs, it is often confined to small pockets of society, poorly distributed, and promoting minimal if any social development or poverty alleviation.

Recent studies, however, have found agriculture as a much more effective economic catalyst among developing economies than previously thought (FAO, 2012). With agriculture occupying an important share of GDP, and in many cases employing up to 70 percent of the population, growth in agriculture has generally led to much greater increases in economic growth and factor productivity than investments elsewhere in the economy. Between 1993 and 2005, agriculture accounted for 32 percent of economic growth in agriculture–based economies of the developing world. In the more developed urbanized economies, agriculture contributed substantially less to economic growth, 5 percent, over the same period (FAO, 2012).

An equally important benefit of agricultural growth in developing economies is its corresponding effect on reducing poverty. Compared to economic growth in non–agricultural (industrial and service) sectors, agricultural growth has been found to be 11 times more effective in reducing poverty (FAO, 2012). Agricultural growth is particularly effective in reducing poverty in developing economies since it directly impacts and empowers the rural areas where a substantial majority of the population lives. Industrial growth concentrates wealth in urban areas where they are much less likely to benefit larger segments of society or reduce poverty.

Agriculture–led growth has been most successful in countries such as China and Viet Nam where smallholder farmers were able produce a marketable surplus. This required providing smallholder producers with access to new technology to increase productivity as well improved marketing conditions to make the new technology profitable. This highlights the importance of increasing smallholder farm profitability through increased productivity (higher yields) and greater market access (higher prices).

Agriculture–led growth has enabled smallholders in many developing economies to transition out of poverty, principally in Asia, whereas in other regions such as Sub–Saharan Africa (SSA) it has been less effective. In SSA, agriculture remains for the most part based on traditional, low input practices, with only limited use of modern inputs including fertilizer. Yield increases have for the most part lagged performance found in other developing parts of the world. Production increases have most often been achieved by land expansion such as Burkina Faso's push onto the frontier in the 1980s that doubled cotton acreage (see previous

section). The industrial and service sectors have also been unable to adequately modernize and become competitive on a regional or global basis, rendering the economic surplus from agriculture impotent in generating economic growth.

Burkina Faso shares many of the conditions favorable to successful agriculture led growth, including agriculture's substantial contribution to GDP, a large smallholder population, and poverty concentrated in rural areas. Despite the economic importance of agriculture, Burkina Faso's current agricultural policies largely neglect long–term, growth–promoting strategies (like research and development) and through its parastatal structure have poorly treated their cotton producers. Prices received by Burkinabe cotton producers from the national cotton companies have often been some of the lowest in the world.

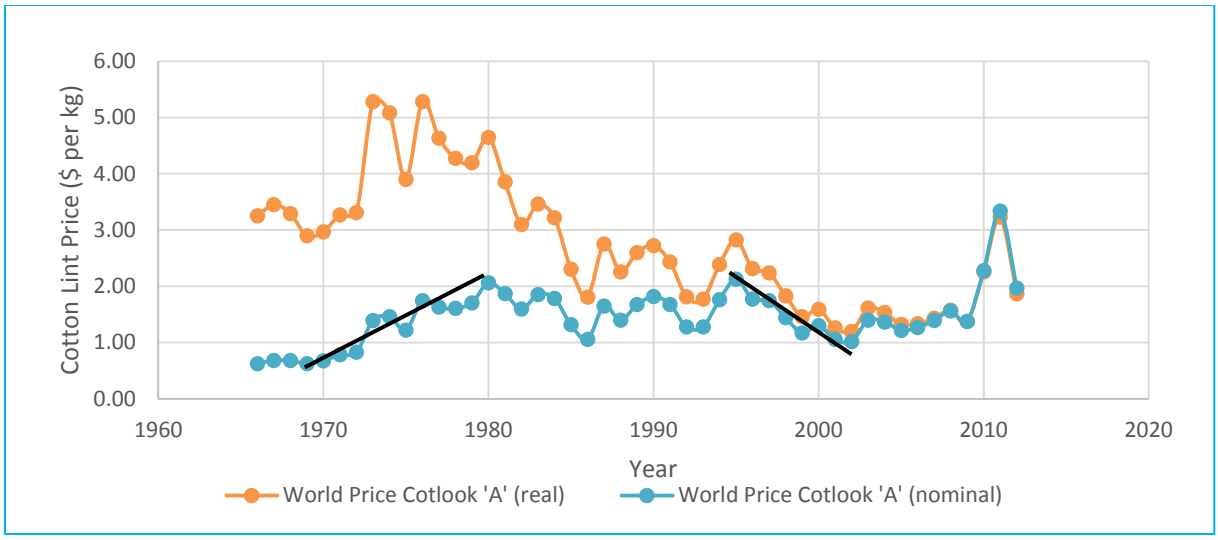
Given the important role of development policies that hinge on agriculture–led growth, this section focusses on some important topics : (1) How have global cotton prices moved over the past few decades; (2) How have Burkina Faso's cotton prices moved over the past few decades; (3) How has the global cotton price been transmitted to Burkinabe producers; (4) Have cotton price changes affected economic growth; (5) In what way cotton price changes affected food security and/or poverty measures; (6) In what way the producers have responded to cotton price changes.

a. Global cotton prices movements over the past few decades

Global cotton prices have generally been on a downward trend since 1980 (in both real and nominal terms) due to the overall competitiveness of the industry, increased supply, and weakened demand (Figure 6). Cotton prices are determined by the supply and demand interactions between cotton producers, ginners, and cotton mills. The global textile industry is highly competitive, and historically has demonstrated a tendency toward reduced costs and increased production, including the geographic realignments of cotton mills, the expansion of production into new parts of the world, and the incorporation of synthetic fibers. Since the 1960s, cotton mills have increasingly moved away from the United States and Europe and into Asia, while major production centres have emerged in China, West Africa and parts of Central Asia (OECD, 2006). Moreover, retail prices of finished products based on cotton, e.g. apparel, have also been on the decline (ICAC, 2007).

On the supply side, both higher cotton yields, achieved by advances in technology, and area expansion, have contributed to higher global cotton production. Since the Second World War, United States cotton producers have continued to reduce production costs through the successful eradication of the boll weevil, mechanical harvesting technology, and most recently GM cotton. Elsewhere, tightly controlled government–run cotton sectors in developing countries have leveraged low cost cotton production through cheaply available labor combined with increasingly modern technology. The net result of new technology and area expansion has been a doubling of cotton production over the past few decades from 10.2 to 20 million tonnes between 1960 and 2001, corresponding to an annual average increase of 1.8 percent (Baffes, 2005).

Figure 6 World cotton prices from 1970 through 2014 in real and nominal terms (2009=100)



Source: World Bank (2015) based on data from the Cotton Outlook.

At the same time, the use of synthetic fibers has increased dramatically, which has negatively impacted on cotton demand. Over the past couple of decades, synthetic fibers surpassed cotton as the most widely used thread in the milling industry. The steady shift from cotton to synthetic fibers has eroded cotton's textile market share from approximately 67 percent in 1960 to 38 percent in 2005 (ICAC, 2007).

In addition to annual production and usage, stock levels also play a large role in determining global cotton prices, as expressed by the stock–to–use ratio in major cotton milling countries. Over the past few decades, thin margins have existed between stocks and usage, making the global cotton market highly volatile when compared to other commodity markets such as maize or wheat. Long–term storage of cotton is rare, as annual cotton production levels are typically consumed at mills within 12–18 months of delivery, resulting in stock to use ratios ranging between 20 and 50 percent (Baffes, 2004).

Despite the general downward trend in cotton prices over the past few decades, short–term booms and busts have also occurred. The early 1970s was a period of strong, extraordinarily high cotton prices that mirrored similarly unusual price movements in virtually all of the global commodity markets (Cooper and Lawrence, 1975). Price increases over the first few years of the decade were, and remain, historically large. Global cotton prices increased by 123 percent from 1970 to 1973 that agricultural producers misinterpreted as a long term trend (Figure 6). Generally speaking, however, the commodity price increases of the early 1970s are explained more by external forces than by supply and demand market fundamentals. Inflationary pressures, and the gradual withdrawal of the gold standard on United States' currency, resulted in a large influx of US$ into the world economy. This created a monetary expansion and inflationary pressure in many countries emerging in the post Second World War global economy – particularly Japan and Germany (Cooper and Lawrence, 1975). Continued fears over inflation in the United States and uncertainty in exchange rate movements also led to an increase in speculative trading in commodities, including cotton, which put further upward pressure on prices. Futures trading on the New York exchange increased by over 50 percent between 1972 and 1973,

and maintained this higher level into 1975 (Cooper and Lawrence, 1975). Speculative trading may also have been influenced by the draw down in United States cotton stocks from the Commodity Credit Corporation, which began to move away from direct commodity support in the mid–1960s. While there were cyclical increases in cotton demand during the early 1970s, supply was for the most part able to keep pace with demand, particularly given the emergence of cotton from developing countries – notably China and various African nations. The failures of wheat crops in Russia and parts of Asia in 1972 may also have contributed to higher cotton prices, as this event incentivized producers to shift from to grain crops in those regions.

The 1980s was a decade of significant change in global cotton prices. The emergence of China and other low–cost producing countries, including West African countries, broke the high price cycle that began in the 1970s. China quickly transitioned from its role as the world's largest net cotton importer (which it held for nearly two decades) into the world's largest cotton exporter (Baffes, 2004). In the United States, cotton prices fell below the loan rate (the price floor established by the USDA) for the first time in the 1980s. This coincided with a paradigm shift in USA cotton marketing, from government regulated stockpiling of cotton through loan payments to that of price support with passage of the 1985 Farm Bill (Baffes, 2004). This policy shift resulted in USA producers selling cotton previously held under the loan rate program onto global markets, which exacerbated the ongoing decline in world prices. Lower production costs through technology adaptation and improved management (e.g. eradicating the boll weevil) was also present in the USA, further raising global cotton supplies.

World cotton prices fell steadily between 1994 and 2001 (Figure 6). On the supply side, cheap oil prices during the 1990s encouraged the growth in synthetic fiber markets. Polyester production, for example, more than doubled in the 1990s, from 39.7 to 93.7 million tonnes (NCC, 2003). Cotton production had more modest global increases, bolstered by lower production costs (fertilizer, fuel, and transportation costs) from not only cheap energy, but also from improved cotton technology (GM cotton introduction in 1996) that increased cotton yields. In the developed countries, low grain prices that prevailed throughout most of this period provided few incentives for producers to shift out of cotton. Fiber demand also weakened during this period, particularly in the late 1990s with the Asian financial crisis. The modest increase in fiber demand that did occur was met primarily by synthetics, which became more competitive with cotton during this period of cheap oil. China restricted cotton imports in the late 1990s, and subsequently released large stocks of cotton that it had accumulated, which placed further downward pressure on prices.

By 2002, world cotton prices reached new lows in both real and nominal real terms (Figure 6). This drastic downturn in global cotton markets brought the debate on producer subsidies to the boiling point. These lower prices revived the debate around the effect of cotton subsidies, and although some countries were able to reach an agreement on the issue (notably the United States and Brazil), West African producers lacked the political or trade leverage to negotiate on this issue. While price movements over the past few decades have been affected by cotton subsidies, though as stated in the previous section, the magnitude of their effect on world prices is not clear. They remain, however, a contentious issue in world

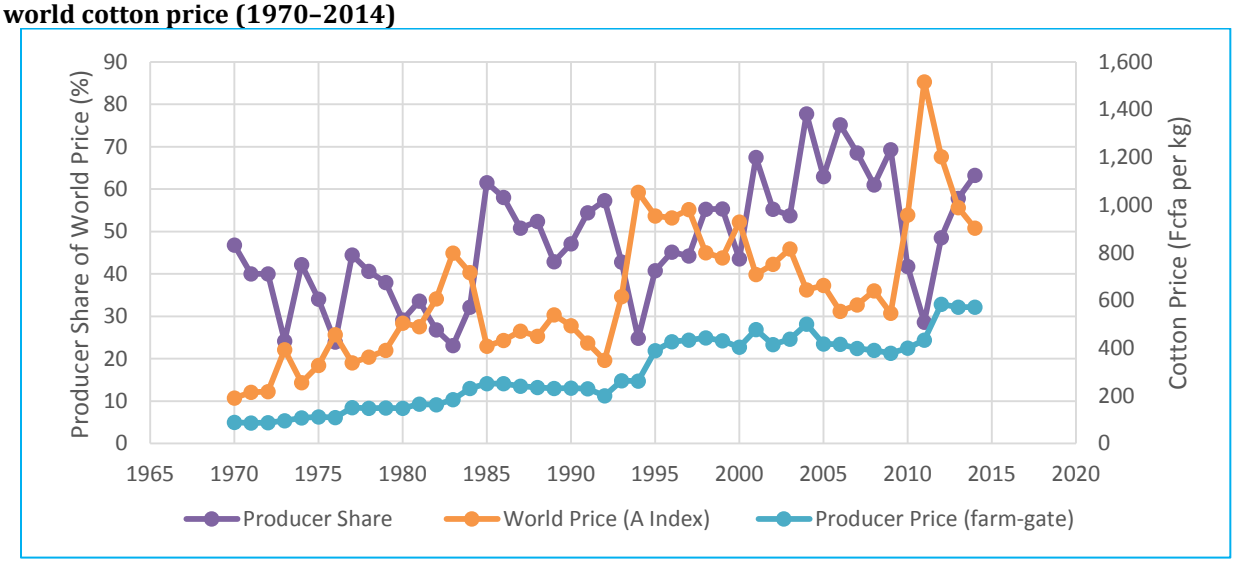
cotton price formation. Cotton prices did recover modestly following the 2002 lows (Figure 6).Global cotton markets did not, however, experience the large run–up in prices that food commodities experienced in 2008. Over the past few years, cotton prices have increased significantly. These recent price spikes, including in 2011, are likely caused by the increased speculation in commodity markets, including cotton, which encourages short terms price increases when production shortfalls occur. In 2010/11, India banned cotton exports and Asian producers, including China and Pakistan, experienced bad weather (freezing in China and flooding in Pakistan) that pushed world cotton prices to an all–time high. Looking forward, global cotton prices will likely continue to be characterized by an auspicious mix of declining real prices and volatility, combined with the effects of agricultural policies in wealthier countries that support cotton producers.

b. Evolution of the transmission of changes in global cotton prices to producers in Burkina Faso

While global cotton prices have seen large fluctuations over the past decades, producer prices in Burkina Faso have fluctuated less due to the parastatal structure of the industry and the price–setting power of the ginning companies. Hence, the parastatal ginning company has for decades been criticized for implicitly taxing cotton producers by exerting monopsony power on raw cotton purchases at the farm gate, establishing prices that approach producers' reservation wage rates instead of prevailing global price levels (Tumusiime *et al.* 2014). The most pernicious period was in the decade or so following independence when cotton production was introduced on a large scale basis (Figure 7). In the post–independence era, the share of the price paid to producers at the farm gate varied from one–third to one–half of the world price, such that substantial rents accrued to the national cotton companies. While the producer share of the world price fluctuated substantially over the past few decades, ranging from a low of 23.1percent in 1983 to a high of 77.8 percent in 2004, larger shares were more often caused by unanticipated changes in world cotton prices between the date of the announced price, just prior to planting, and the time when ginned cotton was sent to market, typically 9–15 months later[6].

