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Is More Chocolate Bad for Poverty? An Evaluation of Cocoa Pricing for Ghana's Industrialization and Poverty Reduction

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Abstract

The purpose of this study is to understand how cocoa pricing options affect local processors' cocoa acquisition, processing, and inventory decisions, with the ultimate goal of determining which policies best meet the multiple, but possibly conflicting, public policy objectives of maximizing government revenue, maximizing and stabilizing processor profits and throughput, and reducing poverty rates among cocoa beans producers. To evaluate these effects, we construct and numerically solve a structural dynamic model of a representative cocoa processor that maximizes the present value of current and expected future profits, given prevailing market conditions and cocoa pricing options. We then take the predicted cocoa pricing options to determine their associated poverty impacts among cocoa producers. We used this model to evaluate the appropriate cocoa pricing regime for attaining Ghana's objectives of increasing cocoa processing capacity to 40% of total cocoa produced in Ghana. We found, for example, that an appropriate 35% discount on main-crop beans will increase processor revenue by 57%, while either reducing government revenue by 36% or reducing cocoa farmers' income by a maximum of 22%, depending on who bears the burden of the discount.

Résumé

L'objet de cette étude est de comprendre comment les options de tarification affectent les décisions d'acquisition de fèves de cacao, de transformation et de gestion de stock des unités de transformations locales ; le but ultime étant de déterminer les politiques adéquates pour satisfaire les objectifs de politique de maximisation de recettes publiques, de maximisation et stabilisation de profits et production des unités de transformation du cacao et de réduction du taux de pauvreté parmi les producteurs de fèves de cacao. Afin d'évaluer ces effets, nous avons construit et résolu numériquement un modèle structurel dynamique d'une unité de transformation de cacao, pris comme échantillon des unités de transformation de cacao, qui maximise la valeur actuelle et future des bénéfices en tenant en compte des conditions du marché et des options de tarification. Ensuite nous avons déterminé les impacts sur la pauvreté parmi les producteurs de fèves de cacao en utilisant les options de tarification de cacao prédites par le modèle ci-dessus mentionné. Nous avons utilisé ce modèle pour évaluer le régime de tarification de cacao approprié afin atteindre les objectifs du Ghana d'accroissement de quantité de fève de cacao localement transformé de 40% sur la production totale de fèves de cacao. Nous avons constaté, par exemple, qu'une réduction de la tarification de 35% sur les fèves de la récolte principale augmentera les revenus des unités de transformation de 57%, tout en réduisant les recettes du gouvernement de 36% ou le revenu des producteurs de fève de cacao de 22% au maximum, en fonction de qui porte le fardeau de la réduction.

1. Background

Ghana's cocoa is produced in forested areas throughout the country, namely the Ashanti, Brong-Ahafo, Central, Eastern, Western, and Volta regions. These regions receive between 1,000 and 1,500 millimeters of rainfall per year. The marketing year begins in October, when harvest of the "main crop" begins, followed by the harvest of a smaller, "light crop" in July. Light crop beans are smaller than the main crop variety but are identical in quality and are grown on the same trees. The main crop accounts for 90 percent of total annual cocoa bean production in Ghana, while the light crop accounts for the remaining 10 percent.[1]

In the early 1960s, Ghana was the world's largest cocoa producer. However, by the early 1980s, Ghana's share of world production had dwindled almost to the point of insignificance, in large part due to catastrophic bushfires of 1983 that destroyed most of the country's cocoa-producing forests. Cocoa bean production in Ghana began to recover in the early 1990s, exhibiting an average annual rate of growth of 6 percent between 1990 and 1999 and 8 percent between 2000 and 2012. The production boom has been attributed to an increase in fertilizer use and a government-sponsored mass pesticide spraying program that began in 2001. Today, Ghana produces slightly less than 700,000 metric tons (MT) of cocoa beans per year on average, making it the world's second largest cocoa bean producer after neighboring Côte d'Ivoire.

Ghana's cocoa bean sector is heavily regulated, with the Ghana Cocoa Board (COCOBOD) serving as the exclusive marketing intermediary between primary producers and processors. COCOBOD buys cocoa beans from producers through Licensed Buying Companies (LBCs) and sells them to processors, in both cases at prescribed multiples of the prevailing world cocoa bean price, and liquidates any surplus on the international cocoa market at the prevailing world price through its wholly owned subsidiary, the Cocoa Marketing Company (CMC). COCOBOD also provides input subsidies and guaranteed prices to farmers; as a result, Ghanaian cocoa bean farmers enjoy far greater price stability than farmers in free market–oriented regimes such as Côte d'Ivoire.

Value addition activities in the cocoa marketing chain are regulated by the Ministry of Trade and Industry (MoTI), which regulates all of Ghana's manufacturing activities. Although Ghana accounts for 20 percent of the $9 billion global cocoa bean market, it is estimated that less than 30 percent of the country's cocoa beans grown are locally processed. This means that Ghana captures only 5 percent of the $28 billion global intermediate cocoa processing industry. The large gap between Ghana's share of global cocoa bean production and its share of processed intermediate cocoa products stems from market failures that have existed since the infancy of the country's

[1] It is important to note this distinction, as it forms the basis of Ghana's industrial policy on cocoa.

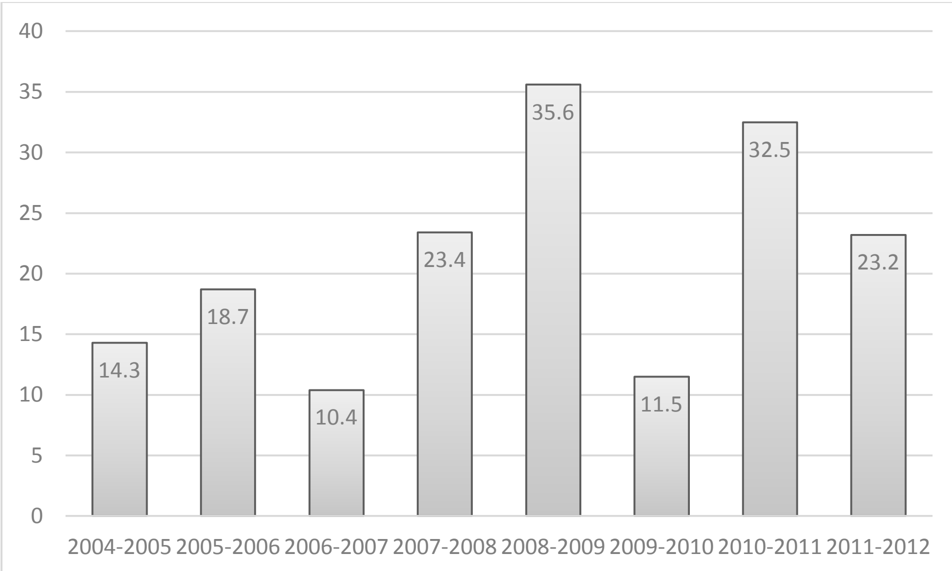
cocoa processing sector. Ghana has been processing cocoa beans for many years, albeit in small quantities; however, the country's markets often fail to correct for the gains that have accrued over time due to increased expertise and declining unit costs. A number of factors have contributed to these market failures, such as poor local market demand for cocoa-based products, high overall manufacturing costs, and increasing tariff rates for intermediate cocoa products imported to Europe.

Ghana's current cocoa value chain policies focus on maximizing revenue from cocoa bean exports. COCOBOD currently retains 9 percent of the cocoa freight on board (FOB) price. COCOBOD's efforts to ensure quality, traceability, and social responsibility have resulted in a 4-6 percent price premium being awarded to Ghanaian cocoa on the international market. However, the only policy in place for attracting and encouraging local cocoa processing is a 20 percent discount given on the light cocoa bean harvest, which has little impact on processors' willingness to increase the quantity processed.

Whether to export raw cocoa beans or to process them locally prior to export is an industrial policy question that has faced several successive Ghanaian governments. In recent years, public policy has shifted toward increasing earnings through increased local processing. MoTI has attempted to promote local processing by subsidizing the price paid by local processors, a strategy in line with Brander and Spencer (1985) for encouraging domestic reallocation of increasing return industries for global market share rivalry purposes. However, this subsidy has come at the cost of reduced revenue for farmers and other upstream value chain players, including COCOBOD, undermining COCOBOD's mission to make cocoa farming an adequate source of income for farmers. The inability to strike the right balance between industrialization and poverty reduction has been, and still is, at the heart of the failure of efforts to address market incompleteness.

