Effect of gold mining on total factor productivity of farmers: Evidence from Ghana

Yaw B. OSEI-ASARE[1], Michael O. ANSAH[1], Akwasi MENSAH-BONSU[1], John K. M. KUWORNU[2]

ABSTRACT

Gold mining comes with several benefits to developing countries, manifested mainly in the form of employment and revenue, but simultaneously impacts negatively on the immediate environment. It affects the economic structure including agriculture and its productivity. Hence, this study investigated the effect of gold mining on total factor productivity of farmers in Ghana using 110 cocoa farmers from Asutifi North and Asutifi South districts of the Brong Ahafo Region, categorised into mining and non-mining areas respectively. About 83 % of the farmers in the mining areas were affected by gold mining through channels such as land disputes, relocation of farm/residence, high cost of labour, illegal small-scale mining and dust settlement on crops. Also, about 64 % of cocoa farmers in the mining areas lost their farm lands (between 0.4 and 3.64 ha as a result of gold mining. The Tornqvist Total Factor Productivity (TFP) indices for cocoa farmers in the non-mining areas (mean TFP of 1.404) were also statistically higher than those in the mining areas (mean TFP of 0.371). The study concluded that gold mining activities adversely affect productivity of farmers in the catchment areas. The study recommends, among others, that a policy of land-for-land should be in place and effectively implemented to ensure that mining companies in order to enhance and ensure continuity of livelihoods must fully replace lands lost through mining activities.

Key words: gold mining; total factor productivity; cocoa; Tornqvist; Ghana

IZVLEČEK

VPLIV ZLATOKOPOV NA CELOKUPNI DEJAVNIK PRODUKTIVNOSTI KMETOV: PRIMERI IZ GANE

Zlatokopi prinašajo v dežele v razvoju številne koristi, ki se kažejo v obliki zaposlitev in prihodku, a imajo hkrati negativne učinke na neposredno okolje. Vplivajo na gospodarstvo, vključno s kmetijstvom in njegovo produktivnostjo. V raziskavi je bil na osnovi ankete med 110 pridelovalci kakava na območjih Asutifi North in Asutifi South, regije Brong Ahafo preučevan vpliv zlatokopov na skupno produktivnost kmetov v Gani, ki so bili razdeljeni na območja z in brez rudarjenja. Okrog 83 % kmetov na območjih z rudarjenjem je bilo prizadetih zaradi te aktivnosti in sicer zaradi prepirov za zemljišča, premestitev kmetij/bivališč, velikih stroškov dela, ilegalnega malopovršinskega rudarjenja in usedanja prahu na posevke. Okrog 64 % pridelovalcev kakava je na območjih z rudarjenjem izgubilo svoja kmetijska zemljišča (od 0,4 do 3,64 ha kot posledica zlatokopov). Indeksi Tornqvistove skupne faktorske produktivnosti (TFP) pridelovalcev kakava so bili na območjih brez rudarjenja statistično značilno večji (poprečje TFP = 1,404) kot na območjih z rudarjenjem (poprečje TFP = 0,371). V raziskavi je bilo ugotovljeno, da zlatokopi negativno vplivajo na produktivnost kmetov na preučevanem območju. Na osnovi raziskave lahko priporočamo med drugim, da je učinkovita uporaba doktrine menjave zemljišča za zemljišče primerna, da zagotovi, da se ob delovanju rudarskih družb spodbuja in zagotavlja kontinuiteta kmetijstva preko popolne nadomestitve zemljišč, izgubljenih zaradi rudarjenja.

Ključne besede: zlatokopi; skupna faktorska produktivnost; kakav; Tornqvist, Ghana

[1] Department of Agricultural Economics and Agribusiness, College of Basic and Applied Sciences, P.O. Box LG 68, University of Ghana, Legon, Ghana

[2] Department of Food, Agriculture and Bioresources; School of Environment, Resource and Development, Asian Institute of Technology, PathumThani 12120, Thailand

1 INTRODUCTION

Ghana's agriculture is vastly dominated by smallholder famers; many commodities including cocoa, maize, cassava and yam produced predominantly on small farms. According to Chamberlin (2007), more than 70 % of Ghanaian farms are 3 hectares (ha) or smaller in size and cocoa and maize represent the two most cultivated crops in Ghana by smallholder farmers (Millennium Development Authority (MiDA) 2010; Asuming-Brempong et al., 2007).