[6] The lack of transparency in the marketing practices of the parastatals throughout most of the past few decades makes it difficult to assess exactly when cotton was marketed, but there appears to have been little to any use of forward contracting or futures markets.

Figure 7. Share of the world cotton price received by Burkinabe producers: ratio of farm gate price to world cotton price (1970–2014)



Source: World Bank (2015) based on data from the Cotton Outlook. Producer Prices from FAOSTAT.

The effects of agricultural policy on prices received by producers can be measured using Nominal Rates of Assistance (NRA) (Anderson and Masters, 2009; Bates and Block, 2009; MAFAP, 2013). The NRA for Burkina Faso's cotton producers allows for a more complete assessment of cotton pricing by accounting for the ginning, transportation, and marketing costs incurred in transforming the raw cotton purchased from producers into cotton lint and shipping it overseas to cotton mills. The NRA is the ratio of the domestic cotton seed price paid to producers compared with the world cotton lint price adjusted for ginning, marketing, and transportation costs. A ratio of one indicates perfectly competitive pricing, i.e. the ginning company is transferring the entire adjusted world price to producers. Values less than one indicate taxation and rent–seeking, since some portion of the adjusted world price is captured by the gin rather than passed through to producers. Subsidies occur when NRA values exceed one, indicating that producers are paid a higher price than the adjusted world price.

The NRA is calculated as the difference between the actual price received by producers at the farm gate, P_{fg}, and the world price that producers would receive at the farm gate after accounting for transportation, border fees and taxes, and freight losses, P_{ref}. To place in a more convenient format, the price difference is divided by the reference price, P_{ref}, so that the price received by producers is calculated as a percent of the world price as follows: $NRA = (P_{fg} - P_{ref})/P_{ref}$. Positive NRA values provide empirical evidence that the policy environment favors producers (incentivizes) through higher prices, while negative values imply that producers are penalized (disincentivized) at the expense of lower prices for consumers.

Calculating NRA for Burkinabe cotton. Location matters when calculating NRA since shipping and transactions costs are highly dependent on: (1) location of the farm gate relative to cotton gin where domestic cotton is purchased from; (2) location of the market where the exported cotton is sold; and (3) the point of destination, where exported cotton is

sold. The cotton reference price, P_{ref}, is taken as the raw cotton (pre–ginned) price in Bobo Dioulasso, Burkina Faso's major ginning centre. The farm gate price is located in the periphery surrounding Bobo Dioulasso, using an average distance of 50 kilometre. The cotton reference price is obtained by accounting for the ginning, shipping, insurance, and related transportation costs from the ginning facility, to the port of exit, and finally to its destination (cotton milling facility). Based on the most commonly used transportation route that accesses the port in Abidjan, the Burkinabe cotton reference price, P_{ref}, is calculated as:

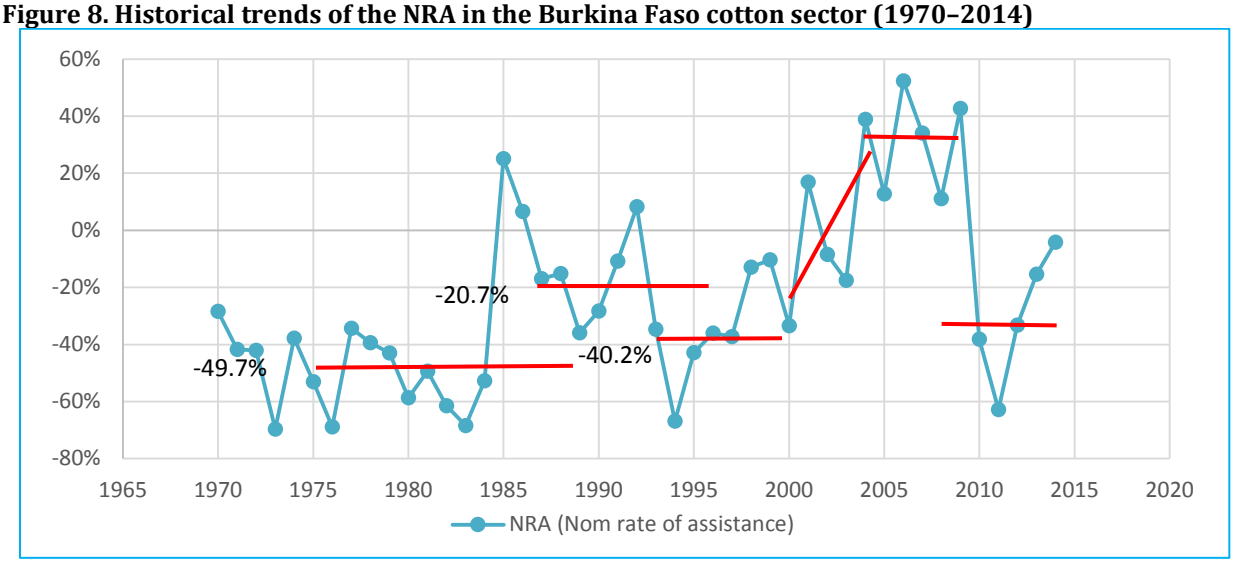
$$P_{ref} = P_{BENCH} - C_{MAR} - C_{PORT} - C_{ABJ-BOBO} - C_{GIN}$$

Where P_{BENCH} is the world price (Cotlook A) received by the ginning company, C_{MAR} is the maritime shipping costs between ports of origin and destination, C_{PORT} is the port charges (taxes, entry fees, etc.) and unloading incurred moving through entry port, $C_{ABJ-BOBO}$ is the overland transportation cost from Abidjan to Bobo Dioulasso, and C_{GIN} are the ginning costs. Maritime shipping costs, port charges, overland shipping, and ginning costs are taken from Baffes (2007).

Based on the NRA calculations and the previous discussion on world cotton price movements, a few periods of distinct trends in NRA emerge (Figure 8). Burkinabe cotton producers were highly taxed in the first decade or so following the post–colonial era. Between 1970 and 1984, the NRA averaged negative 49.7 percent, indicating that cotton producers received about one–half of the adjusted world price (Figure 8). This provides support to the idea that the low producer share of the world price during this period (around one–third) is primarily due to taxation rather than extremely high ginner or transportation costs. It is important to note that although the NRA indicates an approximate sharing of the adjusted world cotton price, the ginner's portion represents an economic rent, whereas the producer's share must still be adjusted downward to account for production costs before profitability can be assessed. During this period, producer cotton income was low, and for the most part producers were just able to break even after accounting for their production costs. Resentment and tension began to grow and escalate during this period throughout many of the Francophone West African cotton producing countries, as the contrast between the well paid ginning companies and the struggling smallholder cotton producers became self–evident.

Beginning in 1985, implicit taxation rates declined substantially compared to the prior couple of decades (Figure 8). Between 1985 and 1997, the NRA averaged minus 21.9 percent, resulting in less than one–half of the implicit tax that producers incurred earlier. For producers, however, the movement in NRA did not provide any substantial change in income as the cotton price paid to producers did not significantly increase throughout the decade. The decline in taxation was due primarily to the precipitous fall in world cotton price that occurred in the mid–1980s, which reduced the share of the world price received by the ginning companies. Hence, producers during this period actually fared better than the ginning companies by managing to at least break–even. Cotton companies, because of the unexpected downward price movements, reached financial austerity in several years during this period and were often forced to resort to government and donor bailouts to pay producers the guaranteed price announced prior to planting.

Figure 8. Historical trends of the NRA in the Burkina Faso cotton sector (1970–2014)



Source: Author's calculations based on Baffes (2007).

In 1994, the FCFA currency was devalued, and the international donor community expected that this devaluation would usher in a period of higher producer prices. Unfortunately for Burkinabe cotton producers, although cotton prices (local currency) did increase significantly following devaluation the price paid to producers changed only marginally. This resulted in NRA values hovering around minus 40 percent in the years following the devaluation (1994–1997), maintaining a fairly high level of implicit taxation eroding the potential benefits of devaluation.

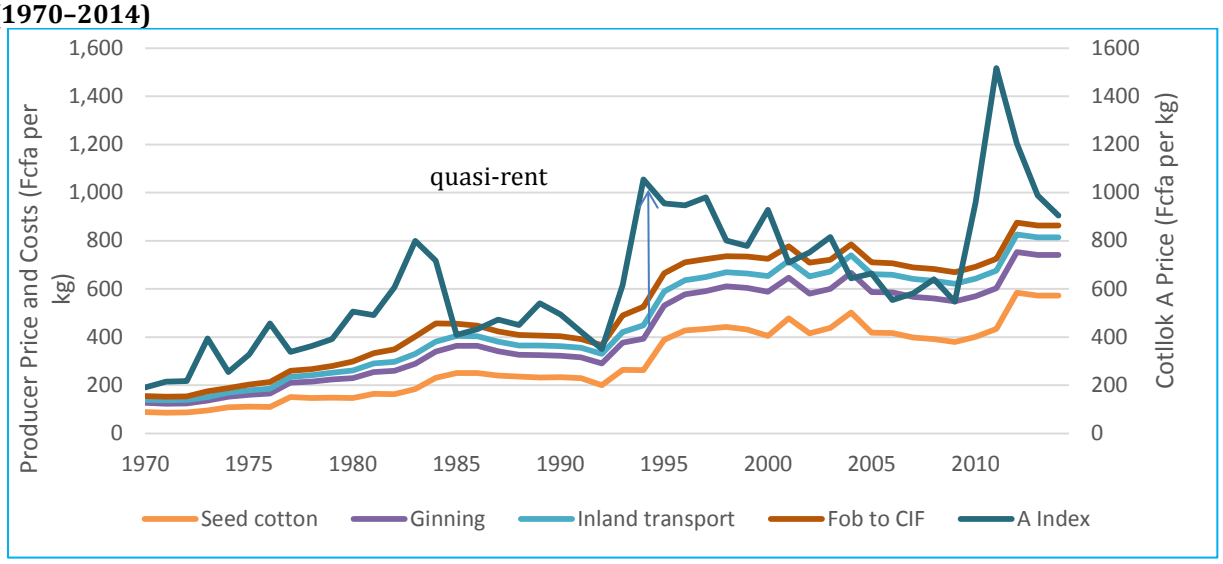
Beginning in the late 1990s, the level of implicit taxation began to gradually decline again (Figure 8). Unlike the 1980s, producers did receive higher producer prices during these years, leading to somewhat higher incomes. From 1998 through 2003, the NRA improved from minus 20 to plus 40 percent due to both higher domestic prices as well as falling world cotton prices (Figure 8). As had happened earlier, the rigidity of the guaranteed cotton price announced prior to planting resulted in a few years when the world price unexpectedly fell between spring planting and the marketing of the ginned cotton several months later. Ginning companies experienced historic levels of debt as they paid farmers the guaranteed price, requiring donor and government bailouts. This time period also coincides with the era in which West African countries and others (primarily Brazil) were engaged in political and legal disagreements with the United States and other developed countries over the effect that producer subsidies had on depressing world cotton markets.

By 2006, world cotton markets had recovered from their historic lows in 2002, and by 2010 had reached near historically high levels (Figure 6). NRA values once again became minus indicating high levels of taxation – as low as minus 63 percent in 2011 (Figure 8). However, during this period producer groups had gained substantially more bargaining power. Beginning in 2006, the guaranteed price was negotiated with direct input from producer groups. The use of a cotton supplement was introduced, which enabled producers to be paid an additional amount should world prices increase after ginned cotton was sent

to market. Over the past few years, prices have fallen somewhat, leading once again to increased NRA values.

As implied by the preceding discussion on NRAs, ginner rents have been one of the major factors preventing world price movements from reaching Burkinabe cotton producers, with substantial rents often extracted by the national cotton companies (Figure 9). The evolution of this ginner rent proceeds directly from the definition of NRA–ginning rent is equal to the world cotton price less the upstream costs of ginning, shipping, and purchase at the farm gate. Rents are illustrated in Figure 9 as the distance between the world price (Cotlook A Index) and the vertical summation of the four upstream cost curves: "Seed cotton", "Ginning", "Inland transport", and "FOB to CIF". The magnitude of the ginner rents corresponds, generally speaking, to the periods discussed in the previous subsection. The largest rents were generated in the post–Independence (1970–1984) and 1994 currency devaluation (1994–1998) periods, when rents averaged US$63 million and US$122 million per year, respectively (Figure 9). These were periods of heavy taxation that the donor and development communities have continued to reference as evidence to support parastatal reform and greater equity among the cotton sector stakeholders. Rents were lowest in the 1980s and during the cotton sector crisis when world cotton markets collapsed, including several years when ginning rents turned negative. During the 1980 price collapse, rents averaged US$15 million and during the cotton crisis, cotton returns averaged minus US$22 million (Figure 9). Negative rents correspond to years of unexpected price movements when the world price received by the ginning company falls precipitously from the time that the guaranteed price paid to producers is announced (prior to planting) and ginned cotton is sold on the world market several months later. More recently, world cotton prices have exhibited higher price volatility, which has coincided with higher producer prices due to their increased bargaining power. This has created both extremely high cotton rents, as well as a few years of negative returns. The calculated ginning rent reached its peak in 2010, surpassing US$700 million. This was created by the historically high world cotton price in 2010, US$3.00 per kg, and is most likely an anomaly rather than a trend, since ginning rents returned to more normal levels in the subsequent two years (Figure 9). This type of turbulent economic performance is likely to continue, and provides more evidence for the stakeholders to adopt a more flexible pricing and marketing mechanism. Such a mechanism would reduce the losses associated with contracting domestic producers at guaranteed prices so far in advance of the sale of cotton lint on world markets. This would require producers managing more risk, and could include the use of forward contracting, hedging, and futures options as marketing alternatives to spot markets.

Figure 9. Evolution of Burkinabe cotton producer prices and rents accruing to ginning companies (1970–2014)



Source: Author's calculations based on Baffes (2007); World Bank (2015); the Cotton Outlook (various years); and FAOSTAT (various years).

