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A Quantitative Assessment of the National Cocoa Disease and Pest Control (CODAPEC) Program in Ghana.

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Abstract

Agriculture in general and cocoa production in particular, has been plugged with many challenges including the high incidence of diseases and pests' infestation. In 2001, the government of Ghana implemented the National Cocoa Disease and Pest Control (CODAPEC) program which aimed at providing free spraying of cocoa plants to cocoa growing farmers to fight against the rising incidence of diseases and pests' outbreak and more importantly, curb the declining cocoa production and quality of yield. This paper, therefore, examines the impact of the CODAPEC program on yield, production and revenue at the aggregate level and diverts from the micro approach widely used in the literature. Overall, the analysis shows substantial growth in production and revenue but particularly strong for the periods following the implementation of the program. The analysis also shows significant differences in mean production and revenue before and after the implementation of the policy. However, much of the growth in production represents a recovery from long years of production slump, hence, had only moderate effect on revenue growth. Nevertheless, to sustain and accelerate economic growth, we strongly recommend that greater investment should be geared towards the agriculture as sector remains key to any development agenda of the government.

Keywords: Cocoa; Production; Yield; Revenue; Decomposition; Ghana.

1. Introduction

Despite the dominance of the mining sector and informal services, agriculture remains the backbone of the Ghanaian economy. The sector employs about 40% of the country's labour force and contributes over 25% to the country's GDP (Research & Information Directorate 2010; Owusu, 2016). However, agriculture in Ghana is dominated by cocoa production. Cocoa continuous to be the country's major agricultural export, key source of foreign exchange and an important source of rural household income in Ghana. In fact, the importance of cocoa to the Ghanaian economy has been well documented. For example, cocoa ranks second to gold in foreign exchange earnings and contributes over 50% to the country's total revenue from agricultural export (Dormon et al., 2004; Lundstedt & Pärssinen 2009; Anang et al., 2013). In terms of employment, it has been estimated that about 865,000 farmers are directly engaged in cocoa production in Ghana while more than 2 million people derive their livelihood from cocoa production (Gakpo, 2012; Anang et al., 2013). Per Ntiamoah and Afrane (2008), the cocoa sub-sector employs about 60% of the country's agriculture labour force (Note 1). Therefore, tackling any threats to the cocoa sub-sector remains an important agenda for any government in Ghana.

However, the agriculture sector in general and cocoa production as a sub-sector is faced with major challenges, among which include access to credit, diseases and pests' infestation, adverse climate and poor soil quality. Together, these factors adversely affected the country's position as the world's leading producer of cocoa beans (Nyanteng, 1980; Obeng & Opoku, 2008; Grossman-Green & Bayer, 2009, Oduro & Omane-Adjepong, 2012) (Note 2). To tackle some of these challenges, there has been several policy reforms/interventions in the agricultural sector and the cocoa sub-sector in particular. One such policy intervention (which forms the focus of this paper) is the National Cocoa Disease and Pest Control (CODAPEC) (Note 3), popularly known as the Mass Cocoa Spraying Exercise, introduced in 2001 under the auspices of then president, John Agyekum Kuffour and in with the Ghana Cocoa Board (COCOBOD) overseeing its implementation. The key objective of this policy intervention was to address the rising and persistent incidence of diseases and pests to arrest declining cocoa production and quality of yield. The program provides mass spraying of cocoa trees to farmers at no cost (Dormon et al., 2004; Abankwah et al., 2010; Duker and Sakpaku, 2011; Oduro and Omane-Agyepong, 2012; Anang et al. 2013). It must be indicated that several similar initiatives had been undertaken by various governments, especially, in the 1950s, 60s and 80s but were mostly discontinued by successive governments,

necessitating the reintroduction of a similar program in 2001.