MoTI's current goal is to raise the proportion of export earnings that come from locally processed cocoa beans to 40 percent. However, Figure 1 shows that it is far from achieving this goal. The proportion of export earnings attributable to locally processed cocoa averaged 25 percent between 2007 and 2011, ranging from a low of 10 percent in 2006–2007 to a high of 36 percent in 2008–2009.

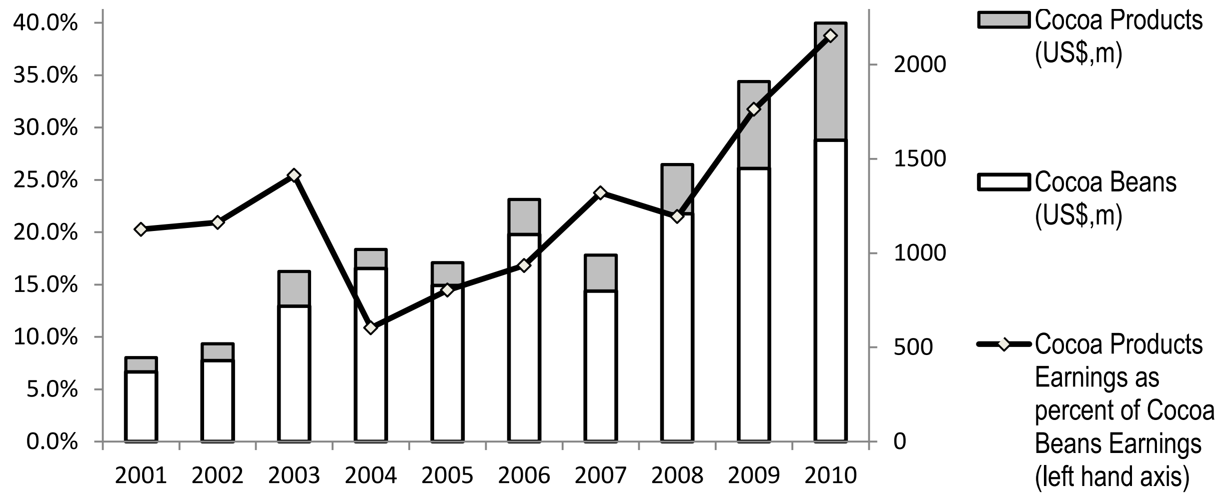
Figure 1: Cocoa Beans Processed as Percent of Exports



Source: African Center for Economic Transformation (ACET), 2012

Figure 2 shows the export earnings from cocoa beans and intermediate cocoa products (butter, cake, and powder). Although the volume of cocoa beans exported has grown more rapidly than that of locally processed beans, the value of locally processed beans has grown more rapidly due to the higher premium afforded to processed products. In fact, the percentage of cocoa export earnings accounted for by processed cocoa beans has risen markedly since 2004, from a little over 10 percent in 2004 to nearly 40 percent in 2010. Despite this growth, a few important questions remain. Should more beans be processed, and under what terms and conditions? And how much progress is truly being made? Answering these questions requires a better understanding of both the cocoa sector supply chain and the prevailing industrial policies governing the sector.

Figure 2: Cocoa Export Earnings: 2001–2010



Source: ACET, 2012

In an attempt to promote economic transformation through agro-processing, the government of Ghana is keen to address the large gap between the country's share of global cocoa bean production and its share of processed intermediate cocoa products. However, the current cocoa pricing model appears sub-optimal for encouraging processors to increase their current capacity, despite the various tax breaks they enjoy by being considered free-zone companies. The nature of Ghana's cocoa value chain is such that a revision of the current cocoa pricing model will have repercussions not only for processors but also for COCOBOD and for farmers. The purpose of this study is to understand how COCOBOD's pricing policies affect local processors' cocoa acquisition, processing, and inventory decisions, with the ultimate goal of determining which policies best meet the multiple, but possibly conflicting, public policy objectives of maximizing COCOBOD revenue, maximizing and stabilizing processor profits and throughput, and reducing poverty rates, especially among cocoa bean producers. To conduct our analysis, we proceed in two steps. First, we construct a structural dynamic model of a representative cocoa processor that maximizes the present value of current and expected future profits, given prevailing market conditions and COCOBOD pricing policies. Second, we take the predicted appropriate cocoa pricing options to determine their associated poverty impacts among cocoa producers. This is done by applying Deaton's (1989) "net buyer, net seller" approach to the 2005 Ghana Living Standards Survey (GLSS5) for cocoa farmers.

The paper goes on to contextualize the global and regional debate on industrial policy in Section 2. In Section 3, we present an overview of Ghana's cocoa supply chain and justify the modeling framework. In Section 4, we present the model, the parameterization approach, and the numerical solution method. In

Section 5, we discuss the poverty implications of industrial policies, and in Section 6, we summarize our findings and draw conclusions.

2. Industrial Policy for Economic Transformation

The Ghanaian government's desire to increase the quantity of locally processed cocoa is a reflection of its strategy to move the country from a primary product economy to an industry-based one. Industrialization through agro-processing has reemerged not only in Ghana but also in the global development policy debate. This reemergence is especially prominent in Africa south of the Sahara (SSA), where both governments and regional institutions, such as the African Development Bank, the UN's high-level panel on the Post-2015 Development Agenda and on Goal 9 of the Zero Draft of the Sustainable Development Goals (SDGs), and the African Union, have all echoed the need for economic transformation and industrialization. Multiple African countries, including Ethiopia, Rwanda, Kenya, and Liberia, have also articulated and begun implementing robust transformation plans, and Ghana is revisiting its national development strategies after many fitful attempts.

For the purposes of this study, economic transformation and industrialization mean the process leading to the narrowing of the gap between SSA countries and industrialized countries in key areas, including technological capacity, productivity, economic diversity, export competitiveness, per capita income, and formal-sector employment, all of which are discussed in the 2014 African Center for Economic Transformation's African Transformation Report (ATR).

Most African countries have agriculture-based economies. It is estimated that 65 percent of the labor force in SSA countries is employed in the agricultural sector, and that the sector contributes about 32 percent of the region's GDP. A natural starting point for promoting economic transformation/industrialization, therefore, is to link the agricultural sector to the manufacturing sector through effective agro-industrial policies. These policies matter for both economic transformation and poverty alleviation because they influence investment in physical and human capital and technology and promote the efficient organization of production. Agro-industrial policies can be used to promote both aggregate economic growth and more equitable distribution of societal resources (Robinson, 2009).

An effectively implemented industrial policy is broadly defined as any set of policies pursued by a government with the explicit goal of promoting the expansion, technological upgrading, or international competitiveness of a targeted set of economic activities (Ansu, 2013). The importance of industrial policies for economic transformation became widely understood after a series of important interpretations of the "East Asian Miracle" economies published by Johnson (1982), Amsden (1989), Wade (1990), and the World Bank (1993). These works put successful industrial policy at the heart of the postwar economic successes of Japan, South Korea, and Taiwan. This research, and other literature like it, argued that market failures are always worse than government failures and that industrial policy is a powerful tool for promoting economic growth.

The appropriate industrial policy depends on the market imperfection at hand. In Latin America, for example, policy took the form of import-substituting industrialization (ISI), effectively closing domestic markets to international competition. In South Korea and Taiwan, it took the form of incentives to induce the development of export industries. As the basic argument of Rodrik (2007) states, one size does not fit all. A successful industrial policy has to be tailored to the specific context or institutions prevalent in the country of interest. Different countries could adopt identical policies and have very different results, as they faced different market failures.

SSA has experienced two important industrial policy regimes. After achieving independence in the 1960s, many African countries' industrial policies centered on ISI. Under this strategy, the state aspired to control the economy, which, in these countries' nascent industrial settings, included the import-substituting factories that were then being promoted. Thus, governments either entered into production themselves through state-owned enterprises or controlled the entry of entrepreneurs and heavily regulated the operations of private firms. Despite some initial success in expanding the manufacturing sector, industrial policies based on state-led import substitution strategies proved quite disappointing.

By the beginning of the 1980s, severe balance-of-payments problems had made the state ISI strategy difficult to sustain in almost all of the SSA countries that employed it, and country after country, including Ghana, turned to the International Monetary Fund (IMF) and the World Bank for help. This help was often contingent on the countries' entrance into macroeconomic stabilization programs with the IMF and programs of structural reform with the World Bank. These programs, often jointly referred to as "Structural Adjustment Programs" (SAPs), typically shared the following features: fiscal adjustment (to reduce fiscal deficits), exchange rate devaluation, trade (particularly import) liberalization, privatization of state-owned enterprises, and reduction of government involvement in production or support to select economic activities and actors. Unfortunately, as with the ISI strategy, the results of the SAPs were also disappointing (Ansu, 2013).