Of course, the existence of ginner rents in and of themselves is not necessarily negative for the industry as a whole, provided that those rents are reinvested in the sector. Unfortunately, whether or not national cotton companies have invested this surplus in a socially responsible manner has been a matter of contention in the sector, with frequent feuding between producers and ginning companies. Donors have also been critical of the concentration of economic surplus within the ginning industry, especially during periods of financial bailouts. On the positive side, cotton–producing zones are comparatively better developed, as cotton companies have often built paved roads and provided other infrastructure at the village and provincial level. Likewise, investments in cotton technology have advanced yields at an impressive rate compared to the performance of non–cash crops such as sorghum and millet. Research and development has resulted in cotton varieties that are well–adapted to local conditions, and extension services have been successful in introducing animal traction and other improved farming techniques that benefitted not only cotton but also cereal crops. Cotton companies have also introduced maize as a rotation crop, which has greatly increased food production since the mid–1980s by providing farmers with a more productive crop than the traditional cereals, sorghum and millet. Still, despite these investments, issues of mismanagement, lack of transparency, and at times corruption have long plagued the national cotton companies, resulting in donor intervention, calls for structural reform, and the rise of producer groups to improve bargaining power.

In conclusion, given the highly centralized historical structure of West African cotton sectors, the presence of implicit producer taxation in Burkina Faso is unsurprising. Early on in the sector's development, this taxation could have been considered justified as a means to recoup the venture capital invested in promoting cotton production, establishing ginning facilities, and developing physical infrastructure. Once these investments are paid off, and as producers accumulate wealth and farming knowledge, they become more autonomous, less

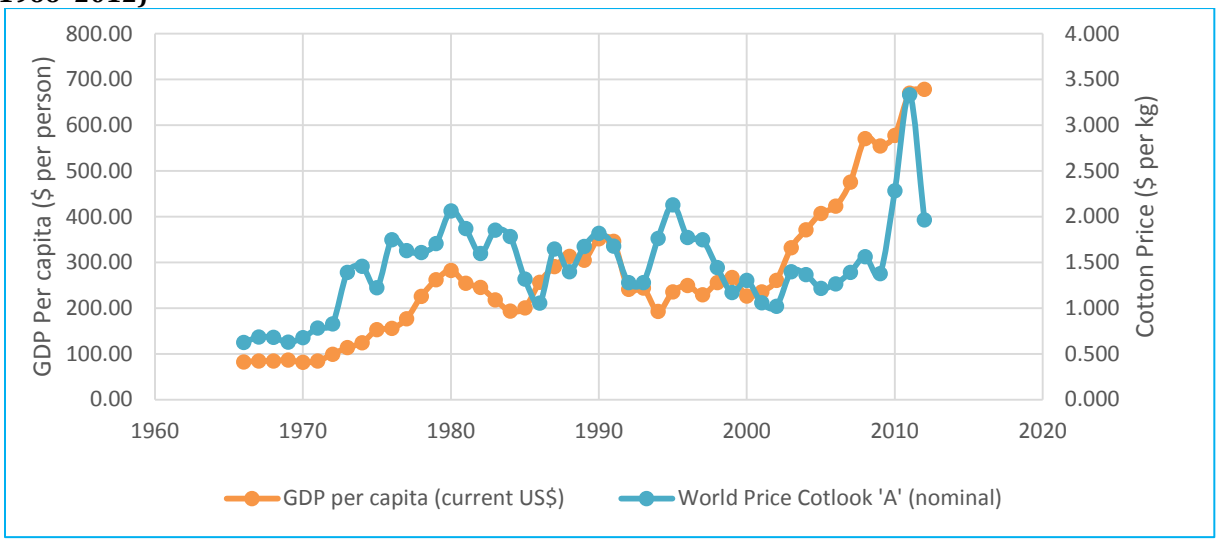
dependent on the ginning companies, and taxation becomes more difficult to impose on them. In Burkina Faso, the rise in power of the cotton growers' associations at the village and national levels has created increased bargaining power. Since around 2006, the announced cotton price paid to producers has been determined through formalized bargaining among producers, ginners, foreign investors, and government stakeholders. This has resulted in lower implicit taxation rates and, on average, greater producer shares of the world price. But in the future, the cotton sector needs to be prepared to face continued volatility on world cotton markets, placing into question the viability of a guaranteed price announced prior to planting. In that vein, there needs to be strong consideration regarding the development of a more flexible pricing mechanism (potentially including the use of futures markets, forward contracts, and hedging) to reduce the rollercoaster swings that have occurred in these markets–extremes of either windfall profits to ginning companies (when markets move unexpectedly higher) or bailouts (when markets unexpectedly fall, such that ginning companies cannot honor the guaranteed price) both have negative effects on producer welfare. The producer share of the world price and NRA have for the most part been improving over the past few decades. More often than not, however, positive movements in NRA and producer price share have been the result of unexpected world price declines that tipped the NRA and world price shares towards producers by coincidence rather than by design. In reality, producers' incomes showed little change when the NRA and world price measures both moved in their favor. Producers have fared better economically than the ginning companies over the past decade, as the low world prices have taken away the large rents that ginning companies had previously extracted. Severe financial distress has ensued in several years, requiring government and donor bailouts of the ginning companies. These trends placed pressure on the ginning companies to be more proactive in negotiating cotton prices with cotton producers. However, more flexible pricing mechanisms should have been put in place decades earlier to adjust prices paid to producers based on world cotton price movements and the prices actually received by ginning companies. Burkina Faso has too often experienced income transfers, usually to ginning companies, which resulted from market uncertainties that with proper marketing mechanisms (futures contracts, hedging, etc.) can be reduced and provide a more certain allocation of income for all stakeholders. This will require producers to accept more price risk and ginning companies to cede more of the world price than in the past.

c. How have cotton price changes affected economic growth

This section examines the channels through which cotton prices have had a significant effect on economic growth. This relationship is examined by focusing on a handful of periods when prices sustained trends that lasted for several years. With few exceptions, world price and Burkinabe economic growth have moved together periods of higher cotton prices led to increased economic growth whereas declining cotton prices lowered economic growth (Figure 10). However, such prima facie evidence requires further scrutiny since the GDP–price movements could be coincidental. Economic growth can be influenced by several other factors, including changes in terms of trade, macroeconomic effects (fiscal and donor investments), weather, pestilence, and output changes in other sectors such as mining, industry, manufacturing, and service. At the end of the report, the section concludes with a

quantitative analysis using time series to underscore the dynamics uncovered in the descriptive analysis.

Figure 10. Comparison of Burkinabe GDP per capita versus world price over the past few decades (1966–2012)



Source: based on data from the Cotton Outlook and the World Bank (various years).

Development economists typically argue that agriculture is the primary engine on which economies can begin to develop, and many have viewed cotton as an excellent crop on which economic development can be bankrolled and fostered. India is considered as one example of a country where linkages were developed to promote economic development in the rural areas first, followed by forward linkages to the urban sector through ginning, thread, cloth, and apparel industries. Throughout this process, cotton earnings are taxed and investments are made in either industrial or value–added sectors. Eventually, cotton production itself becomes the secondary sector, with the more stable industrial sector driving economic growth. This is, of course, a theoretical view whose development trajectories most countries do not follow. As discussed in this section, in Burkina Faso, constraints have limited the ability of the cotton sector to develop adequate forward linkages, and as a result, the economy remains overly dependent on cotton, mining activities, and food crops for economic growth. This has resulted in lukewarm growth compared to the Asian tigers, though cotton has enabled Burkina Faso's economy to grow at an accelerated pace compared to its neighbors. Summarizing the development literature and donor reports (World Bank, IBRD) from nearly five decades of findings, it appears that the effect of cotton on economic growth was greater in the 1980s, though it proved to be based primarily on an area expansion that could not be sustained. The following discussion examines how cotton's contribution to Burkina Faso's economic growth evolved through the decades.

1960–1970: High prices enabled agricultural investments

Following independence in the early 1960s through approximately 1970, both GDP and world cotton prices remained largely stable. World cotton prices fluctuated modestly between US$0.62 and US$0.68 per kg while Burkina Faso's GDP grew steadily at 2 percent

annually (Figure 10). Factoring in population growth, per capita GDP stayed essentially flat throughout the decade. The stagnant growth is partially explained by the lack of an industrial base in the post–colonial economy, as well as a severe drought that occurred during the last couple of years of the decade and lasted into the early 1970s[7] (World Bank, 1975). Drought in particular had a negative effect on cotton, as increased food prices and immediate concerns to satisfy home consumption needs shifted producers away from cotton during the drought period until food crop yields recovered in 1973 (World Bank, 1975). Elseways, more substantial economic growth would likely have occurred during this period. Agriculture, which accounted for 80 percent of the economy during this period, was gaining strength in the post–independence era, led primarily by cotton and to a lesser extent by livestock exports to coastal West African countries. Global cotton markets held steady during the decade and, coupled with the increasing yields, resulted in export earnings of nearly US$9 million for SOFITEX by the end of the decade. Cotton provided Burkina Faso with a needed source of hard currency and contributed to the development of the country's burgeoning industrial sector. Although the share of cotton exports in GDP was modest (between 5 and 8 percent), the largest component of Burkina Faso's GDP during this era (roughly 70 percent) was derived from home–consumed goods (principally subsistence food production), which provided little opportunity for monetary flows to the industrial sector (IBRD, 1964; World Bank, 1975).

High global cotton prices with little transmission to producers led to a ginning surplus during this post–independence era, which positively contributed to Burkina Faso's development efforts. The development plan of the Burkinabe government during this period targeted 4 percent GDP growth with investments focused primarily in rural development and infrastructure (68 percent of total investment), followed by industry (18 percent) and social services (14 percent) (World Bank, 1972; World Bank, 1975; Savadogo *et al.* 2004). Burkina Faso was heavily dependent on foreign aid and assistance to finance these investments, with foreign aid averaging about US$30 million per year by the end of the 1960s. Foreign aid, primarily from France but also from the United States and Germany, covered about three–fourths of all investments – an average of US$22 million per year (World Bank, 1975). Cotton's export earnings likely played an important role in the bi–lateral investment strategies since it was able to provide in–kind contributions and reduce aid packages by about one–fourth, garnering greater investment levels.

Industrial development efforts of the post–independence era period included the start–up of several parastatal firms in the agro–industrial and manufacturing sectors, including a cotton textile facility, VOLTEX, in Koudougou[8]. The industrial strategy during the 1960s was primarily import substitution, which created only marginal opportunities for economic growth, but served an important function by providing the necessary first steps

[7] Sparse rainfall began in 1968 and culminated in a severe drought in 1973. Agricultural production declined by 15 percent between 1969 and 1970, and by a slightly higher amount, 17 percent, between 1969 and 1972. The most severe drought occurred in the northern and central regions of the country, where both crop and livestock losses were reported. To make up the shortfall, food imports of 40 000, 60 000, and 100 000 tonnes were required from 1971 through 1973 (World Bank, 1975).

[8] Reports from this time period list the development of several industries that include sugar, rice, shoe making, etc. (IBRD, 1964)

for the modernization of Burkina Faso's economy. Although the GDP share of the secondary and tertiary sectors did not increase appreciably during the 1960s, IBRD (1972) noted that there was an identifiable increase in the industrial sector during the last few years of the 1960s, and a 5 percent increase in the industrial share of GDP. Moreover, the industrial sector grew much more rapidly in the 1970s (see next section). Hence, although cotton did not provide visible signs of economic growth during this decade, it did provide the financial underpinnings for future growth, and by the end of the decade, the sector had been praised by the international donor community as per its achievements in the economic progress[9] (IBRD, 1972). Even during this period, government planning and the international donor community recognized the dependence of the Burkinabe economy on agriculture. However the structural deficiencies in the macro economy prevented any sizeable shift in development strategy away from agriculture as the main economic driver. Planning was therefore focused on improving output through investments in agricultural research and the eradication of the tsetse fly (which causes river blindness) in the more fertile river valleys of the southwest, leading to a significant expansion in land available for agricultural expansion, including for cotton. The tsetse fly eradication project began a few years later in 1974 (World Bank, 1975).

1970's: Higher prices and rising GDP

The 1970s was a decade of prolonged GDP growth, aided by rising world cotton prices which rose in seven out of ten years (Figure 10). Between 1970 and 1979, per capita GDP grew at an annual rate of 4.2 percent in nominal terms. World cotton prices increased from US$0.68 per kg in 1970 to an historic peak of US$2.06 in 1980. While some of the cotton price increase was eroded by higher transportation and fertilizer prices due to the global energy crisis, this was a lucrative decade for the Burkinabe cotton sector. Cotton exports accounted for 45 percent of GDP during the decade, making cotton the leading export earner of the period (World Bank, 1975). Although substantial progress was made in developing the cotton sector following independence, through new technology introduction that generated significant yield increases and rapid area expansion, at times it often fell short of donor expectations. In 1975, the World Bank reported that ginning capacity was often only at 50 percent, and the impact of the 1968–1972 droughts likely continued to dampen producers' willingness to shift more definitively into cotton. Such concerns were only reduced after the cotton–sorghum rotation was introduced and sorghum production benefitted from the cotton–sorghum rotation, through residual fertilizer affects and greater access to fertilizer and other inputs, and hence provided cotton producers with greater food production than they would have under a sorghum monocrop (World Bank, 1984).

National development plans in the 1970s were similar to earlier ones in both scope and magnitude, but placed greater emphasis on agriculture and the rural areas, and targeted a slightly higher (nominal) growth rate of 6.5 percent (World Bank, 1975). In the Five Year Development Plan (1972–1976), the agricultural sector received the greatest priority with a 29.8 percent share of investments, followed by rural infrastructure (26.2 percent), industry

[9] The relationship between GDP growth and investment was estimated by IBRD during this period. Achieving a 3 percent growth rate in real per capita GDP would require annual investments of US$32 million (IBRD, 1972).

and manufacturing (20.6 percent), and social infrastructure (16.0 percent) (World Bank, 1975). Cotton was a prominent commodity in the development plans of the 1970's, including the Five Year Development Plan and associated projects that continued throughout the early 1980s (World Bank, 1984).

A primary objective of development throughout the 1970s was to promote cotton production by expanding settlement into the fertile river valleys in the southwest where river blindness (*onchocerciasis*) had been eradicated. This was a resettlement effort that in addition to increasing cotton production, helped to alleviate population pressure in the central and northern regions. Along the Black, White, and Red Volta River valleys, a total of 1.6 million ha were planned for development as part of the river blindness eradication program, of which about half was suitable for agriculture (World Bank, 1975). New technology was also introduced into cotton production, including animal traction, improved seed varieties, and more intensive use of inorganic fertilizers. The agricultural plan of the 1970s also targeted achieving food self–sufficiency and greater development of the livestock sector, both of which were shown to be vulnerable in the early 1970s drought (World Bank, 1975; World Bank, 1982). Food imports in this period often constituted 20 percent of total imports and were a particular drag on economic growth during the drought years. New technology was also introduced for the cereal crops, but except for the southwest cotton producing zone, most of the new technology employed on cereals (including animal traction, improved seeds, and chemical fertilizers) was not profitable and little uptake occurred (World Bank, 1982). The lack of profitability on cereal crops was primarily due to poor marketing conditions and limited access to credit that restrained producers' ability to leverage productivity gains into higher income. Noticeable progress was made, however, in improving water harvesting techniques on traditional cereal crops including the construction of micro–catchments that reduced runoff following rainfall events (Sander *et al.* 1996). These were particularly effective in the Sahel region where precipitation occurs only for a handful of times during the growing season. Irrigation was one new technology alternative proposed in the developments plans, aiming to achieve two grain harvests per year and double output to achieve 4 tonnes of food (sorghum or millet) per ha in each harvest. The cotton development projects also included construction of a 20 000 tonnes ginnery at Dédougou (World Bank, 1984).