This policy initiative, not only has the potential of increasing yield but also improving income and the general welfare of the large but poor rural farming households. This paper, therefore, examines the impact of the CODAPEC policy intervention on the country's cocoa yield, production, and revenue (income). To achieve this objective, first, we conduct a trend analysis on yield, production and revenue of cocoa over the past 40 years. Second, we examine these trend analyses using a Mean Differences statistical testing procedure to determine if differences observed in these variables over time, (thus, before and after the implementation of the program), are statistically significant. Next, to have a quantitative assessment of the relative contribution of production to revenue, the growth in revenue accruing from cocoa production is decomposed into its core constituents: (i) the pure price effect, (ii) the pure output (production) effect and (iii) the correlation effect. The decomposition analysis permits the determination of the relative contributions of each component to revenue growth. The paper therefore, contributes to the existing literature by providing a systematic way of quantifying the relative contribution of output (production) growth resulting from the CODAPEC policy intervention to revenue growth.

The paper differs in two ways from past studies that had sought to evaluate the impact and effectiveness of the program. First, whereas most of these studies [see for example Abankwah et al., 2010; Duker and Sakpaku, 2011; Anang et al., 2013; Kumi & Daymond, 2015] had examine this issue from the micro perspective, this paper adopted a macro approach. Second, our paper can quantify the impact of the program on revenue growth vis-a-vis its impact on production. For example, Abankwah et al. (2010) examined the socio-economic impact of the program on cocoa farmers in the Ahafo Ano South District of Ghana. The paper identified that whereas the program indeed increased cocoa production, farmers' real income declined due to pronounced inflationary effect. Their paper, however, focused on only one district and for a five-year period compared to our paper which focuses on the aggregate economy and for a uch extended period. Duker and Sapkaku (2011) also assessed the impact of the program on cocoa production and marketing albeit in only one district (Juaboso Cocoa District) and focusing on farmers' satisfaction or dissatisfaction of the program as opposed to a quantitative assessment. Moreover, whereas Anang et al. (2013) assessed the effectiveness of the program for a sample of 120 cocoa farmers from six communities, Kumi and Daymond (2015) on the other examined farmers' perceptions about the effectiveness of the program for a sample of 150 cocoa farmers from five communities. However, to the best of our knowledge, our paper is the first to quantitatively assessed the program's impact on yield, production and revenue generation at the aggregate level. Although our paper closely relates to the work of Oduro and Omane-Agyepong (2012), we differ in terms of the methodological approach.

The rest of the paper is structured as follows. Section 2.0 provides a general overview of the major policy initiatives that have been undertaken in the agricultural sector in Ghana. Section 3.0 presents a simple methodology of decomposing the growth in revenue into its core constituents as well as a description of the data sources for the study. Section 4.0 presents the analysis (trends, test of differences in mean and revenue growth decomposition) of the study along with discussions. Section 5.0 provides the conclusion and key policy recommendations of the paper.

2. Policy Initiatives in the Agricultural Sector in Ghana

Recognizing the importance of the agricultural sector, the Ministry of Agriculture (MoFA) has over the years outlined its vision for the sector, reiterating the ambition of modernising and structurally transforming agriculture to promote food security, improve employment opportunities and above all reduce poverty by increasing revenue to farmers. Since the fourth republic especially, governmental strategic frameworks and plans have been aimed at infrastructure development, agricultural research and extension to achieve greater agricultural productivity (Government of Ghana, 2007). One such important framework is the Food and Agriculture Sector Development Policy (FASDEP) which was initially introduced in 2002. The framework has its roots in the 1996 Agriculture Growth and Development Strategy and was designed to guide the development and interventions in the agriculture sector with the main objective of modernising the sector (Government of Ghana, 2007). After four years of its implementation, a review of the plan was done to reflect new developments, expectations and lessons learned. Consequently, in 2007, FASDEP II was introduced, with emphasis on sustainable utilization of all resources and commercialization (market-driven growth) of agricultural activities. It strongly aimed to promote food security and income diversification especially among the vulnerable and poor farmers (Government of Ghana, 2007).