Cocoa takes a remarkable position in Ghana's economy since it has long played an important role in Ghana's economic development and remains an important source of rural work and national income. It also remains the country's most important agricultural export crop (Asuming-Brempong et al., 2007; International Cocoa Organization (ICCO) 2010; Boadi-Kusi et al., 2016). Ghana is currently the world's second major producer of cocoa beans, after Cote d'Ivoire with 21 % share of world cocoa production. Cocoa provides the second largest source of export earnings after gold, representing about 19 % of Ghana's total export earnings in 2015 (Ashitey, 2012; ISSER, 2016).

Mining has also been an important component of developing country economies. The grandness of the mining sector, particularly gold mining in the economy of Ghana has increased considerably since the 1980's (Akabzaa, 2009). The Ghana Chamber of Mines report in 2008 indicated that, mining activities generated around 45 % of total export revenue, 12 % of government's fiscal revenue and attracted almost half of Foreign Direct Investment (FDI). Gold exports revenue in 2015 represented 41 % of the total exports of Ghana, followed by cocoa beans, which account for 19 % (Observatory of Economic Complexity, 2016). This mining expansion has been attributed to the structural reforms in the 1980s that encouraged foreign investment in large-scale mines, especially in gold mining (Ghana Chamber of Mines, 2008; Akabzaa, 2009). Ghana has a long tradition of gold mining with an estimated 2,488 metric tons (80 million ounces) of gold produced between the periods of 1493 to 1997. It is the second largest gold producer in Africa, after South Africa, the third-largest African producer of aluminium metal and manganese ore and a significant producer of bauxite and diamond (Coakley, 1999). Mining, specifically gold mining, has contributed immensely to the economy of Ghana through employment generation, attracting foreign direct investment, contributing to export earnings and Gross Domestic Product (GDP).

Gold mining has effects on economic, social, environmental, agricultural and food security of the communities in which the mining takes place (Amankwah & Anim-Sackey, 2003). A lot of studies have established linkages between mining and agriculture with the effects of gold mining either beneficial or detrimental to the affected population or communities. Despite these linkages, the impact of mining on agriculture has not been extensively studied in Ghana especially at the micro level and available results are mixed. According to Mining Facts (2012) (a Resource for Canadian Mining Information), agriculture is growing in some areas as a result of mining and declining in others, depending on local circumstances. According to Aragon and Rud (2013) and Van der Ploeg (2011), most modern mines in the developing world are located in rural areas, where agriculture is noted to be the main source of livelihood and thereby having both direct and indirect effects on them. Gold mining and agriculture are linked directly through the dependence on same or similar inputs (land, water resources and labour). The competition between gold mining and agriculture for key inputs (such as land and labour) and environmental pollution from mining creates potential negative spillovers to farmers (Aragon & Rud, 2013). They are also indirectly linked where mining firms have improved infrastructure in a way that supports agricultural development. A study by Cartier and Bürge (2011) found that mining has the potential to kick-start local economic development, such as agriculture and service oriented industries and also concluded that small-scale agriculture and mining are not livelihood alternatives, but are instead livelihood complements and therefore have the potential to contribute to more sustainable rural livelihoods.

In Ghana, gold mining coincidentally takes place in rural communities/areas where lands earmarked for gold mining are arable lands that farmers cultivate or have reserved for future use. Gold mining therefore reduces farmers' access to their farmlands and degrades the environment where farm lands are located (Aragon & Rud, 2013) and these factors have the potential to affect the productivity of farmers.