Recently, a new model of state-private sector partnership has emerged in the form of "a market-oriented industrial policy," interpreted broadly as a set of policies that promote the efficient production and export of a diverse range of technologically upgraded goods and services from the agricultural, industrial, or services sectors (ATR, 2014; Whitfield and Buur, 2014). The core of this new industrial policy lie in striking the right balance between state and private sector action.

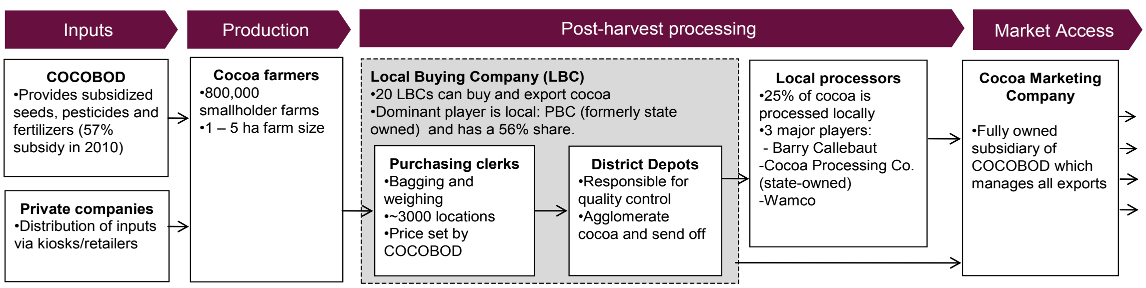
In addition to maintaining macroeconomic stability, one important role for the state in such a partnership is the facilitation of the private sector's capacity to become internationally competitive through, for example, effective subsidization of firms involved in global market share competition (Brander and Spencer, 1985).

3. Overview of Ghana's Cocoa Supply Chain

3.1 Production

The Ghanaian cocoa industry is characterized by fragmented production of cocoa beans, with the greatest volume produced by smallholder farmers, and a highly consolidated supply and processing chain, with many large-scale players active across multiple stages (Figure 3).

Figure 3: Overview of the Cocoa Supply Chain in Ghana



Source: Dalberg, 2012

Prior to sector reforms, the Produce Buying Company (PBC), then a subsidiary of COCOBOD, was the sole buyer of cocoa in Ghana. In 1992–1993, the government of Ghana introduced regulations under which COCOBOD would grant LBCs the exclusive right to buy cocoa beans from producers at no less than announced prices and to deliver them to CMC, if these LBCs adhered to quality standards stipulated by the Quality Control Company (QCC) of COCOBOD. LBCs can be divided into four groups, as illustrated in Table 1. The first category consists of Producer Buying Company (PBC), which controls 32.8 percent of the market. The second category includes domestically owned companies, which control 44.8 percent of the market. The third category is the farmer-based fair trade cooperative Kuapa Kokoo, which controls 5.9 percent of the market, and the fourth category consists of two international companies, Olam and Armajaro, which control 16.4 percent of the market.

Table 1: Market Share of LBCs

Firm	Share
PBC	32.83
Akuapo	11.97
Olam	10.71
Adwumapa	8.62
Fed	7.04
Kuapa Kokoo	5.91
Transroyal	5.72
Armajaro	5.7
Coco Gh	3.17
Diaby	2.7
Others	5.63

Source: Porto, Depetris-Chauvin, and Olarreaga, 2011

The relationship between the LBCs and their suppliers varies. Most LBCs use informal contracts in which farmers are provided with inputs in return for a guaranteed supply of cocoa beans at harvest. Some farmers have organized themselves as a union to buy inputs in bulk and maximize revenue. However, since COCOBOD fixes the minimum price farmers must receive at 72 percent of the international market price, with 8 percent of the price margin kept by the LBCs, there is not much opportunity for enhancing competition at this level.

3.2 Processing

Cocoa beans are first processed into intermediate products, such as liquor, butter, cake, and powder. Between the 2009–2010 season and the 2012–2013 season, Ghana processed 32 percent of its cocoa bean production. Liquor constitutes the largest portion of the processed cocoa products and is either exported "as is" or compressed to produce butter, cake, and powder before being exported, mainly to Europe (see Table 2). It is important to note that import tariffs play a significant role in keeping African countries focused on exporting raw beans. For example, the EU does not levy duties on the import of raw cocoa beans, but it does levy 7.7 percent and 15 percent ad valorem duties on cocoa powder and cocoa cake, respectively.

Table 2: Production of Intermediate Cocoa Products

Production year	Cocoa beans bought by local processors (in MT)	Processing output (in MT)			
		Liquor	Butter	Cake	Powder
2009/10	212,245	122,715	25,326	7,237	16,975
2010/11	229,695	118,437	38,564	12,024	29,593
2011/12	211,709	114,274	30,381	10,375	21,817
2012/13	230,896	117,711	37,174	12,444	26,250

Source: COCOBOD, 2013

Ghana's current installed cocoa processing capacity is 431,000 MT per year, up from 111,500 MT per year in 2000–2001. Cocoa grinding is undertaken by a combination of state-owned, international, and local private enterprises. There are nine cocoa processors in Ghana; three of these (Archer Daniels Midland (ADM),[2] Barry Callebaut, and Cargill) control 47 percent of the country's cocoa processing capacity. The government-owned CPC controls 17 percent of installed capacity and the remaining 36 percent is controlled by local private players, as illustrated in Figure 4.

Ghana also produces chocolate bars through the CPC factory at Portem. However, this local brand produces negligible quantities and has no discernible influence on the international chocolate market.

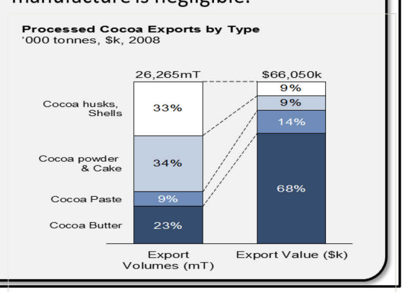
The Ghanaian cocoa processing industry is highly automated, employing only 1,293 workers across all nine processing firms. This is much lower on a per-firm basis than the level of employment in the late 2000s, when two cocoa processing companies employed 884 workers. Employment in the industry has thus fallen from 442 workers per factory in the 2000s to about 117 per factory today. The limited job creation in the cocoa processing sector has been one of the main arguments put forth by COCOBOD against giving any further discount on the cocoa beans it sells to local processors, especially those produced during the main season.

Figure 4: Overview of Ghanaian Cocoa Processing

Ghana has provided generous incentives to attract local processors. However, processing is largely confined to low-value grinding.

Processor	Installed Capacity (MT)	Utilized Capacity (MT)	% Utilization
Barry Callebaut	67,000	63,180	94%
Cargill	65,000	71,408	110%
CPC	64,500	16,952	26%
Real Products	50,000	-	0%
WAMCO	47,000	8,772	19%
ADM	42,000	34,266	82%
Plot	32,000	18,613	58%
Afrotropic	18,000	1,140	6%
CPIL	18,000	15,362	85%
Calf Cocoa	5,000	-	0%
BD Associates	12,500	-	0%
Total	431,000	229,693	53%

- Ghana has provided generous incentives to attract processors, such as discounted beans and tax breaks.
- Ghana processes 25–32% of total beans. Target is to process 60% of beans in the long term.
- However, capacity utilization is still low due to lack of beans.
- Processing is still largely confined to low-value grinding. Chocolate manufacture is negligible.



Source: ACET, 2015

[2] ADM's global cocoa business was acquired by Olam in late 2014.

The Ghanaian government initially targeted an increase in cocoa bean grinding to 40 percent by 2012, with a long-term target of 60 percent. However, only 25 percent of beans are now locally ground, far short of the government's target. Some processors argue that COCOBOD's current cocoa bean pricing scheme is an impediment to further progress, despite COCOBOD's benefits to cocoa bean production.[3] Specifically, local processors buy main crop beans at the international market price, which they believe discourages local processing due to the high cost of utilities.[4]

Cocoa grinding capacity has increased substantially over the past 10 years due to the entry of multinational players, especially Cargill and ADM. These major players and other cocoa processing companies, benefiting from export free zone (EFZ) advantages, were attracted to the Ghanaian market partly because of the discount that COCOBOD gives on light crop beans and partly because of their expectations of receiving greater discounts on main crop beans. EFZ advantages include a 100 percent exemption from the payment of direct and indirect duties and levies on all imports for production and exports from free zones; a 100 percent exemption from the payment of income tax on profits for their first 10 years (after 10 years, these companies pay no more than 8 percent income tax, compared to 25 percent for non-EFZ companies); exemption from value-added tax (VAT) on purchases, including utilities; and no restrictions on fund repatriation.