To encourage the maximisation of income from the agricultural sector, additional poverty alleviating policies have been adopted and implemented. These policies, mostly, have been directly aimed at improving production,

increasing income and by extension reducing poverty. Some of these programs include fertilizer subsidy program, the agriculture mechanization centres program, irrigation development program, the block farming program and National Cocoa Disease and Pest Control (CODAPEC) (Dormon et al., 2004; Obeng & Opoku, 2008; Abankwah et al., 2010; Duker and Sakpaku, 2011; Oduro & Omane-Adjepong, 2012; Anang et al., 2013). Re-introduced in 2008, the fertilizer subsidy program was in response to hikes in prices of fertilizer and its resultant rise in food prices. The program heavily subsidised fertilizer up to 50 per cent of prices (Obeng & Opoku, 2008).

The agriculture mechanisation program was launched mainly to improve upon the low mechanisation of the Ghanaian agriculture industry. The mechanism is to provide agriculture machinery to investors through a flexible credit facility, with the investors subsequently renting out to farmers at discounted rates. Although this mechanisation program has not been as successful as anticipated due to the rather unprofitable nature of the scheme to investors, it was nonetheless well intentioned. The block farming program was launched in 2009 as a component of 'Youth in Agriculture' program. It was mainly aimed at making available, arable land for the cultivation of selected commodities to the youth. The scheme served as another employment generating scheme for the youth in rural areas. In addition to arable lands, the block farms receive a bundle of subsidized mechanization services, inputs and extension services which are repaid in kind after harvest (Obeng & Opoku, 2008).

Historically, the agricultural sector in general and cocoa production specifically, has been susceptible to devastating effects of diseases and pest infestation (Nyanteng, 1980; Obeng & Opoku, 2008; Grossman-Green & Bayer, 2009, Oduro & Omane-Adjepong, 2012). Therefore, in 2001, the government introduced the CODAPEC program also known as the mass cocoa spraying program, specifically, for the cocoa sub-sector. The program's major aims include improving overall yield in cocoa production by combating capsid and black-pod diseases, pests' infestation, providing farm rehabilitation, enhancing cocoa producer price, providing soil fertility management, planting materials, and research and extension services to cocoa farmers. The program was overseen by the Ghana Cocoa Board (COCOBOD) the main body charged with providing support for the cocoa sub-sector and responsible for regulating the marketing of bulk Ghanaian cocoa on the international market (Nyanteng, 1980; Dormon et al., 2004; Obeng & Opoku, 2008; Grossman-Green & Bayer, 2009; Abankwah et al., 2010; Duker and Sakpaku, 2011; Oduro & Omane-Adjepong, 2012; Anang et al., 2013).

The program covered all the six cocoa growing regions in Ghana: Ashanti, Brong Ahafo, Central, Eastern, Western and Volta regions. It had an initial budget of thirty-two million US Dollars (Cocoa Board, 2016). Besides aiming to increase farmers' income, the program had several other objectives in addition to its core intention. Some of these include training farmers and other personnel on the culture and methods of pests and diseases control, education and training of local sprayers on safe use of pesticides and chemicals, and importantly, creating jobs for the unemployed youth in the rural communities (Cocoa Board, 2016).

In terms of structure, the program was broken into national, regional, district and local levels for easier administration and coordination. The national level was to ensure the availability of chemicals, spraying equipment and protective clothing, including the salaries of all workers across the six cocoa growing regions. The regional level administration, which is made up of the regional ministers, chief farmer in the regions, the regional cocoa managers, and the regional representative from licensed cocoa buying companies, are tasked with distributing chemicals, protective cloths and spraying machines to the various districts (Obeng & Opoku, 2008).

The district levels, managed by the district chief executives, the district cocoa managers, the district chief farmers, and the district representative from licensed private cocoa buying companies in the districts, see to the distribution of chemicals, protective clothing, spraying machine and equipment the spraying workers in each community. They ensure this is done in a fair manner and under strict supervision to ensure greater efficiency in the use of materials and chemicals (Obeng & Opoku, 2008).

Finally, the local level management committee consisted the local chief farmers, supervisor of the spraying band, area council assemblymen/women, and local representatives from licensed private cocoa buying companies. The spraying exercise is done by ten sprayers for black pod and six sprayers for capsid. Both groups of sprayers have a supervisor who is responsible for the general supervision at the unit level to ensure efficiency. Farmers at the local levels are responsible for pruning, shade management, removal of black and diseased pods, provision of water for spraying and monitoring of spraying on the farm to for satisfactory results (Obeng & Opoku, 2008).