There have been concerns over the low productivity and environmental impacts on cocoa production which makes the long-term sustainability of the sector uncertain (Gockowski, 2007). Average annual cocoa yield in Ghana is about 400 kg ha^{-1} in recent years and this is among the lowest in the world compared to countries such as Cote d'Ivoire (800 kg ha^{-1}) and Malaysia (1880 kg ha^{-1}). The low productivity has been attributed to environmental conditions (climatic and atmospheric) and other factors such as hybrid seed type, input variables and cultural practices (Kolavalli & Vigneri, 2011; Tom-Dery et al., 2012). Gockowski (2007) showed that cocoa production has focused on

land expansion and intensive use of labour rather than on land productivity. Thus output has increased mainly due to increase in area cultivated and partly due to increase in yield. The arable land and labour used for this expansion is also competed for by mining companies (Aragón & Rud, 2013). Some farmers as a result have portions of their farmlands and others their whole farmlands taken over by mining companies. Talule and Naik (2014) indicated that farmers experienced dust settlement on plantations after gold mining was started in the state of Goa, India which impeded crop growth. These conditions (competition for land and labour, pollution from gold mining) have the potential to reduce crop productivity. There is therefore growing concerns with regard to the real benefits of gold mining to the ordinary Ghanaian farmer in the gold mining communities as it affects their welfare and

productivity (Akabzaa, 2009). Though, gold mining and agriculture have all contributed immensely to the economy of Ghana in general, whether local farmers benefit in any way from gold mining activities within the catchment communities is not well established. Instead, environmental regulators and opponents of the mining industry have focused mostly on other aspects such as risk of environmental degradation, health hazards, and social impacts. What is lacking in the policy debate, however, is the crowding out mechanisms such as loss of land and agricultural output through gold mining. Does gold mining in Ghana reduces farmers' productivities in gold mining areas? This study seeks to determine the factors through which gold mining affects the total factor productivity of farmers in mining and non-mining areas of Ghana.

2 MATERIALS AND METHODS

2.1 Total factor productivity

The two most widely adopted methods employed in agricultural productivity estimations are the superlative index approach and the quantity-only based index approach (Bjurek, 1996; Førsund, 1997). The advantage of using the superlative index method is more apparent when it comes to the issue of aggregation consistency: the superlative index method is robust to various levels of disaggregation while the quantity-only index is not (Sheng et al., 2014). A number of different types of economic indices using the superlative index approach exist. Each type of index offers an approximate scalar measure of a multidimensional change over time in prices, quantities or productivity. The different indices approximate these inter-temporal changes in different ways according to their theoretical properties.

Differences in indices can be viewed as differences in their abilities to provide approximations to the inter-temporal changes in prices, quantities or productivity.

Four economic index numbers are commonly applied in estimating economic index: Laspeyres, Paasche, Fisher Ideal, and Törnqvist. These indices produce different methods of approximation (reflected in the formulae of their aggregator functions) with correspondingly different properties. The Laspeyres and Paasche indices have traditionally been widely applied, but the Tornqvist and Fisher Ideal are increasingly used. The Laspeyres, Paasche and Fisher output quantity indices can be defined as follows, using the quantity aggregates given in Equation (1) – (3) respectively

$$Q_{st}^{L} = \sum_{i=0}^{N} p_{is} q_{it} \bigg/ \sum_{i=0}^{N} p_{is} q_{is} \tag{1}$$

$$Q_{st}^{P} = \sum_{i=0}^{N} p_{it} q_{it} \bigg/ \sum_{i=0}^{N} p_{it} q_{is} \tag{2}$$

$$Q_{st}^{F} = \sqrt{Q_{st}^{L} \times Q_{st}^{P}} \tag{3}$$

Where $q_{it} = [\, q_{it} ,\ldots\ldots q_{Nt} \,]$ and $p_{it} = [\, p_{it} ,\ldots\ldots p_{Nt} \,]$ are output and output price vectors respectively; t and s denote time or period or firms; $i = [1,\ldots. N]$ are different outputs. Thus, p_{it} is the price of i-th good in t-th

period or firm and q_{it} is the quantity of i-th good in t-th period or firm. The input indices, Laspeyres ($Q_{st}^{L^{*}}$), Paasche ($Q_{st}^{P^{*}}$), and Fisher ($Q_{st}^{F^{*}}$) are obtained in a similar fashion and the ratio of output index to the corresponding input index gives the Total Factor

Productivity (TFP) index. Therefore, in general terms, *TFP is* expressed as $TFP^a = Q^a / Q^{a^*}$ where $a = [P, L, F]$ representing Paasche, Laspeyres and Fisher.