3.3 Pricing

International cocoa prices are highly volatile. Since the 1980–1981 growing season, the International Coffee and Cocoa Organization (ICCO) international price index has varied from a peak of 2,320 SDR/ton in 1984 to a low of 685 SDR/ton in 2000.[5]

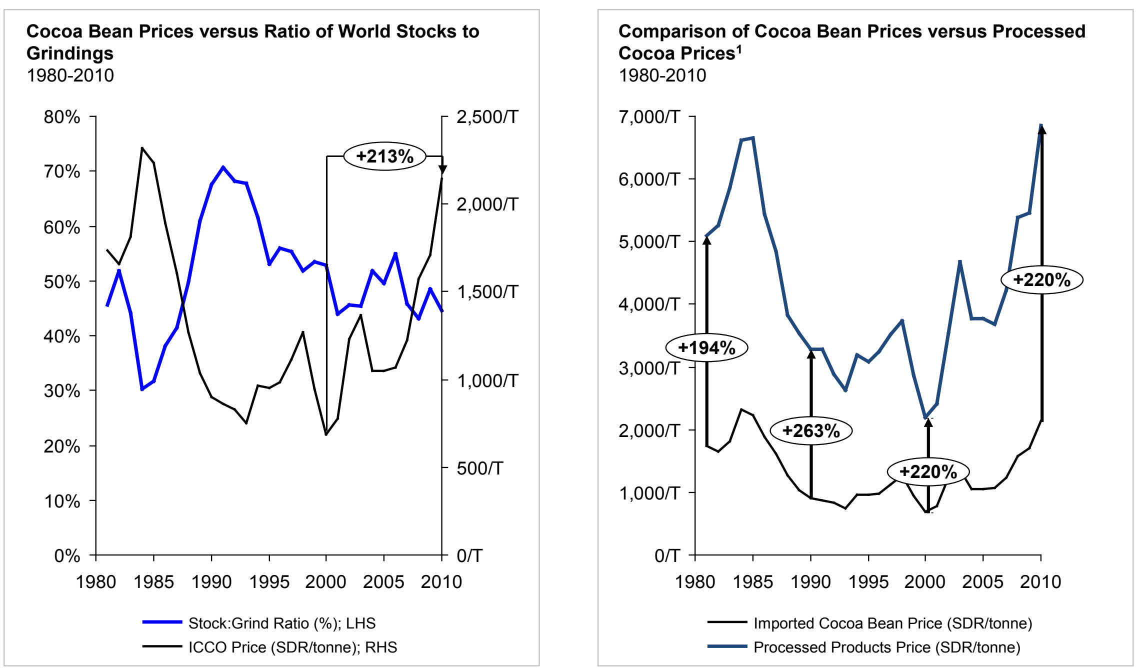
Over the medium term, the prevailing international price for cocoa beans is strongly related to cocoa bean stocks relative to the volume of grinding. This "stock-to-grind ratio" is typically used as a measure of the tightness of the cocoa market and is closely associated with movements in the traded cocoa bean price; a 10 percent increase in the stock-to-grind ratio is typically associated with a 9 percent decrease in the ICCO index cocoa bean price. Recently, prices have risen far above the levels justified by this ratio due to a combination of short-term concerns about the security of supply from Côte d'Ivoire and longer-term concerns over the ability of the cocoa production industry to increase its volumes fast enough to meet expected long-term rises in demand of 2–3 percent per annum. These concerns are driven by a rising

[3] The operations manager for the business unit of Cargill Cocoa and Chocolate, Wouter Evers, told the *Daily Graphic* (a prominent newspaper in Ghana) that "we have the capacity to do more than we do now, but Ghana's cocoa is expensive, and to increase the quantum we process, we will require some incentives."
[4] We noted more than half a dozen newspaper articles in which processors have advocated for more support in the form of cheaper beans from COCOBOD.
[5] Prices are measured in both dollars and Special Drawing Rights (SDR) of the IMF. The latter is used here to eliminate the impact of variation in the value of the US dollar on the nominal price of cocoa over the period.

incidence of disease in all major cocoa-producing regions, as well as by competition for land between producers of cocoa and producers of other agricultural commodities, such as palm oil and rubber.

The prices of intermediate products, such as cocoa liquor, butter, cake, and powder, are commensurate to the underlying spot price of cocoa beans. On a weighted average price basis, intermediate processed outputs earn a relatively stable premium of approximately 200–220 percent over the price of raw cocoa beans, as illustrated in Figure 5. Within this, however, there are substantial differences in the prices of individual intermediates, with cocoa butter earning the highest premium and cocoa powder tending to be less valuable than cocoa beans on a per-ton basis, as the demand for cocoa powder is lower than that for butter or liquor. Since 2008, chocolate manufacturers have attempted to reduce the costs and retail prices of their products in response to lower consumer demand for confectionery, leading to some divergence from the long-term trend. For example, the price of cocoa butter declined from 287 percent of the cocoa bean price in the 2007–2008 season to 204 percent in the period from October 2008 to March 2009; the price of cocoa powder increased from 55 percent to 116 percent of the cocoa bean price over the same period.

Figure 5: Pricing of Processed Cocoa versus Cocoa Beans



1. "Processed Cocoa" price is based on the weighted average price of cocoa butter and cocoa powder, as calculated by the ICCO
SOURCE(S): "World Cocoa Economy," ICCO 2010; Dalberg analysis

In Ghana, COCOBOD determines the price that farmers will receive at the beginning of the season, based on the prevailing international price. If the market price dramatically fluctuates after the COCOBOD purchase price has already been established, the difference is addressed via a stabilization fund. The FOB price allocation among Ghana's cocoa industry players is such that producers receive 72.2 percent of the

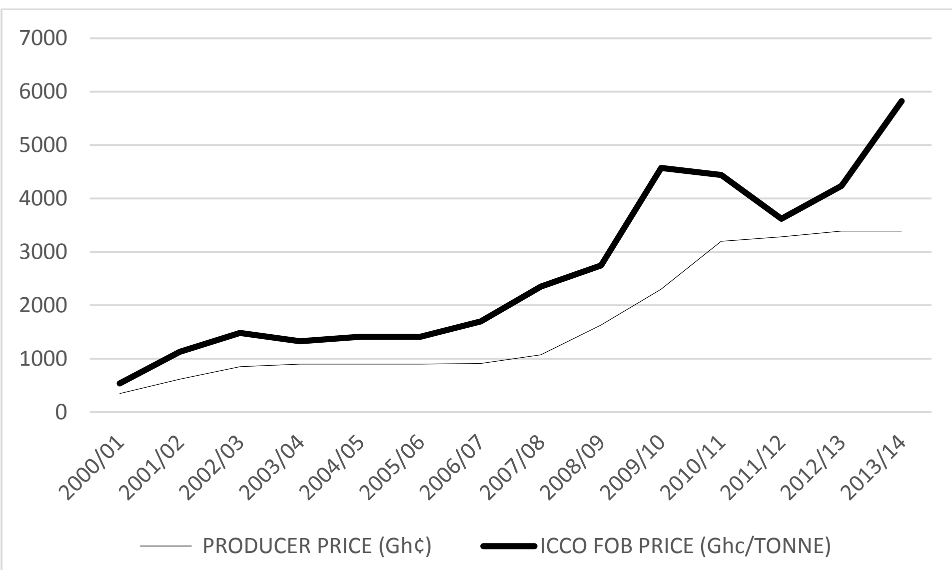
FOB share, LBCs keep 8.4 percent, COCOBOD keeps 9.3 percent, and the rest goes to logistical and farmers' welfare activities, as illustrated in Table 3.