3. Methodology

This section briefly presents the research design and data sources of the paper.

3.1 Research Design – A Growth Decomposition Analysis

Revenue is determined as the product of price and quantity. Hence, growth in revenue can emanate from either a growth in price, output (production) or a combination of both price and output growth (Owusu et al., 2016). Therefore, to determine the relative contribution of output (production) to revenue growth after the implementation of the program, we decompose the growth in total revenue from cocoa production into pure price, pure output and the correlation effects as:

$$\Delta R_t = Q_{t-k}\,\Delta P_t + P_{t-k}\,\Delta Q_t + \Delta Q_t\,\Delta P_t \quad (1)$$

where R denotes total revenue, Q denotes the quantity of cocoa production, P denotes price of cocoa and Δ denotes change. The first component captures the pure price effect, which is the change in total revenue resulting purely from price change. The second component is a measure of the pure output effect, which is the growth in cocoa revenue resulting solely from output growth. The correlation effect captures the combined effects of concurrent changes in both output and price. The following observations are particularly worth noting about the correlation effect component. When price and output growth correlate positively, the growth in revenue is magnified. On the other hand, when the correlation between price and output growth is negative, this term contributes negatively to revenue and growth in revenue is reducing. Therefore, the relative contribution of this term to revenue growth depends on the magnitude and direction of the price and output changes (Owusu et al., 2016) (Note 4).

3.2 Data Source

The Data for the analysis were mainly obtained from the Food and Agricultural Organization of the United Nations (FOASTAT) and World Bank Commodity Price Database. The FOASTAT publishes information on cocoa prices (producer prices), area harvested, yield and production (output) levels for all countries. The World Bank Commodity Price Database publishes data on primary commodity prices in real and nominal US dollars. Price and revenue analysis are done in US dollars. However, data on cocoa producer prices obtained from FOASTAT are stated in local currency units. These prices are therefore converted to US dollars using historical exchange rate data obtained from the Penn World Table (PWT).

4. Results and Discussions

This section presents the results and discussions of the analysis. I first examine the trend analysis on crop yield. This is followed by a mean difference analysis before presenting the result of the revenue growth decomposition analysis.

4.1 Trend and Differences in Mean Analysis

As mentioned earlier, the mass cocoa spraying program (CODAPEC) was initiated predominantly to address the declining trend in cocoa production in Ghana. Therefore, to evaluate the impact of the program, we particularly focus how the program impacted on area harvested of cocoa bean, yield, production and revenue growth. Figure 1 shows the trend in total area harvested for cocoa bean from 1961 to 2013. The analysis shows that prior to 1995, the total area harvested for cocoa bean significantly declined from a land area of 1.76 million hectares to 0.69 million hectares, a cumulative drop of over 60%. Growth in area harvested bounced back in 1995, however, much of this growth was a recovery from past years' slump. Nonetheless, with the implementation of the mass cocoa spraying program in 2001, the total area harvested responded, sharply rising from 1.35 million (ha) in 2001 to 2.0 million (ha) by 2004 before levelling to 1.6 million (ha) in 2013. Overall, between 2001 and 2013, total area harvested grew at a geometric rate of 1.42% per year compared to 7.90% per year between 2001 and 2004 and -0.70% per year between 1961 and 2001.