Burkina Faso remained heavily dependent on foreign aid to finance its development projects, but cotton revenues also contributed. Between 1972 and 1976, development plan budgets averaged US$50 million per year – about 50 percent higher in nominal terms than the earlier development plan (World Bank, 1975). A substantial majority of the investments, about three–fourths, were loans financed by international (e.g. IBRD) and bilateral (e.g. French) donors (World Bank, 1975). Cotton export earnings were a substantial proportion of the domestic investment collected by the Burkinabe government to make up the remaining 25 percent of investment requirements of approximately US$12.5 million per year. Export earnings increased substantially in the last few years of the 1970s. Between 1972 and 1975, export earnings averaged about US$10 million, contributing about 20 percent to development investments (Figure 2). By 1976, cotton exports had reached US$25 million, and contributed about 50 percent to development investments (Figure 2). Reports from the time suggest that the investments made to settle the newly opened lands, primarily

in southwest around Banfora, were justified by the increased revenue they generated from cotton export earnings (World Bank, 1975). The ten year settlement project's cost, from the mid–1970s to mid–1980s, was estimated at US$150 million[10] (World Bank, 1975). Cotton exports during this period, which totaled US$175 million between 1976 and 1985, appear to have been sufficient to recover these large scale start–up costs. Investments in the industrial and manufacturing sectors were slightly lower than in agriculture over this period. Reports from the period indicate that about US$10 million per year were invested as part of the development plan between 1972 and 1976, which targeted primarily agro–processing industries such as sugar refining, vegetable oil and seed crushing plants, and textiles (World Bank, 1975).

Although linkages between cotton prices and economic growth can be identified throughout the 1970s, explicitly explaining economic growth in that decade by the movement of cotton prices is confounded by the complex movement of cotton export earnings. Revenue flows among the ginning company and the stakeholders lack transparency making it difficult to monitor (World Bank, 1975). Likewise, government's ability and/or willingness to collect taxes on the export earnings also appeared to have been lacking, resulting in only modest tax revenues (World Bank, 1975). Based on reports from the 1970s period, the Burkinabe government also had a poor track record of recovering revenue from the development investments made in the rural areas, including those investments targeting cotton such as the river blindness program. In fact, only about 10 percent of the export earnings appear to have been recovered by the government, and due to opaque record keeping, the whereabouts of most of the remaining export earnings was unknown.

While revenues were not flowing back into the government balance sheets as planned, the collected export earnings and revenue generated all along the cotton value chain, including farm income, still managed to have significant positive impacts on the national economy. World Bank reports demonstrated a willingness to accept weakness in the government's repayment of loans since the general consensus of the donor community was that the cotton surplus was still being put to economic use in some type of value–added enterprise (World Bank, 1975). In fact, the correlation between the cotton price and economic growth provides some empirical support to the idea that cotton revenues were being invested back into the economy, and perhaps they were put to better use by entrepreneurs in the rural areas rather than being directed into government treasury.

The composition of GDP stayed essentially constant during the decade, with agriculture maintaining roughly a 30 percent share throughout the 1970s. Given the country's growth rate over the decade, this constant share for agriculture means that the industrial and manufacturing sectors grew at a slightly faster pace than the agriculture and service sectors. However, even with modestly higher growth in the industrial and manufacturing sectors there is little evidence that the historical run–up in cotton prices

[10] Cost of CFAF 4-600 000 (US$1700–2400) to resettle a family on 8 ha of arable land under rainfed agriculture (World Bank, 1975). In Banfora, approximately 180 000 inhabitants were resettled.

generated a large transformation of Burkina Faso's economy, especially if compared to the tremendous growth in the Asian Tigers that was occurring at the same time.

Further economic development may have been limited by the continued dominance of the services sector, primarily comprised of low valued, informal enterprises such as street vending. The informal service sector has few forward linkages and correspondingly low economic multiplier values (World Bank, 1996). It is likely that the service sector maintained its dominant share of GDP due to the structural constraints that limited investments in the industrial and manufacturing sectors. Burkina Faso's industrial and manufacturing strategy was import substitution, a commonly followed strategy throughout the developing world at the time. Due to a variety of structural issues, including the problems of national ownership, low domestic savings and investment, high transportation costs to access international ports, and limited human capital development (formal education, vocational training), output from the industrial and manufacturing sectors was mostly destined for the domestic market and had limited export growth potential. Hence, while the cotton surplus was able to generate a modest level of increased domestic demand, consistent with the growth achieved in the 1970s by the industrial and manufacturing sectors, there were no innovative or export–driven investment opportunities that would have generated much higher GDP growth rates. Had such investment opportunities been available, the GDP share of agriculture and the service sector would have declined relative to the shares of the industrial and manufacturing sectors, creating a more diversified economy that was less dependent on agriculture as its primary source of growth.

1980–1990: Falling prices, recession, and recovery

The experience of the Burkinabe cotton sector in the 1980s provides a typical illustration of the negative consequences that can befall a commodity–dependent developing economy when commodity prices fall. Although Burkina Faso benefitted from rising prices in the 1970s, world cotton prices peaked in 1980. Cotton prices then fell until 1986, and during that time, the same economic forces that grew the Burkinabe economy when prices were rising contributed to an economic recession.

The world cotton price collapse in the early 1980s came at a particularly inopportune time for the Burkinabe cotton sector. The 1980s was a period when agricultural investments in expanding production had reached diminishing returns. Cotton yields had increased annually since independence in the early 1960s, but growth slowed through the 1980s and peaked at 1100 kg per ha in 1986. As yields began to decline, production was increased by expanding cotton area. The river blindness eradication program opened up new lands along the frontier in the fertile river valleys of the southwest, and cotton farming was introduced in many of these areas (World Bank, 1975). Area expansion was facilitated by animal traction, which greatly increased labor productivity over traditional manual farming techniques, but also enabled producers to expand onto marginal lands. Efforts to increase cotton output had only a minimal impact as the push onto marginal lands only added to yield stagnation, principally soil mining of nutrients and the buildup of pest pressure that occurs

after several years of cotton farming. By the mid–1980s land expansion in the frontier river valley areas had mostly ended (Figure 4).

The structural issues in the macro economy left the country particularly exposed to economic decline in the face of falling cotton prices: the industrial and manufacturing sectors remained highly dependent on domestic demand, but demand fell sharply in response to the decline in cotton exports. In the early 1980s, the industrial and manufacturing share of GDP each fell by about 3 percent, while the services sector grew to 50 percent of GDP. This provides further evidence of how dependent the industrial part of the economy was on agriculture and how the overall macro economy had struggled to modernize and innovate new products and services beyond the processing of raw agricultural products and domestic consumables. The increased ginning surplus appears to have been cycled into the informal service sector, presumably since the industrial and manufacturing sectors failed to provide adequate investment opportunities.

Towards the end of the decade, world prices rebounded in 1987 and increased in three of the next four years until reaching a short–term peak in 1990 (Figure 6). As prices rose, GDP recovered, again illustrating the important role that commodity prices played in the Burkinabe economy during this period by increasing domestic demand (Figure 10). Manufacturing and industrial shares of GDP returned to their previous levels, around 20 percent, and the informal services sector fell back to 42 percent of the total economy.

During this period, international donors, along with the development literature, began to argue that much of the ginning surplus was being mismanaged. The overvalued currency (FCFA) made imports cheap, and it was speculated that the surplus was misspent on imported items for the urban elite. Likewise, the government and parastatals were criticized for excessive salaries, lavish buildings, monuments, and other self–serving items. Such leakages further reduced opportunities for investments in the manufacturing and industrial sectors, and may have been a drag on the country's overall economic performance. Donors had been pushing for structural adjustment throughout the developing world beginning in the early 1980s to remedy macroeconomic issues of rampant government spending, inflation, and state control of industry. Reforming the cotton sector was in particular targeted as part of structural adjustment policies, with donors calling for the privatization of the parastatal ginning companies in Francophone West Africa. Structural adjustment was strongly largely resisted by developing countries throughout the 1980s, which led to increased tension between donors and host countries, including Burkina Faso.

1990–2000: Structural adjustment, falling prices, economic diversity, and devaluation

The 1990s was the first decade in which Burkina Faso's economy began to display greater resilience and less dependence on world commodity prices. After a decade of pressure from international donors, in 1991 Burkina Faso adopted a structural adjustment (SA) program (Strengthened Structural Adjustment Facilitating Programme – FASR) that targeted greater fiscal responsibility over the short–term and the privatization of nearly all of the major

industries (including cotton, electricity, telecommunications and airways) over the medium–to–long–term (Kakwani, 1995). Though never achieved in its entirety, by the end of the decade, the positive economic effects of SA on Burkina Faso's economy were evident. World cotton prices, which peaked around 1995, fell precipitously for the next decade. For the first few years, falling cotton prices once again contributed to an economic recession, as per–capita GDP declined by 45.1 percent in nominal terms between 1990 and 1994 (Figure 10). However, in the mid–1990s, the currency devaluation and the diversification/modernization of the Burkinabe economy from the 1991 SA program (implemented in 1994) revitalized the non–agricultural sectors and grew the economy for the latter part of the 1990s, even as world cotton prices continued to fall. Global cotton prices fell by 33.5 percent between 1994 and 1999, from US$1.76 to US$1.17 per kg, while nominal GDP still managed to increase by US$74.1, from US$193.1 to US$267.2 per capita, corresponding to a 38.3 percent increase (Figure 10). Positive GDP growth even occurred following the 1998 production year when pest problems contributed to 30 percent fall in cotton lint exports (Figure 2). Despite the poor export earnings, nominal GDP grew by 4.5 percent between 1998 and 1999. The cotton sectors, though remaining majority government–owned, transferred 30 percent ownership to the producers in 1999 and through improved operating efficiency and reduced operating costs were able to remain financially solvent even as the world cotton price plummeted throughout most of the 1990s. Hence, there is evidence that the combined effect of investments from previous decades of cotton earnings, as well as gold exports and other direct and indirect investments, helped create an economy that was sufficiently robust to overcome global commodity price weakness and continue economic growth throughout the 1990s.

2000–present

Over the past decade and a half, Burkina Faso's economy has clearly become much less dependent upon movements in cotton prices (Figure 1). Even with the global cotton price collapse of the early 21 century, which drew the ire of other emerging countries such as Brazil and Argentina, Burkina Faso was able to continue its economic expansion. Per capita GDP increased from US$227 to US$720 between 2000 and 2014 in nominal terms, equating to an average increase of 14.5 percent per year. The cotton sector contributed to the recent economic growth through improved policy, as part of SA, which fostered improved relationships between ginning companies and producers. Burkina Faso has hence been the most successful sector in the West Africa region in maintaining its cotton acreage and sustaining cotton yields, compared to neighboring countries such as Mali where management issues and poor relations between national ginning companies and producers has resulted in declining cotton acreage and yield stagnation. The commercial introduction of GM cotton, which began in 2009, has had a significant impact on cotton yields, ranging between 60 and 80 percent, and average yield increases of 22 percent. It has generated annual impacts ranging from US$80 to US$120 million per year (Vitale and Vognan, 2015). In an average year since 2009, the commercial use of GM in Burkina Faso has contributed to 12 percent of the annual growth in GDP. Hence, the relationship between economic growth and cotton price has become less tenuous, providing the Burkinabe macro economy with more increased stability and resilience from commodity price fluctuations.

Summary: Cotton's development contribution

This detailed description analysis of the evolution of Burkina Faso's economic growth and the role of the cotton sector in that growth suggests that cotton has, more often than not, been a net contributor to the Burkinabe macro economy, providing export earnings, employment, backward and forward linkages (agricultural inputs, transport, etc.) and, through rotational and spillover effects, greater food security (Savagado *et al.* 2004). Throughout the past five decades, cotton has also been the primary source of "monetized" income for both rural households and the government. As such, cotton production has played a vital role in household budgets, since a large proportion of agriculture's share of GDP is home–consumed (non–traded) subsistence crops, which, although necessary to rural livelihoods, are not liquid and cannot directly contribute to improved economic performance. Cotton also played a pivotal role in eradicating river blindness in the fertile river valleys, which greatly expanded agricultural production in cotton, subsistence crops, and livestock in those areas. Even when efforts to recover cotton export earnings into more formal investment channels failed, the evidence suggests that the cotton surplus was absorbed by the rural communities and at the very least provided modest returns through increased domestic demand, investments in service sector enterprises, and greater investments in social infrastructure (such as education and health).

While poor economic performance during a couple of periods can be blamed on poor management and inefficiency, the greater failure of the cotton sector to provide more visible and sustained economic growth is partially due to the fact that the industry has struggled to extract further downstream domestic value–added from thread, clothing or apparel. Considerable investments were made in the 1960s and 1970s to develop the textile industry (the VOLTEX plant at Koudougou, for example), but none of the mills ever became profitable (World Bank, 1975). Moreover, the Burkinabe economy has yet to undergo significant structural transformation, with its industrial and manufacturing shares of GDP remaining static over the past three decades. This has left the economy dependent on agriculture to generate growth, which is a challenge in Burkina Faso since agro–ecological conditions limit the use of high valued agriculture to cotton, and leaves agriculture subject to the risks of weather, pests, and world markets.

Time series analysis

Time series analysis is presented to provide empirical support for the relationship between GDP and global cotton prices, under the working hypothesis that global cotton prices have a significant effect on Burkinabe economic growth. In the time series domain, two variables such as global cotton price and GDP, are said to have a statistical relationship if they are cointegrated (Engle, 1987). This is an econometric term indicating that the two variables move together when disturbed from their mean levels as they evolve over time. In practical terms, times series typically requires using the first difference of variables, i.e. the change in value of the variable from one time period, so that the times series is stationary. This implies that the variable will have tendency to return back to its long term mean, rather than drift as

a "random walk". It is readily apparent from Figure 10 that neither time series is stationary since both series have a noticeable time trend. In such cases, the first difference of each time series are tested and then used in the Granger cointegration model, i.e. $\Delta GDP_t = GDP_t - GDP_{t-1}$ and $\Delta P_t = P_t - P_{t-1}$.