Table 3: Allocation of Price of Cocoa Beans

Cost items	Share of net FOB (%)	Ghana cedis (GHS)[6] per MT	GHS per bag (64 kg)
Producer price	72.16	2400.05	150.00
Stabilization fund	1.50	49.89	3.12
Buyers' margin	8.42	280.05	17.50
Haulers' cost	3.40	113.08	7.07
Storage and shipping (CMC)	1.16	38.58	2.41
Quality control	1.66	55.21	3.45
Crop finance	1.06	35.26	2.20
Scale inspection and phytosanitary	0.01	0.33	0.02
Government/COCOBOD	9.34	310.65	19.42
Farmers' housing scheme	0.04	1.33	0.08
Replanting/rehabilitation	0.64	21.29	1.33
Farmers' social security	0.61	20.29	1.27
Total	**100**	**3326.01**	**207.87**

Source: Kolavalli et al, 2012

Figure 6: Producers' Prices versus FOB Prices (GHS/MT)



Source: COCOBOD, 2014

[6] As of June 10th 2015, $1=4.1 GHC

Farmers have not always received 72 percent of the FOB price; their percentage has varied between 45 percent and 90 percent between 2000–2001 and 2013–2014, as illustrated in Figure 6. The increase in farmers' share of the FOB price began during the 2001–2002 season, when COCOBOD started its mass spraying activities, which led to notable growth in productivity.

4. The Model

4.1 Representative Processor

Consider an infinitely-lived cocoa processor that maximizes the present value of current and expected future profits. The marketing year is divided into a "main" season, denoted by *i* = 1, and a "light" season, denoted by *i* = 2, with the former accounting for the greater share of annual production. At the beginning of each season *i*, the processor observes the quantity of cocoa it holds in inventory s_i, the quantity of cocoa offered for sale by COCOBOD $\tilde{y}_i$, the international price of cocoa $\tilde{p}_i$, and the gross premium for processed cocoa offered on the international market $\tilde{\epsilon}_i$. The processor must then decide how much cocoa a_i to acquire from COCOBOD, how much cocoa q_i to process, and how much cocoa to hold in inventory x_i at the end of the season.

The processor's decisions are subject to capacity constraints

$$0 \leq a_i \leq \tilde{y}_i \tag{1}$$

$$0 \leq q_i \leq \bar{q}_i \tag{2}$$

$$0 \leq x_i \leq \bar{x}_i \tag{3}$$

and to a material balance constraint

$$s_i + a_i = q_i + x_i \tag{4}$$

Here, (1) states that the quantity of cocoa acquired by the processor cannot exceed the quantity offered for sale by COCOBOD; (2) states that the quantity of cocoa processed cannot exceed a fixed processing capacity $\bar{q}_i$; (3) states that the processor's ending inventory cannot exceed a fixed storage capacity $\bar{x}_i$; and (4) states that the initial inventory of cocoa plus new acquisitions must be either processed or held in inventory at the end of the season. Since the inventory held at the end of one season equals the inventory held at the beginning of the following season, $s_{i+1} = x_i$, provided we interpret the subscript *i* + 1 to mean 1 when *i* = 2.[7]

The processor's profit in season *i* is

$$\pi_i = \tilde{\epsilon}_i \tilde{p}_i q_i - \alpha_i \tilde{p}_i a_i - c_i(q_i) \tag{5}$$

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[7] We assume, without loss of generality, that $\bar{q}_{i+1} \geq \bar{x}_i$.

where α_i is the discount on cocoa offered by COCOBOD to the processor and $c_i(q_i)$ is the processor's total cost of processing; we assume the processor's fixed unit cost of inventory to be negligible, where $0 < \alpha_i < 1$. We assume the total cost of processing is a convex quadratic function of the quantity processed. This assumption is not made arbitrarily, but rather in light of both the capital-intensive nature of cocoa processing in Ghana and the short-run nature of our analysis, which keeps capacity fixed and assumes that marginal cost rises over the normal range of utilization, becoming higher as we approach capacity.

$$c_i(q_i) = \overline{c_i} + \eta_i q_i + \frac{1}{2}\gamma_i q_i^2 \qquad (6)$$

where $\overline{c_i} > 0$, $\eta_i > 0$, and $\gamma_i > 0$.

The processor maximizes the present value of current and expected future profits. The processor's dynamic decision problem is thus characterized by a Bellman equation whose value function V_i specifies the maximum expected present value of profit attainable by the processor in season i, given its current inventory s_i, available new production $\widetilde{y_i}$, the prevailing international cocoa price $\widetilde{p_i}$, and the prevailing gross processed cocoa premium $\widetilde{\epsilon_i}$:

$$V_i(s_i, \widetilde{y_i}, \widetilde{p_i}, \widetilde{\epsilon_i}) = \max_{a_i, q_i, x_i} \{\pi_i + \delta_i E_i V_{i+1}(x_i, \widetilde{y_{i+1}}, \widetilde{p_{i+1}}, \widetilde{\epsilon_{i+1}})\} \qquad (7)$$

subject to constraints (1) through (4). Here, $\delta_i \in (0,1)$ is the market discount factor between season i and the subsequent season.

Quantities of cocoa beans acquired by COCOBOD but not purchased by the processors are sold on the international market at the prevailing international price. Therefore, COCOBOD does not hold inventories, and its net income in a given period is:

$$\pi_i^C = \widetilde{p_i}(\widetilde{y_i} - a_i) + \alpha_i \widetilde{p_i} a_i - \beta_i \widetilde{p_i} \widetilde{y_i} \qquad (8)$$

where β_i is COCOBOD's discount to cocoa bean producers.

Cocoa production, the international cocoa price, and the international cocoa processing margins are assumed to be exogenous and random.

4.2 Analytical Solutions

Assume that there is no carryout between marketing years and that any surplus may be disposed of freely at the end of the year, so that $s_{ti} = 0$. Under these assumptions, $q_2 = q_2(s_2, \widetilde{y_2}, \widetilde{p_2}, \widetilde{\epsilon_2})$, the optimal quantity processed in season 2, and $a_2 = a_2(s_2, \widetilde{y_2}, \widetilde{p_2}, \widetilde{\epsilon_2})$, the optimal quantity acquired in season 2, are both functions of the quantity held by the processor at the beginning of the season s_2, available new production $\widetilde{y_2}$, the international cocoa price $\widetilde{p_2}$, and the gross processed cocoa premium $\widetilde{\epsilon_2}$. More explicitly,

$$q_2(s_2, \widetilde{y_2}, \widetilde{p_2}, \widetilde{\epsilon_2}) = min\{\bar{q}_2, s_2 + \widetilde{y_2}, max\{0, \widetilde{q_2}\}, max\left\{s_2, \widetilde{y_2} - \frac{\alpha_2 \widetilde{p_2}}{\gamma_2}\right\}\} \qquad (9)$$

and

$$a_2(s_2, \widetilde{y_2}, \widetilde{p_2}, \widetilde{\epsilon_2}) = max\{0, q_2(s_2, \widetilde{y_2}, \widetilde{p_2}, \widetilde{\epsilon_2}) - s_2\} \tag{10}$$

where $\widetilde{q_2} \equiv \frac{\widetilde{\epsilon_2}\widetilde{p_2} - \eta_2}{\gamma_2}$. It also follows that the profits realized by the processor are

$$\pi_2 = \widetilde{\epsilon_2}\widetilde{p_2}q_2 - \alpha_2\widetilde{p_2}a_2 - c_2(q_2) \tag{11}$$

and the profits realized by COCOBOD are

$$\pi_i^C = \widetilde{p_2}(\widetilde{y_2} - a_2) + \alpha_2\widetilde{p_2}a_2 - \beta_2\widetilde{p_2}\widetilde{y_2} \tag{12}$$

It follows that the profit expected in season 2, which is conditional on information available in season 1, is solely a function of the carryout in season 1, allowing us to write:

$$f(x_1) = E_{\widetilde{\epsilon_2}\widetilde{p_2}\widetilde{y_2}}\widetilde{\epsilon_2}\widetilde{p_2}q_2 - \alpha_2\widetilde{p_2}a_2 - c_2(q_2) \tag{13}$$

where $q_2 = q_2(x_1, \widetilde{y_2}, \widetilde{p_2}, \widetilde{\epsilon_2})$ and $a_2 = a_2(x_1, \widetilde{y_2}, \widetilde{p_2}, \widetilde{\epsilon_2})$ are as above. In season 1, the processor thus solves

$$\min_{q_1, x_1}\{\widetilde{\epsilon_1}\widetilde{p_1}q_1 - \alpha_1\widetilde{p_1}(q_1 + x_1) - c_1(q_1) + \delta f(x_1) \tag{14}$$

subject to constraints

$$q_1 \leq x_1 \leq \widetilde{y_1} \tag{15}$$

$$0 \leq q_1 \leq \bar{q}_1 \tag{16}$$

$$0 \leq x_1 \leq \bar{x}_1 \tag{17}$$

Equation (15) restricts firms' cocoa bean inventory to greater than or equal to the quantity of beans processed and less than or equal to COCOBOD's inventory. This assumes that firms cannot import cocoa beans to process in Ghana. If we assume that $\widetilde{y_1} \geq \bar{q}_1 + \bar{x}_1$ with certainty, then the first constraint may be ignored and the optimal amount processed q_1 and ending inventory x_1 would be characterized by the independent complementary conditions

$$0 \leq q_1 \leq \bar{q}_1 \perp (\widetilde{\epsilon_1} - \alpha_1)\widetilde{p_1} - \eta_1 - \gamma_1 q_1 \tag{18}$$

$$0 \leq x_1 \leq \bar{x}_1 \perp \delta\hat{f}'(x_1) - \alpha_1\widetilde{p_1} \tag{19}$$

To numerically solve the model, we formulate a finite-dimensional approximation for the expectations function f by explicitly computing its value at prescribed nodes and using cubic spline interpolation to compute its values at other points of its domain as needed. We also use Gaussian quadrature methods to replace the continuous random variables with discrete approximation (Miranda and Fackler, 2002).