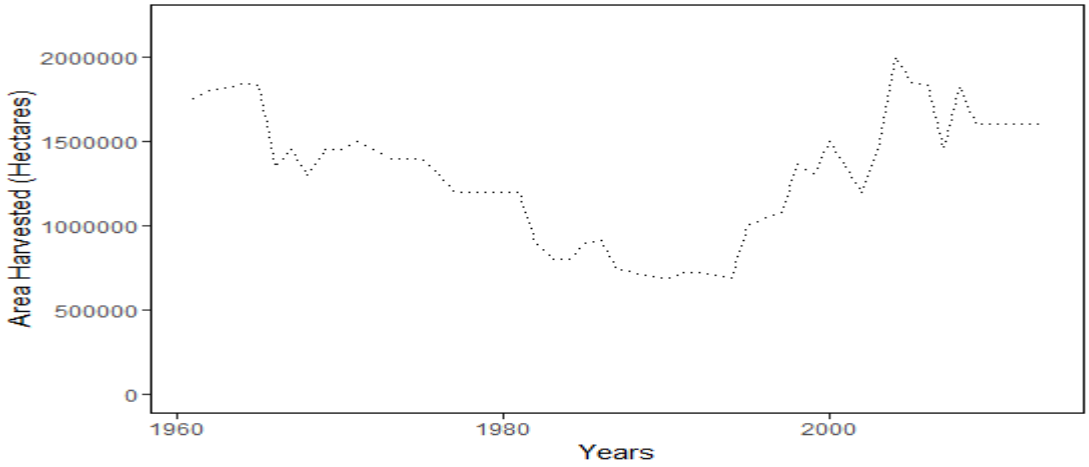

Figure 1. Area Harvested (Hectares) for Cocoa Bean Production in Ghana for the period 1961-2013.
Source: Data obtained from the Food and Agricultural Organization (FOASTAT) Database. Accessed Online on December 22, 2016.

Aside the sharp rise in total area harvested, the impact of the policy has also been particularly strong on both production and yield per hectare (Hg/Ha). Figure 2 presents a trend analysis on cocoa yield and production for the period 1961 to 2013. The analysis shows that both yield and production level had been particularly strong, especially, after 2001. The analysis shows that over the period 1961 to 2013, cocoa production grew at an annual rate of 1.3%. Prior to 2001, production was sluggish and grew at a rate of -0.20% per year between 1961 and 2001. However, growth was particularly strong after 2001, with an annual growth rate of 6.4% 2001 and 2013. The analysis on yield is similar to production. Over the period under consideration, yield per hectare rose from 2364 (Hg/Ha) in 1961 to 5221 (Hg/Ha) in 2013, an equivalent annual growth of 1.52%. However, prior to 2001, yield grew at an average rate of 0.50% per year compared to its rate of 4.94% per year between 2001 and 2013. The strong growth in both yield and production also corresponds to periods under the implementation of the mass spraying program, again lending further evidence to the overall effectiveness of the program.

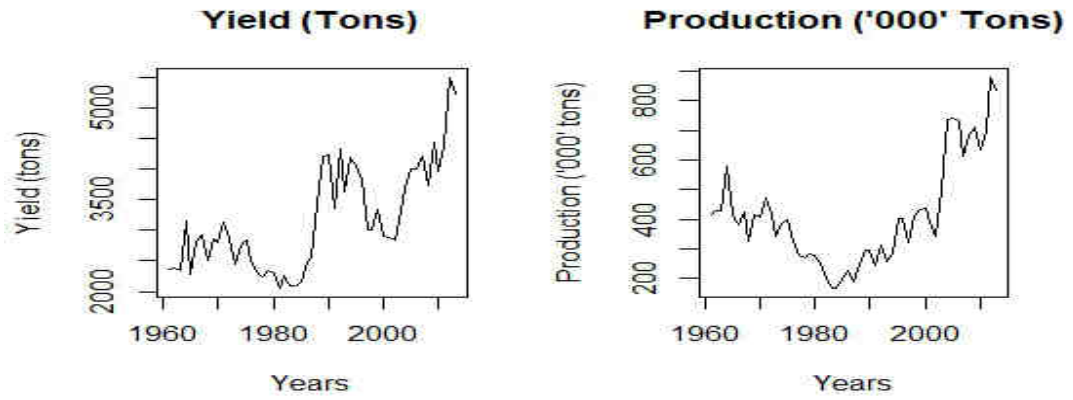

Figure 2. Cocoa Bean Yield (Tons) and Production (‘000 of Tons’) in Ghana for the period 1961-2013
Source: Data obtained from the Food and Agricultural Organization (FOASTAT) Database. Accessed Online on December 22, 2016

The above analysis thus, provides some crude, albeit, weak evidence in support of the positive impact of the program on the economy and farming households’ welfare in particular. However, to provide further quantitative assessment of the program’s impact, we use a two-stage approach. First, we quantitatively and statistically examine the dynamics in yield, production and revenue before and after the implementation of the program using Differences in Mean Test. This statistical analysis split the data into sampled groups, examine their means and statistically test for the significance in the differences in mean. Table 1 presents the result of the analysis.