Statistical software packages such as SAS have well–developed approaches (such as PROC ARIMA and PROC VARMAX), to analyze times series variables and test for cointegration and Granger causality using Dickey–Fuller and related types of hypothesis testing[11]. When analyzed using PROC ARIMA, it was found that the GDP per capita and cotton price time series were both highly non–stationary, with augmented Dickey–Fuller tests of P=0.937 and P=0.928 (see Appendix). When taking first differences, however, each variable was found to be stationary, with augmented Dickey–Fuller tests of P<0.001 for both variables (see Appendix). Since the focus of this report was to establish a relationship between GDP and cotton prices, PROC VARMAX was used to test for Granger causality. If causality exists, under reasonable conditions it is implied that the two variables would also be cointegrated. Hence, using the first difference variables, the following econometric model was estimated using PROC VARMAX (see Appendix):

$$\Delta GDP_t = a + b_1*\Delta GDP_{t-1} + b_2*\Delta GDP_{t-2} + b_3*\Delta GDP_{t-3} + c_1*\Delta P_{t-1} + c_2*\Delta P_{t-2} + c_3*\Delta P_{t-3} + \Delta e_t \ ,$$

where a through c are the regression coefficients estimated by PROC VARMAX and e_t is the error term. Because the GDP and cotton price time series are stationary, the econometric model is solved using standard OLS techniques. PROC VARMAX tests for causality (testing the hypothesis that cotton prices have significant explanatory power on GDP) and provides results of the test using standard defined P values. PROC VARMAX is flexible enough so that the user can determine the number of time lags to include for the difference variables (auto and cross–regressive terms), and the error terms (moving average terms). When alternative econometric models were analyzed, the statistical fits and tests were best given a three period time lag and a single lag error term.

The annual changes in cotton price and GDP per capita follow a similar time trend (Figure 10). Since independence in the early 1960's, the annual change in cotton price has experienced about seven peaks, occurring for the most part once every three years. The peaks have been followed by subsequent price declines of approximately the same magnitude. Likewise, the annual change in GDP per capita also experienced roughly seven peaks since independence, most of which occurred once every three years. Those annual cotton price and GDP trends are evident in the regression model estimated by PROC VARMAX:

$$\Delta GDP_t = 4.590 + 0.049*\Delta GDP_{t-1} + 0.230*\Delta GDP_{t-2}\ 1.459\Delta P_{t-1} + 9.465*\Delta P_{t-2} \ ,$$

where only the constant and the second period lagged change in price were found to be significant (P<0.05) (see the Appendix for complete model results). According to the

[11] The SAS PROC ARIMA (autoregressive-integrated-moving average) statement can be used to test for co-integration of time series and the SAS PROC VARMAX statement can be used to test for Granger causality.

regression results, the annual change in GDP averages $US4590 million, and that change is significantly influenced by previous changes in cotton prices. The signs on the lagged GDP and cotton price regression coefficients are consistent with prior expectations. The lagged GDP coefficients are positive, as years with increased GDP would likely generate higher spending and investment (assumed proportional to ΔGDP) that would feed forward to the following year or two. Similarly, the coefficients on the lagged cotton prices are positive, indicative of how higher cotton prices in a particular year would likely increase investment opportunities that accelerates GDP growth in subsequent years. According to the model, higher cotton prices have a statistically significant effect on GDP two periods later, which is consistent with the cyclical patterns illustrated in Figure 10, as well as the previously discussed peaks that occur about once every three years. For example, a marginal cotton price increase of US$0.01 per kg in one year would be expected to result in an average GDP increase of approximately US$1459 million in the following year, and GDP growth of US$9465 million two years later. Hence, according to the model results, a marginal price increase in cotton would result in nearly twice the GDP gains compared to a scenario where prices remained unchanged. Burkinabe policy makers need to be aware of how sensitive their overall economy is to changes in cotton prices and how price shocks ripple over time. Given the shared importance of cotton with other export earners such as gold mining and livestock, the effect of changes in cotton prices on economic growth should also include those exports. Given the high degree of correlation among commodity prices, it is likely that time series analysis of the other food crops would show similar time dynamics.

Although this work has identified a link between cotton prices and GDP, further research is needed to clarify the complicated mechanisms through which the two are related. For example, other factors including oil prices, exchange rates, mining activities, crop yields, production area, donor investment, and government expenditures may provide additional explanatory power. Given the high significance of global cotton prices in the model found in this report, it is unlikely that the significance of global cotton prices would be substantially weakened.

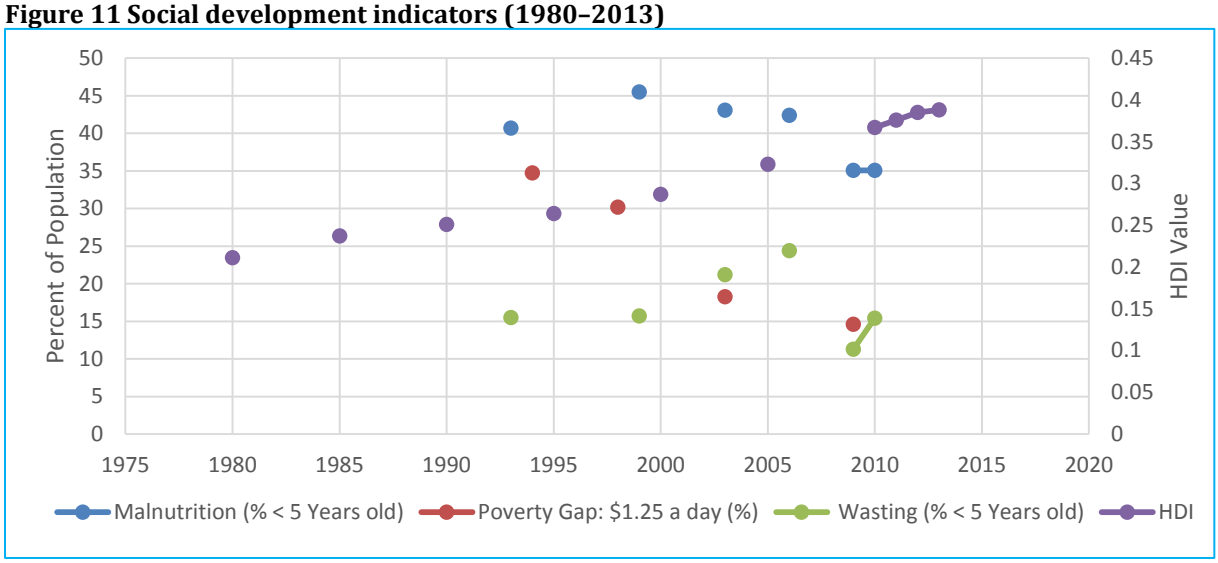
The effect of cotton price changes on poverty and food security

Although cotton prices seem to have had a positive relationship with Burkina Faso's GDP, GDP alone does not tell the full story of a country's socio–economic well–being. Economic growth, as measured by GDP, has not always translated into broader avenues of human and social development, particularly throughout SSA where wealth is often concentrated among urban and political elites, creating a substantial rural–urban divide. International donor agencies have thus stressed the need to reach beyond economic growth and monitor a comprehensive array of social and economic indicators to measure achievement in human development. The United Nations Human Development Index (HDI) is one of the most widely used measures that assesses human and social development across three main pillars of an individual's welfare: life expectancy, education, and income. Across time, the evolution of HDI indicates whether economic growth has been inclusive, signaling the level of success that a government's development policies have had on improving the welfare of its citizenry. Cross country comparisons can reveal whether countries with similar economic growth

rates and incomes have significantly different HDI values, a useful planning tool to identify policies that have promoted the greatest level of human development.

The upward movement in the HDI measures is a positive sign for Burkina Faso and reflects the increase in schooling, health and nutrition (through longer life expectancy), and income that has been achieved over the past few decades (Figure 11). Cotton has been a substantial contributor in these indices, as its decades of export earnings has fueled economic development as well as investments in the physical and social infrastructure.

Figure 11 Social development indicators (1980–2013)



Source: World Development Indicators, The World Bank, various years.

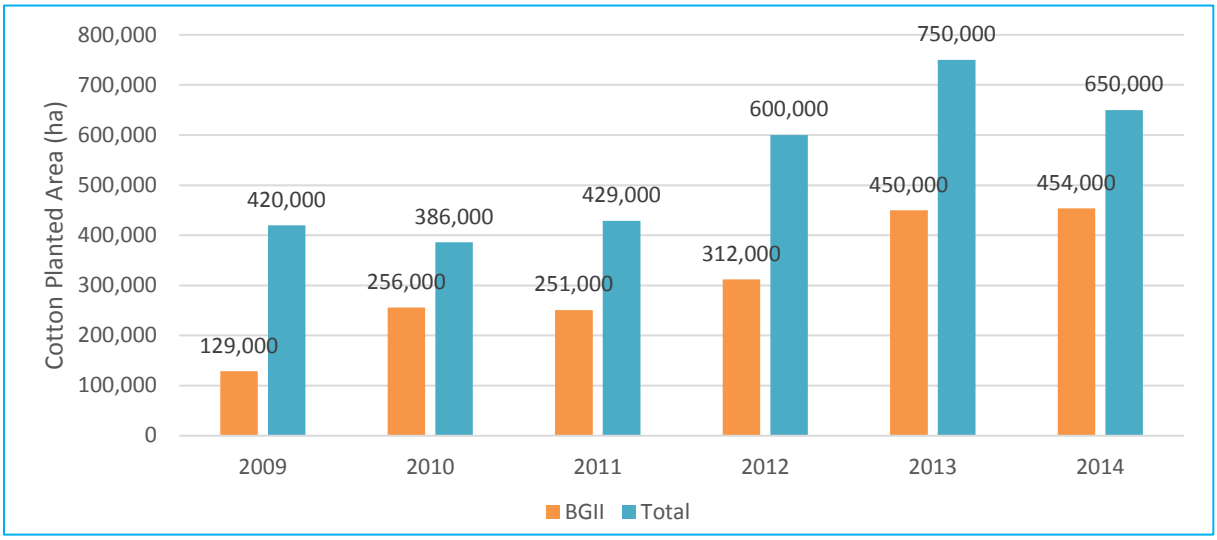
This report was able to gather a handful of additional development indicators that were not included in the HDI to assess how cotton prices have affected food security and poverty (malnutrition prevalence, poverty gap, wasting, and undernourishment). The food security and poverty dataset is not extensive enough to provide the same type of rigorous time series analysis as performed with the GDP in the previous section. However, as will be shown at a later stage, descriptive statistics are well equipped to provide meaningful insight into how cotton price changes have had an effect of food security and poverty reduction.

The adoption of Bt technology and inclusive growth in Burkina Faso

Unfortunately for this work, the commercial cultivation of Bt cotton in Burkina Faso (which beginned only in 2009) is too recent for sweeping conclusions to be drawn about its potential contribution to development and inclusive growth. However, evidence to date has suggested that, at the very least, the adoption of this new technology has been inclusive. Bt cotton has increased cotton farmer income in greater proportion compared to ginning companies and seed companies. Bt cotton has also improved the competitiveness of Burkinabe exports on the world market. As of 2014, the adoption of Bt cotton had already approached 80 percent of total planted area – the level considered by many in the production literature as the long–term upper limit of new technology adoption (Figure 12). Bt cotton has significantly and consistently outperformed conventional cotton in each of the six years of commercial

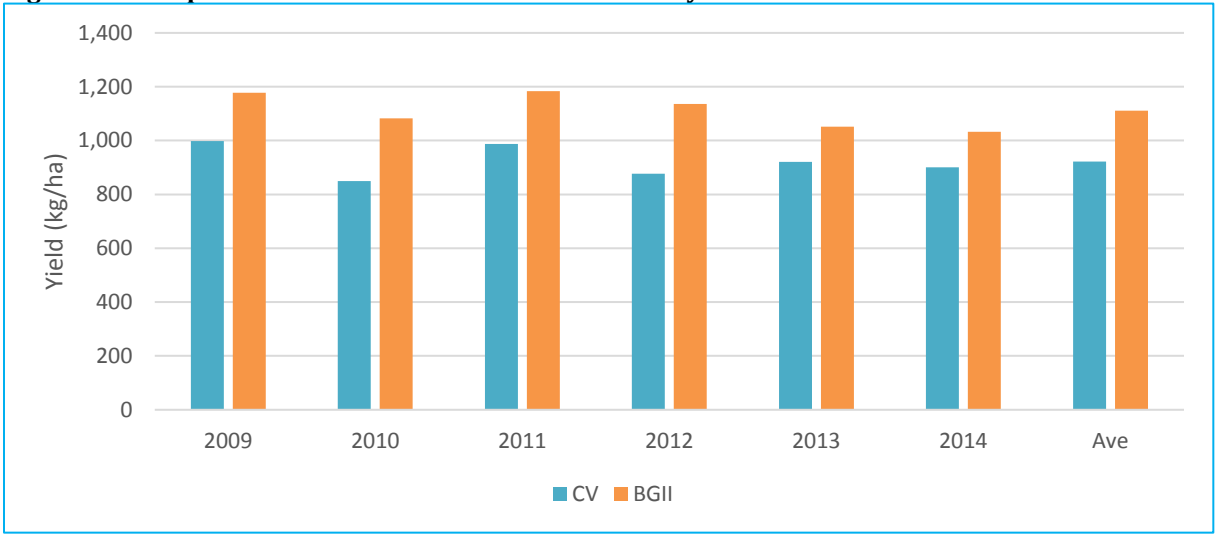
production, with yield increases that averaged 20 percent per year (Figure 13). The widespread adoption of the technology, combined with its improved yield performance, has translated to higher cotton production for the average Burkinabe cotton farmer. At the same time, the technology has allowed for reduced expenses on inputs, which has reduced average producer costs. At the producer level, higher production combined with lower costs has raised average producer returns, leading to improved overall household welfare. At the aggregate country level, higher production (as a result of the significant yield increase) has translated to greater cotton exports – which has helped Burkinabe cotton ginning companies to cope with lower global prices post–2011 – particularly when compared to neighboring countries that have yet to embrace biotechnology.

Figure 12. Adoption profile of Bt cotton in Burkina Faso



Source: Vitale and Vognan, 2015.

Figure 13. Comparison of Bt versus conventional cotton yields in Burkina Faso



Sources: Vitale and Vognan, 2015.

III. Policy implications and conclusions

Cotton has often been one of the most important cash crops in developing economies, providing needed export earnings that can be used to generate economic growth in industrial and service sectors (Wang and Chidmi, 2009). The case in Africa, however, is mixed, with success appearing more elusive, including numerous cases in both East and West Africa where countries have shifted in and out of cotton numerous times over the past century (Tumusiime *et al.*, 2014). The recent "cotton problem" and depressed world prices has plagued many African cotton producers and left them at a crossroads, deciding whether incentivizing cotton production should remain a viable policy option (Baffes, 2007).