4.3 Parameterization

The model is a production inventory model with two distinct production periods, the main season and the light season. The processors decide what quantity of cocoa beans to buy and process in each season and how to adjust inventory when prices (or discounts) change between seasons. We collected a series of data for both main and light seasons from various sources to calibrate the model. The parameters that must be specified to make the model numerically soluble include:

1. Raw cocoa produced
2. International price of raw cocoa
3. International price of processed cocoa
4. COCOBOD's gross sales discount offered to processors
5. COCOBOD's gross purchase discount offered to producers
6. Quantity of raw cocoa purchased from COCOBOD by processors
7. Quantity of raw cocoa processed by processors
8. Quantity of raw cocoa acquired by processors in the main season but processed in the light season

Table 4 specifies the values of these parameters, deduced using data collected from COCOBOD, ICCO, and various papers and reports.

We ignore fixed cost in our analysis, as they do not affect the optimal quantities acquired, processed, or stored. Cocoa processing may well be characterized by an increasing-return-to-scale technology, with plants of greater capacity able to achieve lower average cost of production at their technical optimal throughput. However, in the short run, the scale of the plant is fixed and designed to operate most efficiently at a technically prescribed optimal throughput. In the short run, the plant can operate at lower or higher throughputs but at diminished efficiency and thus higher average cost of production, justifying a convex short-run cost function. An assessment of how policies might affect long-run capital investment by processors is beyond the scope of this study.

Table 4: Calibration Parameters

Parameter	Symbol	Season 1	Season 2	Units
Mean new production	μ_i^y	731.7	64.6	thousand tons
Standard deviation of new production	σ_i^y	119.3	15.9	thousand tons
Mean international price	μ_i^p	2.75	2.85	thousand USD per ton
Standard deviation of international price	σ_i^p	0.42	0.36	thousand USD per ton
Mean gross processing premium	μ_i^ϵ	1.87	1.95	unitless
Standard dev. of gross processing premium	σ_i^ϵ	0.28	0.24	unitless
Processor's fixed cost	$\bar{c_i}$	0	0	million USD
Processor's marginal cost function constant	η_i	0	0	thousand USD per ton
Processor's marginal cost function slope	γ_i	0.018	0.049	USD per ton-squared
COCOBOD gross discount to processors	α_i	1	0.8	unitless
COCOBOD gross discount to producers	β_i	0.7	0.7	unitless
Discount factor	δ	0.97		unitless

Source: Cocobod, ICCO, ACET, 2015

5. Numerical Solutions

The numerical solution to the model is presented in Figures 7 through 10. Figure 7 presents the quantity of main crop beans acquired by processors at different main season discount rates. We note from the graph that processors' demand for cocoa beans is highly sensitive to the main crop bean discount. The higher the main crop discount, the higher the proportion of main crop beans demanded by processors. The slope capturing the main crop beans acquired by processors becomes flatter as the discount rate increases, implying a higher demand as the discount increases. Figure 8 presents the carryover from the main season to the light season. A higher main season discount increases the quantity of beans carried over from the main season to be processed during the light season. This is because the main crop discount reduces the cost of processing during the main season, causing processors to reallocate cocoa beans to be processed in the light season in order to smooth yearly processing. Figure 9 shows the quantities of cocoa beans processed in both seasons as a function of the main crop discount. The main crop discount has a positive impact on the quantity of beans processed.