Overall, the analysis shows significant differences in mean yield, production and revenue for two sub-periods,

1970-2001 and 2001-2011. The mean yield, production and revenue for post program implementation were respectively 3766.72 Hg/Ha, 616.01 thousand tons and $699.12 million which are substantially higher than the prior program implementation levels of 2959 Hg/Ha, 309.08 thousand tons and $137.71 million respectively in 2001. These differences are also statistically significant even at 1% level (Note 5).

Cocoa production generates significant foreign exchange (revenue) to the Ghanaian economy and income to farming households. Therefore, the second stage quantitatively assesses the contribution of cocoa production to revenue growth before and after the implementation of the program using a growth decomposition analysis. Before discussing the results, it is important to briefly discuss prices. Alternative set of prices available for the analysis are: international (nominal/real) and domestic/producer prices.

Table 1. A Test of Differences in Mean Production and Revenue of Cocoa Bean

Category	**Yield (Hg/Ha)**		**Production (000 Tons)**		**Revenue (US $M)**	
	Prior to 2001	After 2001	Prior to 2001	After 2001	Prior to 2001	After 2001
Mean	**2959**	**3766.72**	**309.08**	**616.01**	**137.71**	**699.12**
Mean Difference Test:						
t-Stat	-3.85		-6.67		-5.90	
t Critical two-tail	2.07		2.16		2.23	
P(T<=t) two-tail	**0.00**		**0.00**		**0.00**	

Source: Authors own calculation based on data obtained from the Food and Agricultural Organization (FOASTAT) Database. Accessed Online on December 22, 2016. The test assumed unequal variance given the un-even sample sizes.

The choice of price can be particularly critical for this type of analysis. However, given the similarities in the dynamics of prices as shown in Figure 3, this should not significantly bias the results. The figure shows a high correlation across the three prices (real, nominal and producer price), especially, in recent years. Therefore, for the purpose of this study, the producer price is the preferred price and we justify this as follows. First, this price closely reflects the average price receive by farming households. Thus, for welfare considerations the producer price is the ideal. Second, producer prices exhibit less volatility compared to real and nominal prices. Even though real prices could have also been ideal (given that they adjust for inflation), nonetheless, they largely reflect global/international market conditions. Most producers end up getting less than this price, hence not ideal for welfare considerations.