Burkina Faso provides an empirical case illustrating that cotton can be a strong contributor to economic growth, but it is not a magic bullet. Over the past few decades, one can point out several contributions that cotton has made to economic growth in both the rural and urban areas. Even at its peak, however, cotton's share of Burkinabe GDP never surpassed 10 percent and was unable to counteract the large imports that Burkina Faso had grown dependent on, including food and energy. The poor terms of trade from an overvalued currency and high transport costs eroded the cotton surplus, resulting in a dependence on foreign aid to finance investments for economic development. This level of agricultural surplus from cotton production is too low to generate enough economic growth in value–added sectors to enable Burkina Faso to takeoff into a developed country. Countries that have successfully taken off based on export driven agriculture and/or resource extractive growth strategies have had export shares of GDP reaching 50–60 percent (FAO, 2012). Hence, any cotton development strategy needs to be developed in conjunction with other enterprises to provide adequate export earnings as well as those that reduce imports. To this end, agricultural planners need to identify complementary production systems that increase cotton output while increasing staple food production, or at least maintaining it at current levels. Potential gains from cotton exports are quickly eroded if cotton crowds out food production in countries where food imports are required to satisfy domestic subsistence.

One issue potentially restraining economic growth is a lack of economic diversification. Both within the cotton sector and in the greater economy, diversification is a challenge that has yet to be adequately addressed. Clearly, the same challenges that were present following independence, when autonomy brought optimism for economic growth, are still present today (landlocked, lack of human capital, inadequate governance). Agriculture is still counted on as the country's primary engine of economic growth – a strategy that has worked in many developing countries, but one that has been constrained in Burkina Faso due to the Sahel's agroecological conditions. Frequent drought and struggles to improve productivity have made it difficult for the sector to create an agricultural (i.e. cotton) surplus that can be invested in the wider economy.

Burkina Faso has made noticeable gains in reducing poverty over the past few decades, yet several key–social development indicators remain critically low, even when compared to other countries in the region. Moreover, most of the gains came from improvements in urban areas. For instance, despite the real economic growth achieved in

the late 1990's, poverty increased slightly between 1994 and 1998 (IMF, 2000). While the cotton production cannot single handedly transform rural livelihoods, it still should be able to assist in improving education and human capital formation. A forward–thinking cotton sector, which has been demonstrated by its leadership in Bt cotton commercialization, should be able to leverage the human capital of the rural communities as it strives to maintain competiveness with the rest of the world. This will likely include transforming production to more efficient, mechanized agriculture. As it does, it should include the rural communities in this process, making sure to provide meaningful employment rather than displacing them with technology. Establishing agricultural engineering and technology colleges similar to those in the United States so that the rural population can continue to obtain livelihoods from agriculture, even if employment in primary production is no longer available, is one way to support agricultural livelihoods. A transformation to a cotton sector from its current practices based on a large supply of inexpensive labor to a more modern, science–driven and value–added sector would continue to employ significant proportions of the population.

Despite the obstacles against development noted in this report, new technology and policy tools could ensure that cotton price changes, in either direction, can provide benefits to raise economic growth, reduce poverty, and increase food security. Agriculture–led economic growth flourishes when it is technology–driven, reduces production costs and improves labor productivity. Developing economies like Burkina Faso have often been stuck in macroeconomic quagmires since their agricultural base focuses primarily on subsistence agriculture. In addition to being highly dependent on weather, growth rates in such a scenario are primarily based on rising yields and domestic demand. It is perhaps not surprising, then, that economic growth has been limited given stagnant yield growth and domestic demand growth that is based largely on population trends. Efforts have been ongoing, by both the public and private sectors, to improve cotton yields and introduce other technological innovations to reduce production costs and make cotton more profitable. These trends must continue in order to maintain growth in agriculture and to provide investment opportunities for other sectors where higher returns are achievable. Hence, for the time being, agriculture production is likely to maintain a large share in GDP, but should do so with a highly productive base in cotton and the subsistence cereal crops. Over time, the share of agriculture will decline somewhat, but with continued investments in value–added activities its share of GDP should level off around 20 percent, similar to developed countries.

GM cotton has already illustrated how introducing modern technology can increase yields. Further gains can be achieved by using herbicide tolerant GM varieties. The long–term success of GM cotton will also require continued updating of the cotton variety used to insert the GM traits, and biosafety monitoring to prevent unintended environmental consequences**.** Further investments in irrigation infrastructure could also improve productivity and be growth–promoting. The southwest production zone of Burkina Faso in particular contains possibilities for improved water management and irrigation. Investments of this type could provide producers with a second season that could be used to grow additional food crops, including winter crops such as wheat, as well as increasing the area of cotton in the primary season**.** Another technological advancement that would be beneficial to the Burkinabe cotton sector by increasing labor productivity is mechanization. Rural labor is continually being

pulled into urban areas. Today's millennial generation, with greater access to urban areas, is less likely to stay on–farm earning agricultural wages of US$2 per day, especially when confronted by labor–intensive activities like cotton picking and hand weeding. Greater use of mechanical power, even based on small 25 HP tractors, is expected to be an alternative increasingly used on Burkinabe cotton farms.

Technological advancement of the industry would also benefit from significant investments in human capital and research institutions. These investments would strengthen the sector's productive capacity and meet the challenges it faces over the coming decades. As noted above, the Burkinabe cotton sector needs technological breakthroughs to cut production costs and improve labor productivity. To achieve these goals, a well-educated and trained corps of agricultural scientists to prescribe agronomic and entomologic treatments is needed. In this context, particular emphasis should be placed on Burkinabe scientists attaining advanced degrees needed to develop GM crops, which will require developing and monitoring phytosanitary and biosafety protocols and other legal statutes.

Future success of the cotton industry depend on continued reform to the industry's structure. Reforming the institutional structure of ginning industries has resulted in only limited, and typically fleeting, degrees of success. While the long history of government rent–seeking in the cotton sector has for the most part ended, continued monitoring of ginning efficiency and management practices will be required. This should include improved marketing strategies to manage risk, better use of cotton by–products, and as appropriate increasing domestic capacity in the textile and apparel industries.

Increased regional specialization could provide an opportunity for the Burkinabe cotton industry. If recent trends continue, it is conceivable that specialization will occur within the West African region. Mali, which has struggled with its cotton sector, has continued to make substantial in–roads in its food sector. Burkina Faso could develop into a specialized cotton sector while Mali transforms itself into a food basket for West Africa. Burkina's cotton company SOFITEX could be positioned to take over the Mali cotton sector in the Sikasso region, as agronomic and socio–economic conditions are similar. Likewise, it is possible that Mali's cereal sector could begin to market its seed or other technology components in Central and Northern Burkina Faso, as well as other countries with similar agroecological zones such as Niger.

Concluding Remarks

Cotton has been one of the more successful agricultural crops in West Africa over the past few decades. The mixed success of cotton elsewhere in Africa, and the emergence of structural, marketing, and production issues over the past several years, has led many countries to question cotton's role in their development plans. Burkina Faso's cotton sector has emerged as a working model of how those problems can be overcome and cotton sustained well into the 21 century. Although government ownership and control remains stronger than initially envisioned by the SA, the essence of reform has been achieved by virtue of their openness and willingness to innovate and conform to change. The commercial

introduction of GM cotton is perhaps the best example of their progressive approach. Burkina Faso broke free from strong regional aversion to biotechnology, and succeeded in placing the needs of their producers and ginning companies in front of political affiliations. The smallholder community of cotton farmers, which produce virtually all of Burkina Faso's cotton, have been given equal status among the industry's stakeholders, and pricing policies have shifted much closer to competitive outcomes than in the past. Cotton remains an economically viable crop that has not been crowded out by food crops, an on–going trend in the region.

Cotton should continue to play a significant role in Burkinabe agriculture. The future success of agriculture–led growth from cotton will depend not only on continued advancements in productivity, but more importantly improved forward linkages to the industrial and service sectors. To accomplish this, future research should investigate more specifically industries and enterprises that would be available for generating the economic growth in the rural and urban areas once an agricultural surplus is generated. This will be a challenge since the parastatal traditions in Burkina Faso and throughout the Sahel have created an opaque business environment that has only modestly improved since the SA. This would include identifying commercial industries targeting rural areas for the processing and manufacturing of agricultural products, including a modernization of cotton byproducts such as cotton oil and cotton seed as well as the commercialization of cereal crops (maize, sorghum, and millet) grown in the cotton rotation.

References

Abate, T., van Huis, A. and Ampofo, J. 2000. Pest Management Strategies In Traditional Agriculture: An African Perspective. *Annu. Rev. Entomol.* 45: 631–659.

Anderson, K. and Masters, W. (Eds.). 2009. Distortions to Agricultural Incentives in Africa. World Bank. Washington, DC. Available at: http://siteresources.worldbank.org/INTTRADERESEARCH/Resources/544824-1146153362267/Africa_e-book_0309.pdf. Accessed Oct. 29, 2015.

Ajayi, O. C. and Waibel, H. 2003. *Economic Costs of Occupational Human Health of Pesticides among Agricultural Households in Africa*. Paper presented at the conference on Technological and Institutional Innovations for Sustainable Development, Gottingen, Germany, October 2003.

Aronson, A. I., Beckman & W., Dunn. 1986. Bacillus thuringiensis and related insect pathogens. Microbiol*. Rev.* 50: 1–24.

Baffes, J. 2007. Distortions to Cotton Sector Incentives in West and Central Africa. Agricultural Distortions Working Paper 48526, World Bank.

Baffes, J., Badiane, O., Nash, J. 2004. *Cotton: Market structure, policies and development issues*. Presented at the WTO African Regional Workshop on Cotton, Cotonou, Benin, March 2004.

Baquedano, F. G., Sanders, J. H. & Vitale, J. 2010. Increasing incomes of Malian cotton farmers: Is elimination of US subsidies the only solution?. *Agricultural Systems* 103: 418–432.

Banwo, O. O., Adamu, R.S. 2003) Insect pest management in African agriculture: challenges in the current millennium. *Arch Phytopathol Plant Prot* 36(1):59—68.

Bassett, T. 2001. *The Peasant Cotton Revolution in West Africa Cote D'Ivoire, 1880–1995*. Cambridge, Cambridge University Press.

Bates, R. H. and Block, S. A., 2009. *Political Economy of Agricultural Trade Interventions in Africa.* Agricultural Distortions Working Paper 50302, World Bank.

Drafor, I. 2003. Pesticide Use and Consumer and Worker Safety: Experiences from Kenya and Ghana. Paper presented at the 25th International Agricultural Economics Conference, Durban, South Africa, August 2003.

FAO. 2004. "The Impact of Cotton Sector Support on Developing Countries: A Guide to Contemporary Analyses." FAO, Rome, September. Available online: ftp://ftp.fao.org/docrep/fao/007/y5533e/y5533e01.pdf. Accessed 25 October 2017.

FAO. 2012. The role of agricultural growth in economic growth, and poverty and hunger reduction. Chapter (unnumbered) in the report The State of Food Insecurity in the World: Economic growth is necessary but not sufficient. Annual report published by Food and Agricultural Organization (FAO). Rome. Pages 28–35.

Engle, R. F. and Granger, C. W. J. 1987. Co–integration and Error Correction: Representation, Estimation and Testing. *Econometrica*. 55: 251–276.

Gilbert, C.L. and C.W. Morgan. 2010. Food Price Volatility. *Philosophical Transactions of the Royal Society B-Biological Sciences* Vol. 365 (1554): 3023-3034.

Greenplate, J., Mullins, J., Penn, S., Dahm, A., Reich, B., Osborn, J., Rahn, P., Ruschke, L. and Shappley, Z. W. 2003. Partial characterization of cotton plants expressing two toxin proteins from Bacillus thuringiensis: Relative contribution, toxin interaction, and resistance management. *Journal of Applied Entomology* 127: 340–347.

Hulme, P. 2005. Adapting to Climate Change: Is There Scope for Ecological Management in the Face of a Global Threat? *Journal of Applied Ecology* 42: 784–794.

IBRD. 1964. The Economy of Upper Volta. World Bank report. Washington, DC. Available at: http://documents.worldbank.org/curated/en/341011468236068515/pdf/multi0page.pdf Accessed Oct. 29, 2017.

ICAC. 2007. *ICAC 2007 Cotton Price Model*. Available at: https://www.icac.org/cotton_info/publications/press/2007/pr_august_07_price_model.pdf. Accessed Oct. 29, 2017.

IMF, 2002. Burkina Faso: Staff Report for the 2000 Article IV Consultation and First Review Under the Poverty Reduction and Growth Facility. MF Staff Country Report No. 00/86. International Monetary Fund, Washington, DC. Available at: https://www.imf.org/external/pubs/ft/scr/2000/cr0086.pdf.

Kakwani, N. 1995. Structural adjustment and performance in living standards in developing countries. *Development and Change*, Vol. 26(3), 469–502.

Liebhardt, J. 2005. *White gold or fool's gold: what will a rollback of U.S. cotton subsidies mean for farmers in Burkina Faso?* Multinational Monitor 26, No. 5–6.

MacIntosh, S. C., Stone, T. B., Sims, S. R., Hunst, P. L., Greenplate, J. T., Marrone, P. G., Perlak, F. J., Fischhoff, D. A. & Fuchs, R. L. 1990. Specificity and Efficacy of Purified Bacillus thuringiensis Proteins against Agronomically Important insects. *Journal of Invertebrate Pathology* 56: 258–266.

Martin, T., Chandre, O. & Vaissayre, M. 2002. Pyrethroid Resistance Mechanisms in the Cotton Bollworm Helicoverpa Armigera (Lepidoptera: Noctuidae) from West Africa. *Pesticide Biochemistry and Physiology* 74: 17–26.

MAFAP. Barreiro-Hurle, J. and Witwer, M. 2013. MAFAP Methodological Implementation Guide: Volume I. Analysis of price incentives and disincentives. MAFAP Technical Notes Series. FAO, Rome, Italy.

Maumbe, B. M. and Swinton, S. M. 2003. Hidden Health Costs of Pesticides Use in Zimbabwe's Smallholder Cotton Growers. *Social Science and Medicine* 57: 559–1571.

McMillian, D., Sanders, J., Koenig, D., Akwabi–Ameyaw, K., Painter, T. 1998. New Land is not Enough: Agricultural Performance of New Lands Settlement in West Africa. *World Development* 26: 187–211.

National Cotton Council (NCC). 2003. Major Factors Affecting World Cotton Price Behavior Prepared in Response to Brazil's WTO Challenge of the U.S. Cotton Program (Executive Summary). Available at: https://www.cotton.org/issues/2005/upload/WorldCottonMarket.pdf.

OECD. 2006. *The Development Dimension Cotton in West Africa: The Economic And Social Stakes*. Available at: http://www.oecd.org/dev/insights (Accessed on 31 May 2011).

Oerke, E. C. 2002. *Crop Losses due to Pests in Major Crops*. Wallingford, UK: CAB International.

Oerke, E. C. 2006. Centenary Review Crop Losses to Pests. *Journal of Agricultural Science* 144: 31–43.

Oerke, E. C., Dehne, H., Schönbeck, F. & Weber, A. 1999. Crop Production and Crop Protection – Estimated Crop Losses in Major Food and Cash Crops. Amsterdam, Netherlands: Elsevier.

Perlak, F. J., Deaton, R. W., Armstrong, T. A., Fuchs, R. L., Sims, S. R., Greenplate, J. T. & Fischhoff, D. A. 1990. Insect Resistant Cotton Plants. *Bio/Technology* 8: 939–943.