$$Q_{st}^T = \prod_{i=1}^{N} \left[\frac{q_{it}}{q_{is}} \right]^{\frac{\omega_{is} + \omega_{it}}{2}}$$

(4)

$$\ln Q_{st}^T = \sum_{i=1}^{N} \left[\frac{\omega_{is} + \omega_{it}}{2} \right] (\ln q_{it} - \ln q_{is})$$

(5)

$$\ln Q_{st}^T = \frac{1}{2} \sum_{i=1}^{N} \left[\left(P_{is} q_{is} / \sum_{i=1}^{N} P_{is} q_{is} \right) + \left(P_{it} q_{it} / \sum_{i=1}^{N} P_{it} q_{it} \right) \right] \ln \frac{q_{it}}{q_{is}}$$

(6)

The ratio of $\ln Q_{st}^T$ to its input counterpart $(\ln Q_{st}^{T\,*})$ provides the Tornqvist TFP index. Fisher is geometric average and hence may also be a good approximation of TFP. However, Tornqvist uses share weights often

The Tornqvist (or Translog) index is an alternative index, which is the weighted average of growth rates of microeconomic data. For the output quantity index, this is expressed as follows:

expressed in log-change form for calculation. Tornqvist is thus a geometric weighted average, while Laspeyres and Paasche are arithmetic and harmonic averages, respectively.

$$TFP^T Index_{st} = \frac{Output^T index_{st}}{Input^T index_{st}}$$

(7)

$$\ln TFP^T Index_{st} = \ln Output^T index_{st} - \ln Input^T index_{st}$$

(8)

$$\ln TFP_{st}^T = \frac{1}{2} \sum_{i=1}^{N} (\omega_{is} + \omega_{it}) (\ln q_{it} - \ln q_{is}) - \frac{1}{2} \sum_{j=1}^{K} (\delta_{js} + \delta_{jt}) (\ln x_{jt} - \ln x_{js})$$

(9)

N is number of outputs and K is the number of inputs, q is output quantity, x is input quantity, ω denotes output revenue share and δ denotes input cost share. This approach (equation 9) of estimation is also known as the Hicks-Moorsteen Approach and defines productivity index simply as the ratio of output and input index numbers (Diewert, 1992).

According to Diewert (1976), there are two methods used to assess the suitability of an index formula and they are; economic theory or functional approach (exact and superlative index number) and axiomatic or Test approach (index numbers that satisfy a number of desirable properties). The Tornqvist and Fisher indices provide more accurate approximations to changes than the Laspeyres or Paasche index because intermediate substitution possibilities are incorporated. According to the index number theory, Tornqvist and Fisher Ideal indices are a group of index numbers whose underlying formula, as shown in equation 3 and equation 9, provides a second order differential approximation to

any unknown production function (Diewert, 1976) and these indices can be interpreted as a production function shift (Technical change) if we assume technical efficiency, allocative efficiency and constant return to scale. This second order flexibility makes the Fisher and Tornqvist indices 'superlative' indices (Mishra & Pujari, 2008). Diewert (1976) demonstrated that the Tornqvist index is an exact index for (*i.e.* is consistent with) a "translog" structure of production whiles fisher is exact for quadratic. But the Laspeyres and Paasche employs simplistic linear production function. The merits of the translog production function include the fact that it places fewer restrictions on input (and output) relationships than other functions (Dean et al., 1996).

The Tornqvist index satisfy almost all the basic and commonly used axioms (positivity, proportionality, continuity, units invariance, time-reversal, mean value, factor). However, the axiom of circularity (transitivity) and factor reversal test are not satisfied by the Tornqvist

index but the factor reversal test it is not considered very serious and important (Diewert, 1992; Mishra & Pujari, 2008). The non-transitive indices are transformed into transitive ones by applying the Elteto-Koves-Szulc (EKS) transformation. The transitive property is very important for a proper comparison

between various time periods or among various cross-sections (Diewert, 1992; Mishra and Pujari, 2008). EKS method constructs geometric mean of all indirect comparisons via the N firms in the sample. EKS adjustment is a minimum mean squared deviation from original index. It is expressed as

$$\mathbf{I}_{st}^{Transitive} = \prod_{r=1}^{N} \left[\mathbf{I}_{sr} \times \mathbf{I}_{rt} \right]^{\frac{1}{N}}$$