Figure 7: Quantity Acquired by Processors vs. Processors' Main Season Discount

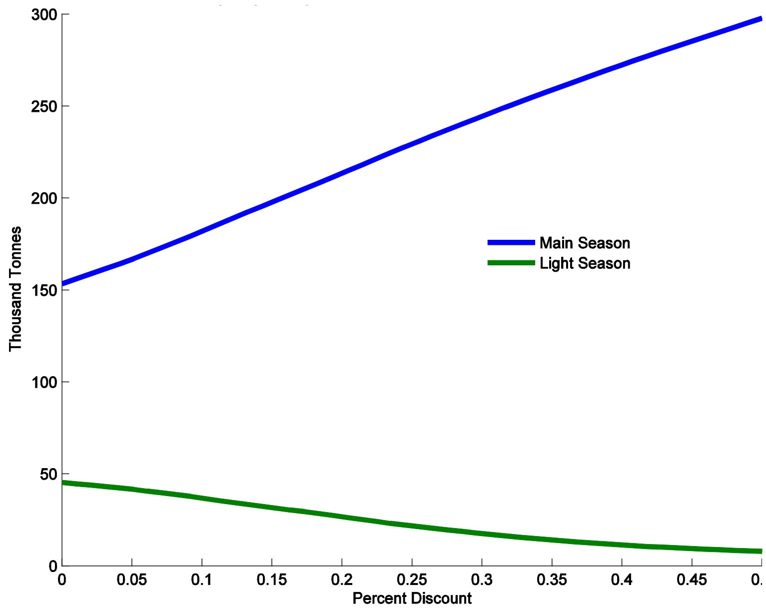


Figure 8: Processor Intra-Season Crossover vs. Processor Main Season Discount

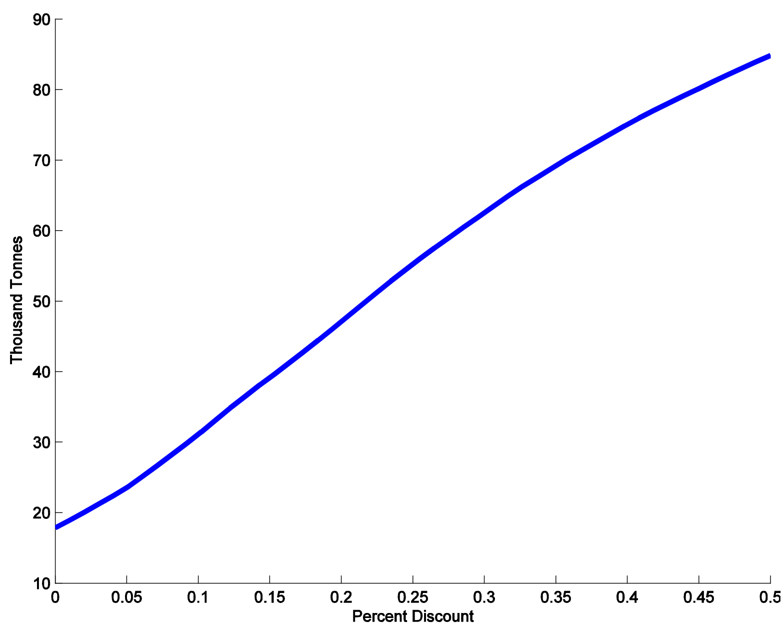


Figure 9: Quantity Processed vs. Processor Main Season Discount

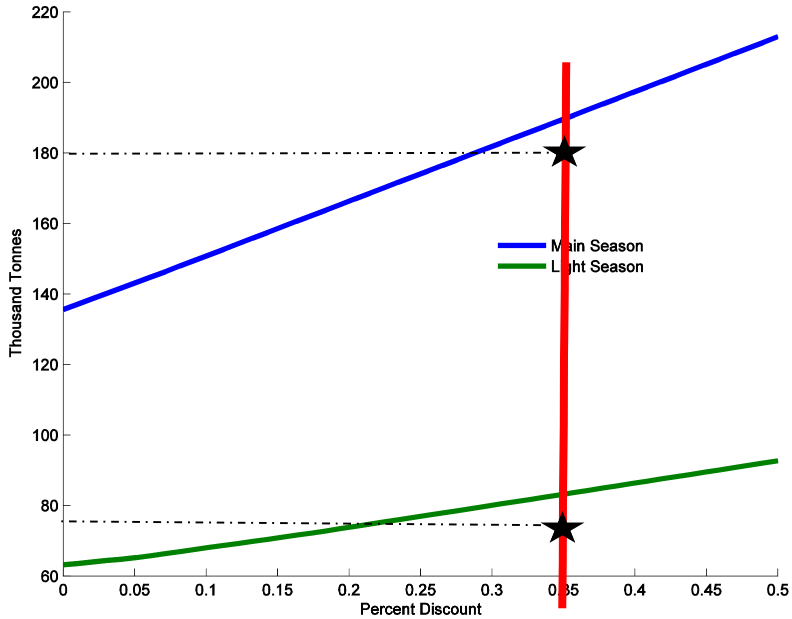
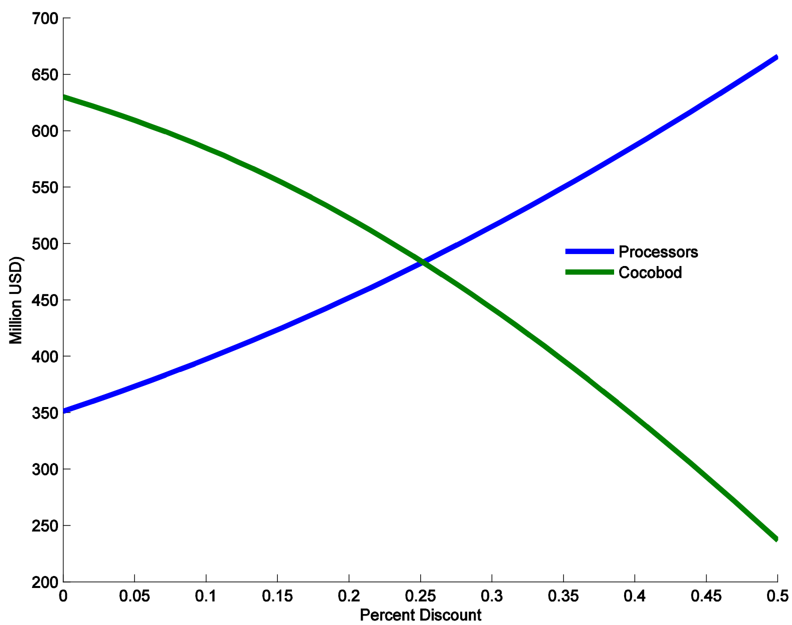


Figure 10: Annual Net Revenue vs. Processor Main Season Discount



Finally, Figure 10 presents the resulting revenue change for both COCOBOD and the representative processor as a function of the main crop discount. We note that at a 26 percent discount, COCOBOD's revenue equals that of the processor. Reaching MoTI's goal of locally processing 40 percent of the total quantity of cocoa beans processed will require a main crop discount of almost 35 percent, which will in turn reduce COCOBOD's revenue by 36 percent and increase processors' revenue by 57 percent.

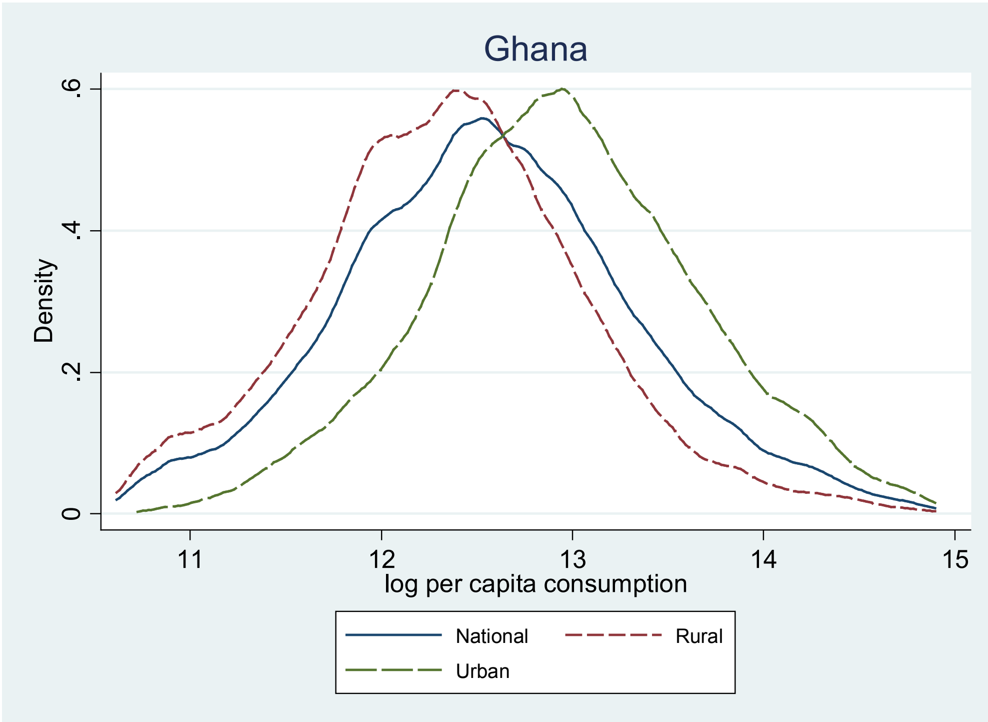
6. Implications for Cocoa Farmers' Welfare

The first-order effects of the estimated industrial policy are seen both on the price that farmers will receive and on the wages generated from newly created jobs in the cocoa processing sector. Söderbom and Teal (2004) identify the creation of more, and higher wage, jobs as the sole pathway through which industrial policy affects poverty. Job creation is directly linked to firms' demand for labor, which in turn is determined by the technology with which firms operate. However, capital-intensive firms such as cocoa processors are not expected to generate many new jobs. Thus, the only way that the Ghanaian cocoa policy will affect poverty is through the farm-gate price, which is determined by COCOBOD. COCOBOD may maintain the share of the international market price that is guaranteed to farmers in a given industrial policy regime, but the reduced profit to COCOBOD identified earlier will exert indirect negative impacts on producers. In fact, farmers may experience a reduction in annual bonuses, social services such as mass spraying, social security contributions, housing, and other technical supports. If COCOBOD gives discounts to processors, it is fair to assume that farmers will receive lower prices if the auxiliary services provided by COCOBOD are maintained. Depending on the share of income that cocoa beans sales represent for individual farmers, the anticipated price changes will affect the poverty rate.

To understand how COCOBOD's pricing policies affect poverty, first consider the income distribution in Ghana. (The household data in the following analysis comes from the 2005 "Ghana Living Standard Survey 5".) Figure 11 shows the estimated density function of the logarithm of household per capita expenditure at the national level and for urban and rural regions separately. As expected, the density for urban areas lies to the right of the density for rural areas, thus indicating that urban households enjoy, on average, a higher level of expenditure per capita than rural households.

Figure 11: The Distribution of Income

Density of (log) per capita Household Expenditure



Source: Ghana Living Standard Survey 5, 2005

Second, consider the patterns in sources of income across Ghanaian households shown in Table 5. As expected, rural households have lower shares of cash income (66.9 percent) because a significant part of their income is agricultural and auto-consumed. On the other hand, urban cash income represents 89.5 percent of total income, of which 10 percent is associated with agricultural income. Within the category of agricultural income, maize, cassava, and yam are the most important sources of income in rural areas. Taken together, these three crops account for almost 20 percent of all income in rural areas, but less than 6 percent for households in urban areas. Cocoa sales account for only 2.9 percent of rural income, but this proportion may be higher when we consider wages paid by the sector or by cocoa producers.