Pimentel, D. 1993. Climate Changes and Food Supply. *Forum for Applied Research and Public Policy* 8: 54–60.

Roberts, R. L. 1997. *Two worlds of cotton: Colonialism and the regional economy in French Sudan, 1800–1946*. Cambridge, U.K.: Cambridge University Press.

Savadogo, K., Couilbaly, S. and C. McCracken. 2004. Analysing Growth in Burkina Faso Over the Last Four Decades. African Economic Research Consortium Growth Working Paper No. 4. Nairobi, Kenya. Available at: http://dspace.africaportal.org/jspui/bitstream/123456789/32041/1/BurkinaFaso.pdf?1. Accessed Oct. 29, 2017.

Schnepf, R. 2005. *Background on the U.S.-Brazil WTO cotton subsidy dispute*. CRS Report for Congress, July 11.

Sheperd, C. and Delpeuch, A. L. B. 2007. *Subsidies and Regulatory Reform in West African Cotton: What are the Development Stakes?* Groupe d'Economie Mondiale at Sciences-Po Policy Brief GEMPB-2007-01, February.

Sanders, J. H., Shapiro, B. I. & Ramaswamy, S. 1996. *The Economics of Agricultural Technology in Semiarid Sub–Saharan Africa.* Baltimore, Md.: Johns Hopkins University Press.

Speirs, M. 1991 Agrarian Change and the Revolution in Burkina Faso. *African Affairs* 90: 89–110.

Schwartz, A. 1996. Attitudes to cotton growing in Burkina Faso: Different farmers, different behaviours. In *Economics of agricultural policies in developing countries*, eds. Benoit-Cattin, M., Griffon, M., & Guillaumont, P. Paris: Revue Française d' Economie. Pages: 341-363. Available at: http://www.documentation.ird.fr/hor/fdi:010009872.

Teft, J. 2004. Building On Successes in African Agriculture Mali's White Revolution: Smallholder Cotton From 1960 to 2003. *International Food Policy Research Institute Policy Brief.*

Toe, A. 2003. *Limites Maximales de Résidus de Pesticides Dans les Produits Agricoles d'exportation Dans trois pays du CILSS–Etude du Burkina Faso.* Bamako, Mali, FAO/CILSS.

Traoré, D., Héma, O., Ilboudo, O. 1998. Entomology and Phytosanitary Experimentation. *Entomologie et expérimentation phytosanitaire. Rapport annuel campagne agricole 1998–1999*. Annual agricultural report for the period of 1998–1999. Bobo Dioulasso, Burkina Faso: INERA. 1998.

Vaissayre, M., Cauquil, J. 2000. *Principaux Ravageurs et Maladies du Cotonnier en Afrique au Sud du Sahara.* Paris, France, CIRAD.

Vitale, J. and G. Vognan. The Socio-Economic Impacts of GM Cotton in Burkina Faso: Results of Five Years of Field Surveys. A selected paper presented at The 19th International Consortium on Agricultural Biotechnology Research Conference. Ravello, Italy. June 16-19, 2015.

Vognan, G., Ouédraogo, M.,Ouédraogo, S. 2002. *Description de la filière cotonnière au Burkina Faso. Rapport intermédiaire* Description of the cotton system in the Burkina Faso region. Intermediary report. Institut de l'Environnement et de Recherches Agricoles (INERA). Bobo Dialasso, Burkina Faso.

Wang, Q. and Chidmi, B. 2009. Cotton Price Risk Management across Different Countries. Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Atlanta, Georgia. January 31–February 3, 2009.

World Bank. 1972. *World Bank atlas 1972: population, per capita product and growth rates*. Washington, DC: World Bank. Available at:

http://documents.worldbank.org/curated/en/229221468336682848/World-Bank-atlas-1972-population-per-capita-product-and-growth-rates. Accessed Nov. 1, 2017.

World Bank. 1975. *World Bank annual report 1975.* Washington, DC: World Bank. Available at: http://documents.worldbank.org/curated/en/814771468764420120/World-Bank-annual-report-1975. Accessed Nov. 1, 2017.

World Bank. 1982. World development report 1982. World Development Report; World Development Indicators. Washington, DC: World Bank Group. Available at: http://documents.worldbank.org/curated/en/948041468152100530/World-development-report-1982. Accessed Nov. 1, 2017.

World Bank. 1984. World Development Report 1984. New York: Oxford University Press. © World Bank. https://openknowledge.worldbank.org/handle/10986/5967 License: CC BY 3.0 IGO. Accessed Nov. 1, 2017.

World Bank. 1996. The World Bank annual report 1996. Washington D.C.; World Bank. http://documents.worldbank.org/curated/en/357461468137379235/The-World-Bank-annual-report-1996. Accessed Nov. 1, 2017.

World Bank. 1996. World Development Report 1996: From Plan to Market. New York: Oxford University Press. © World Bank. https://openknowledge.worldbank.org/handle/10986/5979 License: CC BY 3.0 IGO. Accessed Nov. 1, 2017.

World Bank. 2000. *The Administered Monopoly Model in the Era of Competition and Globalization*. Washington, DC, World Bank.

World Bank. 2004. *Cotton Cultivation in Burkina Faso - a 30 Year Success Story*. Paper presented at Global Learning Process for Scaling Up Poverty Reduction and Conference in Shanghai, May 25-27, 2004.

World Bank (2015). *Commodity Price Data: Pink Sheet*. Development Prospects Group, Washington DC.

Appendix

The following is the SAS program used to generate the time series analysis:

```
/* Input data */
/* THIS IS CONSTANT GDP */
data BF_gdp_ct_price_temp;
input t   BF_GDP_Curr      P_cott_world ;
datalines;
```

1960	189.9	.	1979	251.6	1.707	1998	334.5	1.445
1961	194.9	.	1980	247.9	2.062	1999	349.3	1.171
1962	204.1	.	1981	252.5	1.871	2000	345.6	1.302
1963	198.8	.	1982	269.9	1.597	2001	358.1	1.058
1964	200.5	.	1983	264.1	1.854	2002	363.0	1.019
1965	205.0	.	1984	252.9	1.785	2003	380.1	1.399
1966	202.9	0.625	1985	267.4	1.318	2004	385.7	1.366
1967	217.3	0.683	1986	281.3	1.056	2005	407.0	1.217
1968	220.2	0.679	1987	273.4	1.648	2006	419.9	1.266
1969	220.8	0.627	1988	281.8	1.399	2007	430.8	1.392
1970	217.3	0.676	1989	280.4	1.674	2008	448.8	1.563
1971	216.6	0.783	1990	271.4	1.819	2009	448.8	1.376
1972	217.7	0.827	1991	288.2	1.677	2010	472.8	2.282
1973	214.8	1.391	1992	281.2	1.278	2011	489.3	3.334
1974	228.4	1.459	1993	283.1	1.280	2012	506.1	1.964
1975	230.8	1.223	1994	279.1	1.763	2013	524.8	1.994
1976	245.8	1.748	1995	287.1	2.128	2014	530.8	1.822
1977	241.9	1.629	1996	310.0	1.773			
1978	247.9	1.607	1997	320.6	1.748			

```
;
proc print data=BF_gdp_ct_price_temp; run;
/* Dickey Fuller test on UnTrended GDP series Un Lagged  */
PROC ARIMA data=BF_gdp_ct_price_temp;
IDENTIFY VAR=BF_GDP_Curr
STATIONARITY=(ADF=(1,4));
Run;
/* Dickey Fuller test on UnTrended GDP series Lagged  */
/* Syntax ML_GDP_t(1) is the first differece in ML_GDP_t */
PROC ARIMA data=BF_gdp_ct_price_temp;
IDENTIFY VAR=BF_GDP_Curr(1)
STATIONARITY=(ADF=(1,2,3,4));
Run;
/*                */
/* World cotton price tests */
PROC ARIMA data=BF_gdp_ct_price_temp;
IDENTIFY VAR=P_cott_world
STATIONARITY=(ADF=(1));
Run;
/* World cotton price tests  */
PROC ARIMA data=BF_gdp_ct_price_temp;
IDENTIFY VAR=P_cott_world(1)
STATIONARITY=(ADF=(1));
Run;
/* If the P value for the Granger causality is <0.05 then there is causality with group 2 causing group
1 */
```

```
/* other wise no causality exists   and yes the order matters even in the two variable case */
proc varmax data=BF_gdp_ct_price_temp;
model  BF_GDP_Curr P_cott_world/ p=2 dify =(1);
      /* Test for Causality */
causal group1=(BF_GDP_Curr) group2=( P_cott_world);
run;
proc varmax data=BF_gdp_ct_price_temp;
model  BF_GDP_Curr P_cott_world/ p=4 dify =(1);
      /* Test for Causality */
causal group1=(P_cott_world) group2=( BF_GDP_Curr);
run;
```

The following is the SAS output generated by the above program:The SAS System

Obs	t	BF_GDP_Curr	P_cott_world
1	1960	189.9	.
2	1961	194.9	.
3	1962	204.1	.
4	1963	198.8	.
5	1964	200.5	.
6	1965	205.0	.
7	1966	202.9	0.625
8	1967	217.3	0.683
9	1968	220.2	0.679
10	1969	220.8	0.627
11	1970	217.3	0.676
12	1971	216.6	0.783
13	1972	217.7	0.827
14	1973	214.8	1.391
15	1974	228.4	1.459
16	1975	230.8	1.223
17	1976	245.8	1.748
18	1977	241.9	1.629
19	1978	247.9	1.607
20	1979	251.6	1.707
21	1980	247.9	2.062
22	1981	252.5	1.871
23	1982	269.9	1.597
24	1983	264.1	1.854
25	1984	252.9	1.785
26	1985	267.4	1.318
27	1986	281.3	1.056
28	1987	273.4	1.648
29	1988	281.8	1.399
30	1989	280.4	1.674
31	1990	271.4	1.819
32	1991	288.2	1.677
33	1992	281.2	1.278
34	1993	283.1	1.280
35	1994	279.1	1.763
36	1995	287.1	2.128
37	1996	310.0	1.773
38	1997	320.6	1.748
39	1998	334.5	1.445
40	1999	349.3	1.171
41	2000	345.6	1.302
42	2001	358.1	1.058
43	2002	363.0	1.019
44	2003	380.1	1.399
45	2004	385.7	1.366
46	2005	407.0	1.217
47	2006	419.9	1.266
48	2007	430.8	1.392
49	2008	448.8	1.563
50	2009	448.8	1.376
51	2010	472.8	2.282

Obs	t	BF_GDP_Curr	P_cott_world	Obs	t	BF_GDP_Curr	P_cott_world
52	2011	489.3	3.334	**54**	2013	524.8	1.994
53	2012	506.1	1.964	**55**	2014	530.8	1.822

The SAS System

The ARIMA Procedure

Name of Variable = BF_GDP_Curr

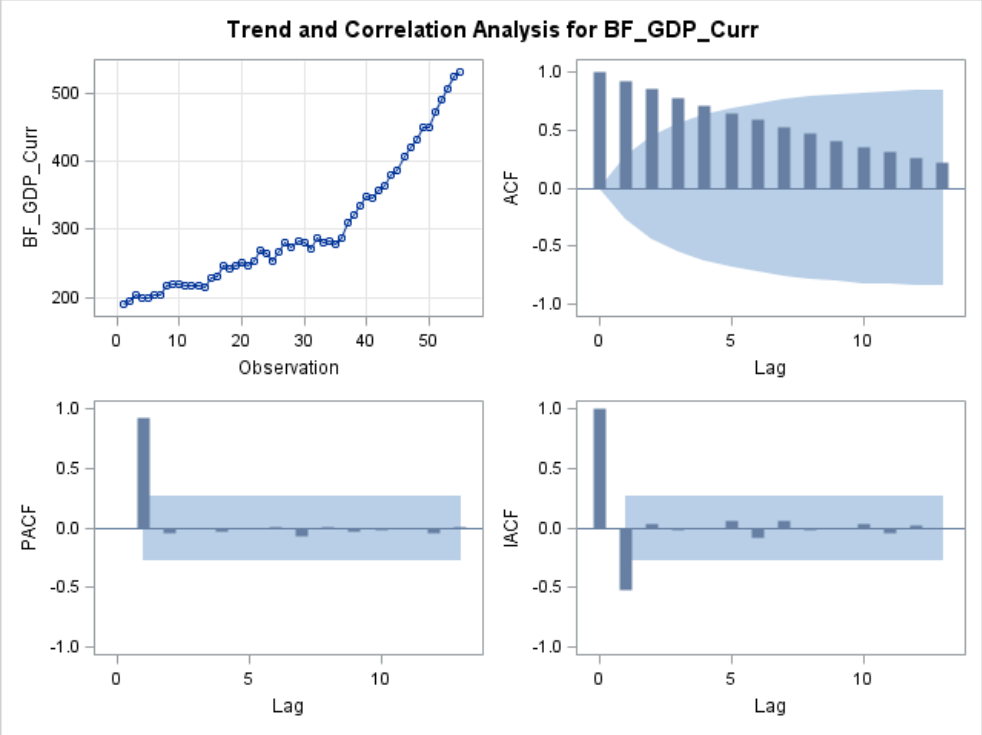
Mean of Working Series	300.9982
Standard Deviation	93.46247
Number of Observations	55

Autocorrelation Check for White Noise

To Lag	Chi–Square	DF	Pr > ChiSq	Autocorrelations					
6	208.22	6	<.0001	0.925	0.850	0.780	0.710	0.645	0.587
12	272.44	12	<.0001	0.523	0.465	0.410	0.357	0.308	0.259

Augmented Dickey–Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	**1**	1.2278	0.9381	5.28	0.9999		
	4	1.1799	0.9320	2.92	0.9989		
Single Mean	**1**	2.4586	0.9986	3.92	0.9999	17.64	0.0010
	4	2.3735	0.9984	3.14	0.9999	7.36	0.0010
Trend	**1**	1.7303	0.9994	1.04	0.9999	7.67	0.0207
	4	2.0836	0.9996	1.28	0.9999	4.85	0.2429


Trend and Correlation Analysis for BF_GDP_Curr
BF_GDP_Curr
500
400
300
200
0
10
20
30
40
50
Observation
ACF
1.0
0.5
0.0
-0.5
-1.0
0
5
10
Lag
PACF
1.0
0.5
0.0
-0.5
-1.0
0
5
10
Lag
IACF
1.0
0.5
0.0
-0.5
-1.0
0
5
10
Lag