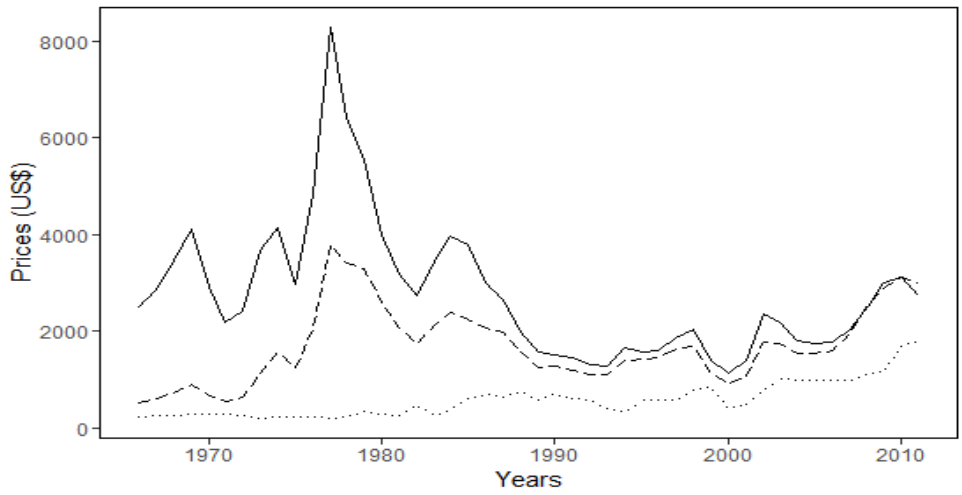

Figure 3. Nominal, Real and Producer Prices for Cocoa Bean Production.
Source: Data obtained from the Food and Agricultural Organization (FOASTAT) Database. Accessed Online on December 22, 2016. The solid line denotes real prices the dashed line denotes nominal price and the dotted line denotes producer price.

Figure 4 shows a trend analysis on cocoa revenue in Ghana from 1970 to 2011. Over this period, the analysis

show that revenue grew at an annual geometric rate of 5.81%, rising from a low level of $119.40 million in 1970 to 1.27 billion in 2011. However, as is evident from the figure, there are significant dynamics in revenue growth over this period. For example, between 1961 and 2001, growth in cocoa revenue stagnated, growing marginally at 1.55% per year. The stagnation in revenue was mainly due to combinations of declining production level and low cocoa prices. Over this period, cocoa production declined by 4.13% whereas prices appreciated by approximately 52.05%, thus the 1.55% yearly growth in revenue. On the other hand, between 2001 and 2011 growth in revenue was particularly strong, with revenue growing at a yearly rate of 19.04% (cumulative growth of 195.16%). Further analysis showed that between 2001 and 2011, cocoa production increased (cumulative growth) by almost 60% whereas prices appreciated by over 130%, an equivalent geometric annual growth rate of 5.86% and 13.18% respectively.

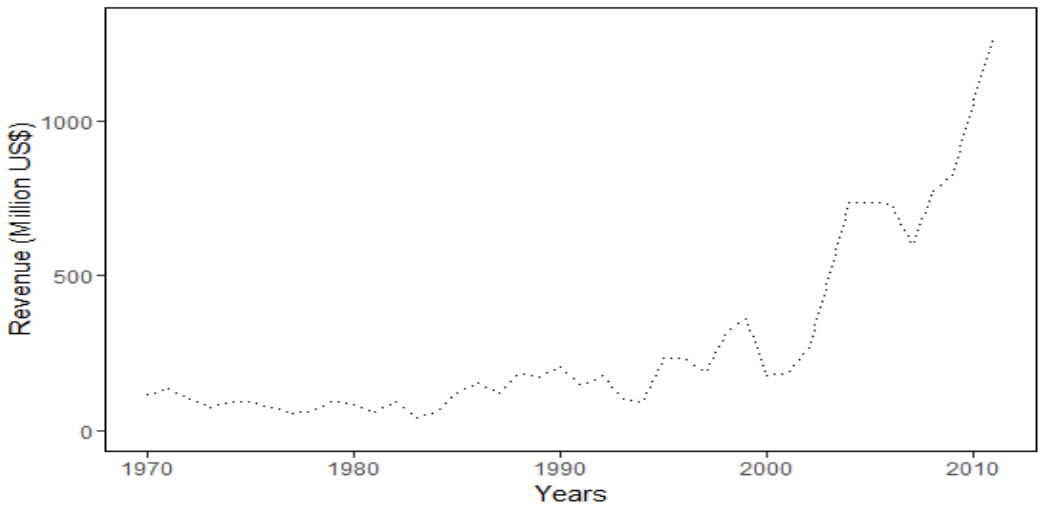

Figure 4. Total Revenue from Cocoa Production in Ghana for the Period 1970-2011
Source: Authors own calculation. Revenue is calculated as price of cocoa bean (US$) times the quantity of cocoa bean produced. Data on price and quantity are obtained from the Food and Agricultural Organization (FOASTAT) Database. Accessed Online on December 22, 2016.