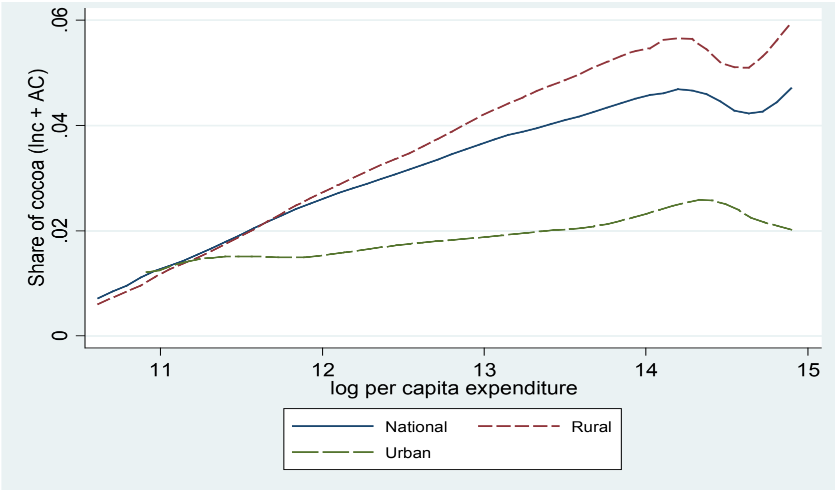
Table 5: Income Shares

Ghana	Total	Rural	Urban
Total Income per capita	**100,0**	**100,0**	**100,0**
Incomes	**72,3**	**63,3**	**89,5**
Food (agriculture)	27,0	36,8	8,2
Wage	14,6	6,9	29,1
Enterprises	25,0	15,7	42,6
Transfers	5,8	3,8	9,5
Auto-consumption	**27,7**	**36,7**	**10,5**
Auto-consumption food	25,3	34,9	7,3
Auto-consumption others	2,3	1,9	3,2
Total Food income and AC	**52,3**	**71,7**	**15,5**
Total crops	**24,8**	**33,9**	**7,6**
Maize	6,3	8,2	2,6
Rice	1,0	1,4	0,2
Poultry	0,9	1,2	0,2
Livestock	1,6	2,1	0,5
Wheat	0,0	0,0	0,0
Cassava	4,7	6,2	1,8
Sorghum	1,8	2,6	0,2
Millet	2,2	3,3	0,1
Cowpea	0,5	0,8	0,1
Yam	3,8	5,0	1,4
Cocoa	2,1	2,9	0,6

Source: Ghana Living Standards Survey 5, 2005

To evaluate the impact of industrial policy on poverty, we first characterize the distribution of income with the (log) of per capita household expenditure (*log pce*) and then plot estimates of non-parametric regressions of cocoa income on the *log pce*. Figure 12 displays cocoa income share across the income distribution. Income share from cocoa increases almost monotonically with the level of income in rural households. While the poorest rural households receive less than 1 percent of their income on average from cocoa production, this share increases to almost 6 percent on average for those households on the upper end of the distribution.

Figure 12: Cocoa Income Share across the Income Distribution



Source: Depetris-Chauvin, Porto, and Mulangu, 2015

Table 6: Change in Income Resulting from 1 Percent Change in Cocoa Price

Change in Income of Cocoa-Producing Households Only		
Total	Poor	Non-poor
0.624	0.596	0.659
Change in Income of All Households		
Total	Poor	Non-poor
0.103	0.102	0.105

Source: Depetris-Chauvin, Porto, Mulangu, 2015

Table 6 illustrates the corresponding income changes, for both cocoa-producing households and all households, resulting from a 1 percent change in the cocoa producers' price. While the impact of the price change is predictably higher (by almost six times) for cocoa producers than for all households, we did not find any significant differences between poor and non-poor cocoa producers and households. In other words, a change in the cocoa farm-gate price does not necessarily affect poor farmers and households more than it affects non-poor ones. However, the impact seems slightly higher for non-poor households, mainly because non-poor households get a higher share of their income from cocoa than poor ones, as illustrated in Figure 12.

Finally, we noted earlier that MoTI seeks to reach 40 percent processing capacity. One possible way to do this would be by issuing a 35 percent discount rate for processors on main crop beans, which would result in a reduction of COCOBOD's revenue by 36 percent, an increase in processors' revenue by 57, and no impact on farmers, as we have assumed in our model that COCOBOD bears the full cost of the discount.

However, if COCOBOD were to pass on the cost of the full discount rate to cocoa farmers, cocoa producers' income would be reduced by a maximum of 22 percent.

7. Conclusion

The purpose of this study is to understand what cocoa pricing option best meets the multiple, but possibly conflicting, public policy objectives of maximizing the Ghanaian government's tax revenue, maximizing and stabilizing processor profits and throughput, and reducing poverty rates, especially among cocoa bean producers. To conduct our analysis, we proceeded in two steps. First, we evaluated what would need to be changed within Ghana's current industrial policy regime to increase the country's cocoa processing capacity to 40 percent. Second, we estimated the impact on cocoa farmer's welfare. We found that this could be accomplished with a 35 percent discount on main crop beans, which would increase processors' revenue by 57 percent while either reducing COCOBOD's revenue by 36 percent or reducing cocoa farmers' incomes by 22 percent.

While a discount on main crop beans proves to generate sufficient incentives for processors to increase their capacity, the reality is that it reduces sum of profits across the cocoa value chain as a whole. In addition, cocoa processors already benefit from tax breaks, given that they mostly operate in the EFZ. This position prevents the government from compensating producers with any additional income tax revenue collected from processors, since processors in the EFZ are not required to pay income taxes for 10 years. In addition, the capital-intensive nature of the cocoa processing industry does not guarantee substantial job creation. We illustrated that the number of workers per factory has decreased, from 442 in the early 2000s to 117 today. Finally, other sectors may benefit from spillover effects, such as technology transfer, associated with the expansion of the cocoa processing sector. While this is hard to measure, we can argue that the insular nature of EFZ companies may reduce these spillover effects to the rest of the economy.

If Ghana wants to increase the quantity of cocoa processed locally, it must either revise cocoa processing firms' EFZ incentives before adjusting their cocoa pricing options or seek to attract more processing firms into the sector. However, Ghana should not expect to gain much in terms of employment expansion or tax revenue as long as it keeps attracting new cocoa processing firms via the EFZ benefit.

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Appendix

Data Sources

The data presented below were collected from various sources, including COCOBOD, ICCO, and various reports on cocoa value chains found online.

1. **Raw Cocoa Produced, Main Season and Light Season**

Table A: Raw Cocoa Produced, Main Season and Light Season

Year	Quantity Produced Main Crop	Quantity Produced Light Crop	Quantity Purchased by Processors Main Crop	Quantity Purchased by Processors Light Crop	Quantity Processed by Processors Main Season	Quantity Processed by Processors Light Season	Quantity of Main Crop Carried Over to Light Season
2009/10	587,794	44,243	168,003	44,243	128,462.90	83,783.10	39,540.10
2010/11	626,518	73,502	156,193	73,502	137,047.67	92647.33	19,145.33
2011/12	800,207	79,141	132,569	79,141	117,267.37	94,442.63	15,301.63
2012/13	770,466	65,000	165,897	65,000	137,296.81	93,600.19	28,600.19
2013/14	880,000	50,000	178,800	50,000	153,736.23	75,063.77	25,063.77
All quantities measured in metric tons.							

While drier weather resulting from climate change and variability could have an impact on bean size, the proportion of small beans (i.e., light crop) has averaged about 10 percent of total production in the last decade. This has implications for the cocoa grinding sector in Ghana.

2. **International Price of Raw Cocoa**

The main season runs from October to June, and the light season from July to September. We used monthly international cocoa prices to estimate the corresponding international prices for the two seasons.

Table B: International price of cocoa beans

Year	Main season	Light season
2009	2863.78	2963.62
2010	3157.74	3058.73
2011	2961.69	3035.12
2012	2357.79	2494.12
2013	2236.57	2469.67
2014	3007	3227

3. **International Price of Processed Cocoa**

This is a composite price of butter, cake, and powder, the three main intermediate cocoa products.

Table C: International price of processed cocoa

Year	Main season	Light season
2009	5464.69	5655.21
2010	6025.63	5836.70
2011	5651.52	5791.64
2012	4499.16	4759.30
2013	4267.84	4712.65
2014	5737.98	6157.79

4. **COCOBOD Gross Sales Discount Offered to Processors for Main Crop Beans and Light Crop Beans**

The light season COCOBOD gross sales discount offered to processors is 0.80 and has not changed over the years. The main season COCOBOD gross sales discount offered to processors is 1.0 and has not changed over the years.

5. **COCOBOD's Gross Purchase Discount Offered to Producers**

Today farmers receive 72 percent of international market price

Table D: Share of cocoa beans price received by farmers over the years

Year	Gross discount to producers in seasons 1 and 2
07/08	66%
08/09	75%
09/10	66%
10/11	68%
11/12	72%
12/13	72%
13/14	72%

6. **Quantity of Raw Cocoa Purchased from COCOBOD by Processors, Main and Light Season**

See Table A.

7. **Quantity of Raw Cocoa Processed by Processors, Main and Light Season**

See Table A.

8. **Quantity of Raw Cocoa Acquired by Processors in Main Season, but Processed in Light Season**

See Table A.

9. **What is the monthly processing capacity of processors?**

See Table A.

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