The ARIMA Procedure

Name of Variable = BF_GDP_Curr

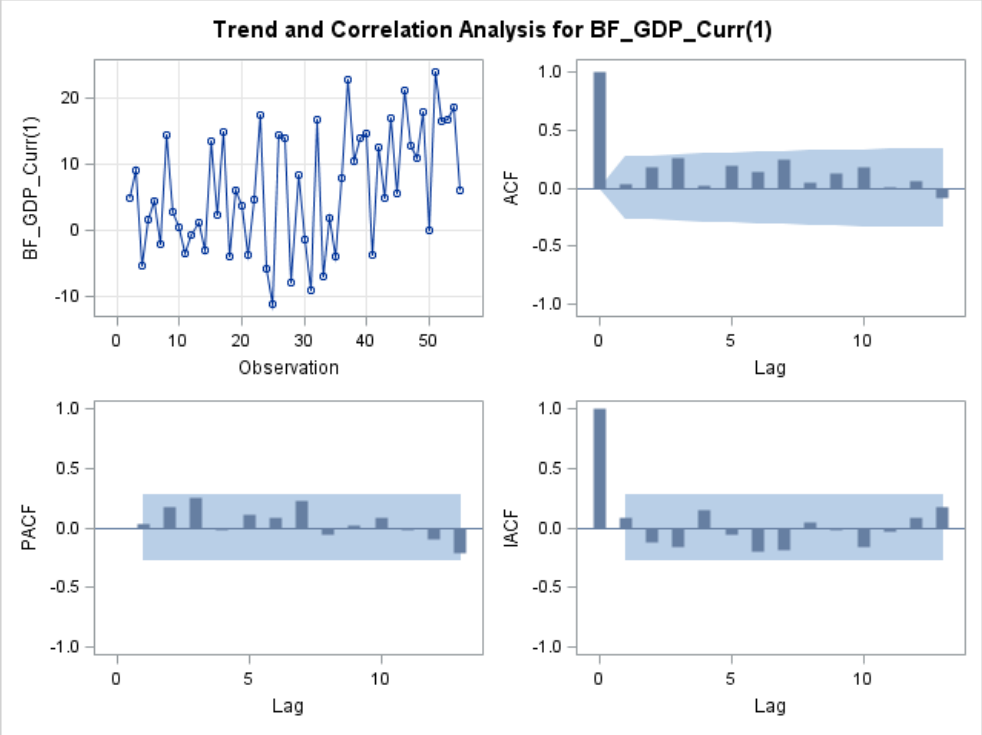
Period(s) of Differencing	1
Mean of Working Series	6.312963
Standard Deviation	9.035999
Number of Observations	54
Observation(s) eliminated by differencing	1

Autocorrelation Check for White Noise

To Lag	Chi–Square	DF	Pr > ChiSq	Autocorrelations					
6	9.37	6	0.1539	0.034	0.182	0.256	0.020	0.190	0.140
12	16.85	12	0.1554	0.241	0.046	0.123	0.184	0.008	0.058

Augmented Dickey–Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	**1**	–15.3966	0.0044	–2.67	0.0084		
	2	–5.2386	0.1103	–1.36	0.1590		
	3	–3.8136	0.1748	–1.06	0.2588		
	4	–1.3132	0.4185	–0.47	0.5065		
Single Mean	**1**	–34.3817	0.0005	–3.99	0.0029	7.97	0.0010
	2	–16.2545	0.0196	–2.48	0.1257	3.15	0.2773
	3	–15.6802	0.0230	–2.24	0.1961	2.63	0.4197
	4	–8.7551	0.1609	–1.56	0.4974	1.43	0.7131
Trend	**1**	–70.0678	<.0001	–5.83	<.0001	17.01	0.0010
	2	–47.7599	<.0001	–3.87	0.0206	7.50	0.0238
	3	–80.5297	<.0001	–3.70	0.0314	6.86	0.0470
	4	–67.1634	<.0001	–3.06	0.1270	4.77	0.2577


Trend and Correlation Analysis for BF_GDP_Curr(1)
BF_GDP_Curr(1)
Observation
ACF
Lag
PACF
Lag
IACF
Lag

The ARIMA Procedure

Name of Variable = P_cott_world

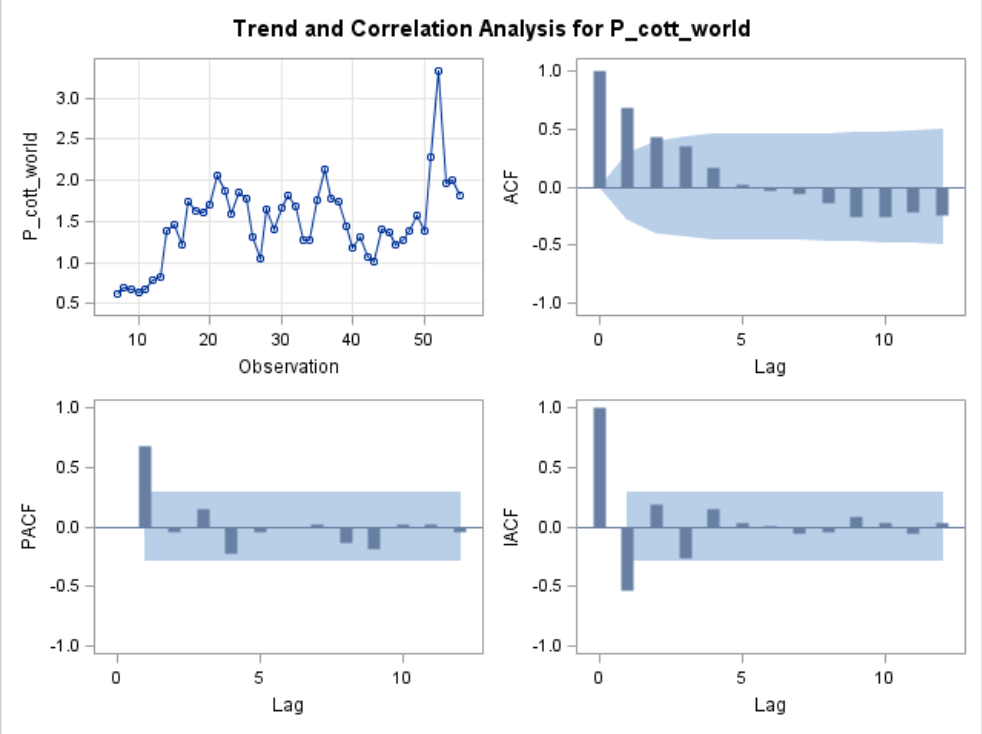
Mean of Working Series	1.476816
Standard Deviation	0.491009
Number of Observations	49

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	42.42	6	<.0001	0.676	0.435	0.356	0.169	0.021	−0.025
12	59.14	12	<.0001	−0.053	−0.142	−0.254	−0.255	−0.223	−0.239

Augmented Dickey–Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	**1**	−0.4536	0.5761	−0.30	0.5718		
Single Mean	**1**	−15.8829	0.0211	−2.92	0.0507	4.41	0.0746
Trend	**1**	−20.3124	0.0373	−3.14	0.1094	5.00	0.2149



The ARIMA Procedure

Name of Variable = P_cott_world

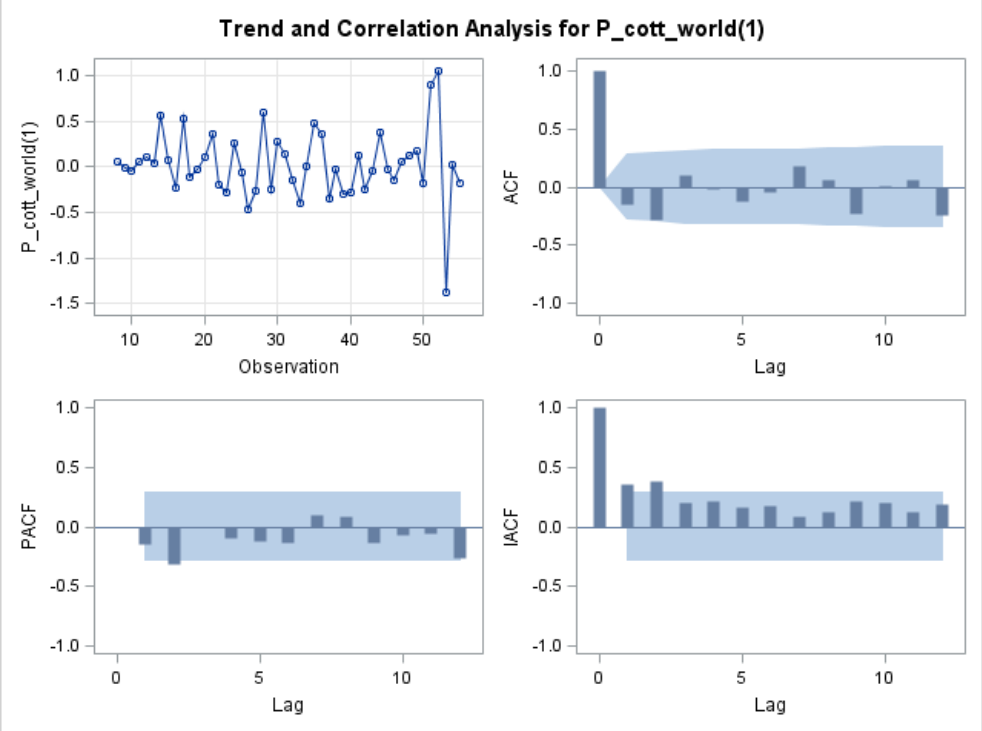
Period(s) of Differencing	1
Mean of Working Series	0.024938
Standard Deviation	0.375768
Number of Observations	48
Observation(s) eliminated by differencing	1

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	6.93	6	0.3272	−0.151	−0.287	0.103	−0.015	−0.121	−0.039
12	16.55	12	0.1674	0.185	0.057	−0.224	0.004	0.065	−0.247

Augmented Dickey–Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	**1**	−99.9738	<.0001	−6.90	<.0001		
Single Mean	**1**	−102.552	0.0001	−6.90	0.0001	23.81	0.0010
Trend	**1**	−103.302	0.0001	−6.85	<.0001	23.50	0.0010



The VARMAX Procedure

Number of Observations	48
Number of Pairwise Missing	6
Observation(s) eliminated by differencing	1

Simple Summary Statistics

Variable	Type	N	Mean	Standard Deviation	Min	Max	Difference
BF_GDP_Curr	**Dependent**	54	6.83125	9.40338	–11.20000	24.00000	1
P_cott_world	**Dependent**	48	0.02494	0.37974	–1.37000	1.05200	1

Granger–Causality Wald Test

Test	DF	Chi–Square	Pr > ChiSq
1	2	7.04	0.0297

Test 1: Group 1 Variables: BF_GDP_Curr

Group 2 Variables: P_cott_world

The VARMAX Procedure

Type of Model VAR(2)

Estimation Method Least Squares Estimation

Model Parameter Estimates

Equation	Parameter	Estimate	Standard Error	t Value	Pr > |t|	Variable
BF_GDP_Curr	**CONST1**	4.59028	1.90456	2.41	0.0205	1
	AR1_1_1	0.04901	0.14309	0.34	0.7337	BF_GDP_Curr(t–1)
	AR1_1_2	1.49530	3.56845	0.42	0.6774	P_cott_world(t–1)
	AR2_1_1	0.23002	0.14462	1.59	0.1194	BF_GDP_Curr(t–2)
	AR2_1_2	9.46515	3.56824	2.65	0.0113	P_cott_world(t–2)
P_cott_world	**CONST2**	0.08676	0.07927	1.09	0.2801	1
	AR1_2_1	–0.00200	0.00596	–0.34	0.7390	BF_GDP_Curr(t–1)
	AR1_2_2	–0.21083	0.14851	–1.42	0.1633	P_cott_world(t–1)
	AR2_2_1	–0.00497	0.00602	–0.83	0.4140	BF_GDP_Curr(t–2)
	AR2_2_2	–0.33705	0.14851	–2.27	0.0286	P_cott_world(t–2)

Covariances of Innovations

Variable	BF_GDP_Curr	P_cott_world
BF_GDP_Curr	82.17501	0.01524
P_cott_world	0.01524	0.14234

Information Criteria

AICC	2.716934
HQC	2.812829
AIC	2.663912
SBC	3.061443
FPEC	14.3771

The VARMAX Procedure

Number of Observations	48
Number of Pairwise Missing	6
Observation(s) eliminated by differencing	1

Simple Summary Statistics

Variable	Type	N	Mean	Standard Deviation	Min	Max	Difference
BF_GDP_Curr	**Dependent**	54	6.83125	9.40338	–11.20000	24.00000	1
P_cott_world	**Dependent**	48	0.02494	0.37974	–1.37000	1.05200	1

Granger–Causality Wald Test

Test	DF	Chi–Square	Pr > ChiSq
1	4	0.56	0.9677

Test 1: Group 1 Variables: P_cott_world

Group 2 Variables: BF_GDP_Curr

The VARMAX Procedure

Type of Model VAR(4)

Estimation Method (Least Squares Estimation)

Model Parameter Estimates

Equation	Parameter	Estimate	Standard Error	t Value	Pr > |t|	Variable
BF_GDP_Curr	**CONST1**	3.42763	2.13356	1.61	0.1171	1
	AR1_1_1	–0.11227	0.16578	–0.68	0.5027	BF_GDP_Curr(t–1)
	AR1_1_2	3.52944	3.94346	0.90	0.3769	P_cott_world(t–1)
	AR2_1_1	0.22956	0.15824	1.45	0.1558	BF_GDP_Curr(t–2)
	AR2_1_2	10.33902	4.02275	2.57	0.0146	P_cott_world(t–2)
	AR3_1_1	0.33091	0.15048	2.20	0.0346	BF_GDP_Curr(t–3)
	AR3_1_2	5.81054	5.15178	1.13	0.2670	P_cott_world(t–3)
	AR4_1_1	0.03590	0.15919	0.23	0.8229	BF_GDP_Curr(t–4)
	AR4_1_2	–1.22391	5.79752	–0.21	0.8340	P_cott_world(t–4)
P_cott_world	**CONST2**	0.10443	0.09657	1.08	0.2869	1
	AR1_2_1	–0.00098	0.00750	–0.13	0.8966	BF_GDP_Curr(t–1)
	AR1_2_2	–0.19410	0.17848	–1.09	0.2843	P_cott_world(t–1)
	AR2_2_1	–0.00287	0.00716	–0.40	0.6914	BF_GDP_Curr(t–2)
	AR2_2_2	–0.39073	0.18207	–2.15	0.0389	P_cott_world(t–2)
	AR3_2_1	–0.00267	0.00681	–0.39	0.6970	BF_GDP_Curr(t–3)
	AR3_2_2	0.00923	0.23317	0.04	0.9686	P_cott_world(t–3)
	AR4_2_1	–0.00205	0.00720	–0.28	0.7774	BF_GDP_Curr(t–4)
	AR4_2_2	–0.18493	0.26240	–0.70	0.4856	P_cott_world(t–4)

Covariances of Innovations

Variable	BF_GDP_Curr	P_cott_world
BF_GDP_Curr	79.79669	0.06944
P_cott_world	0.06944	0.16346

Information Criteria		Information Criteria	
AICC	3.138843	**SBC**	3.658349
HQC	3.199134	**FPEC**	18.91886
AIC	2.928454		

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