4.2 Revenue Growth Decomposition Analysis

To quantitatively examine the dynamics and relative contributions of price and output (production) to revenue growth, Table 2 presents the result of the revenue decomposition analysis, for the overall period as well as sub-periods corresponding to periods prior to and after the implementation of the program. The analysis shows that despite the significant growth in production, its contribution to overall revenue growth has been relatively small. With an overall annual revenue growth of 5.81% between 1970-2011, the contributions from the pure output and price effects were respectively 0.43% and 3.12%, representing a relative percentage contribution of 7% and 54% to revenue growth respectively.

The sub-period analysis shows slightly different dynamics, nonetheless with the strongest relative contribution coming from again price appreciation rather than production growth. For example, prior to the implementation of the program in 2001 (thus, between 1970-2001), revenue stagnated, and the relative contributions from pure output and price effects were respectively -0.10% and 1.72%, representing a relative percentage contribution to revenue growth of -7% and 111% each. This essentially implies that the growth in revenue resulted solely from price appreciation and nothing from output/production growth. In fact, the decline in production level over this sub-sample period constrained revenue growth.

Table 2. Decomposition of Revenue Growth into Pure Price, Output and Correlation Effects

Year	Pure Output Effect	Pure Price Effect	Correlation Effect	Overall Revenue Growth
1970-1980	- 3.73	0.61	- 0.19	- 3.31
1980-1990	0.36	8.17	0.48	9.01
1990-2001	3.12	- 2.97	- 0.97	- 0.82
1970-2001	**-0.10**	**1.72**	**-0.07**	**1.55**
2001-2011	**2.66**	**9.12**	**7.27**	**19.04**
1970-2011	**0.43**	**3.12**	**2.26**	**5.81**
% Contributions:				
1970-2001	**-7%**	**111%**	**-4%**	**100%**
2001-2011	**14%**	**48%**	**38%**	**100%**
1970-2011	**7%**	**54%**	**39%**	**100%**

Source: Authors own calculation based on data obtained from the Food and Agricultural Organization (FOASTAT) Database. Accessed Online on December 22, 2016.

On the other hand, the analysis for after the program's implementation in 2001 showed a much stronger contribution from output growth, with the pure output effect contributing about 14% to revenue growth, or equivalently, an annual growth rate of 2.66%. Also, comparison across the various sub-periods also shows a much stronger contribution from the pure output growth, with relative contribution of 2.66% after 2001 compared to -0.10% for 1970-2001 and 0.43% for 1970-2011. Nonetheless, comparison across the different growth sources show that despite the significant growth in cocoa production, its contribution remains relatively small and significant growth in revenue has resulted from the pure price and the correlation effects.

5. Conclusion and Policy Recommendations

This paper quantitatively, examines the impact of the mass cocoa spraying program on the economy of Ghana with particular focus on yield, production and revenue growth. The analysis shows that although yield and production appears to have responded positively to this policy intervention, much of the gains represent a recovery from lengthy years of drop in production. Thus, despite the significant surge in cocoa production following the implementation of the program, its contribution to revenue growth remains relatively small and much of the growth in revenue has result from the strong growth in prices. Nevertheless, to sustain and accelerate growth, we strongly recommend that greater investment (private and public) should be geared towards the agricultural sector in general and specifically, cocoa production. This will involve sustaining such important policies as CODAPEC, conducting periodic reviews and improving upon these programs, doing well to in-cooperate valuable lessons learnt. To improve results, it is important that such policies have an inclusive and a multi-stakeholder approach to them to deepen the institutionalization of their implementation. This will require engaging with farmers, agro-businesses, civil society and other actors during the design, implementation and monitoring of policies and strategies for growth within the cocoa sub-sector.

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NOTES

Note 1. It is estimated that about 70-100% of smallholder farmers' annual income is derived from cocoa production (Anang, Mensah & Asamoah, 2013).

Note 2. Currently, Ghana ranks next to Ivory Coast as the leading producer of cocoa.

Note 3. Detailed description of the CODAPEC program is provided in section 2 of paper.

Note 4. See Owusu et al. (2016) for detailed treatment of this methodology and McMillan & Rodrik (2011).

Note 5. The t-test statistic for the mean difference in yield, production and revenue 3.85, 6.67 and 5.90 respectively.

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