(10)

$$\ln TFP_{st}^{Transitive} = \left[\frac{1}{2} \sum_{i=1}^{M} \left(\omega_{it} + \overline{\omega_i} \right) \left(\ln q_{it} - \overline{\ln q_i} \right) - \frac{1}{2} \sum_{i=1}^{M} \left(\omega_{is} + \overline{\omega_i} \right) \left(\ln q_{is} - \overline{\ln q_i} \right) \right]$$
$$- \left[\frac{1}{2} \sum_{j=1}^{K} \left(\delta_{jt} + \overline{\delta_j} \right) \left(\ln x_{jt} - \overline{\ln x_j} \right) - \frac{1}{2} \sum_{j=1}^{K} \left(\delta_{js} + \overline{\delta_j} \right) \left(\ln x_{js} - \overline{\ln x_j} \right) \right]$$

(11)

where

$$\omega_{is} = p_{is}q_{is} \Bigg/ \sum_{i=1}^{M} p_{is}q_{is} \quad \delta_{js} = p_{js}x_{js} \Bigg/ \sum_{j=1}^{K} p_{js}x_{js}$$

q_i denotes output, x_j denotes inputs and the p_i and p_j are the output price and input cost respectively. The bars refer to sample means. The transitive Tornqvist can be calculated directly using equation 11. In productivity studies, the Fisher index has been used less frequently than the Törnqvist. However, the Tornqvist index method has been preferred by many researchers in the area of productivity measurement and analysis because of the desirable properties outlined above (Dean et al, 1996; Ali & Iqbal, 2004). Tornqvist Total Factor Productivity approach therefore was used to estimate the TFP index of various respondents for this study.

The Tornqvist TFP has been used by several researches after its development but mostly at macro levels with few at the micro level (Mishra & Pujari, 2008). Kumar and Mruthyunjaya (1992) analysed the TFP growth of wheat in India. They used the Divisia-Tornqvist index to compare the total output, total input, TFP and input price indices for wheat grown in the major states of India, based on micro-level data. Coelli (1996) investigated productivity growth in agriculture in Western Australia using Tornqvist indices using three output groups (crops, sheep products and other) and five input groups (livestock, materials and services, labour, capital and land) from 1953/4 to 1987/8. The total factor productivity was observed to grow at an average annual rate of 2.7 %. Rosegrant and Evenson (1992) assessed the sources of TFP growth in the crops sector in India, and compared the same with Pakistan and Bangladesh. They used the Tornqvist index to analyse TFP for 271

districts in India from 1956 to 1987 and the study covered five major and fourteen minor crops. They concluded that the main sources of productivity growth have been public research and extension and private research. Sidhu and Byerlee (1992) analysed technical change and wheat productivity in Punjab, in the post-Green Revolution period and found that the use of inputs such as fertilizers and herbicides increased from the 1970s to the 1980s but the use of labour-saving technologies such as tractors increased rapidly which was also synonymous with the TFP changes. Kumar and Rosegrant (1994) assessed TFP growth in 15 states of India and examined the sources of productivity growth. They used the Divisia Tornqvist index for computing the total output, total input and TFP indices for rice, using farm-level data from 1971 to 1988. They found TFP and growth in crop inputs to have contributed roughly 3.5 per cent per year to rice production growth and have enabled India to increase rice production per capita in the presence of high population growth rates and limited land resources within the period.

2.2 Study area

The Brong Ahafo Region, as shown in Figure 1 is the second largest region in Ghana with a land area of 39,557 km^2 and 27 administrative districts/municipalities. It covers 16.6 % of the country's total land area. The region has an estimated population of 2,310,983 (2010 census) and located within longitude 00 15' E-30 W and Latitude 80 45' N-70 30' S in the west central part of Ghana which is in the transition zone of Ghana. The transition zone

stretches across the centre of the country from East to West, where soils are deep, friable, and well drained, and there is less dense forest cover. It has a bi-modal rainfall with average annual rainfall and temperature of 1,300 mm and 27 ^{0}C respectively. The productive soil and bimodal rainfall season permit all year round cocoa production.
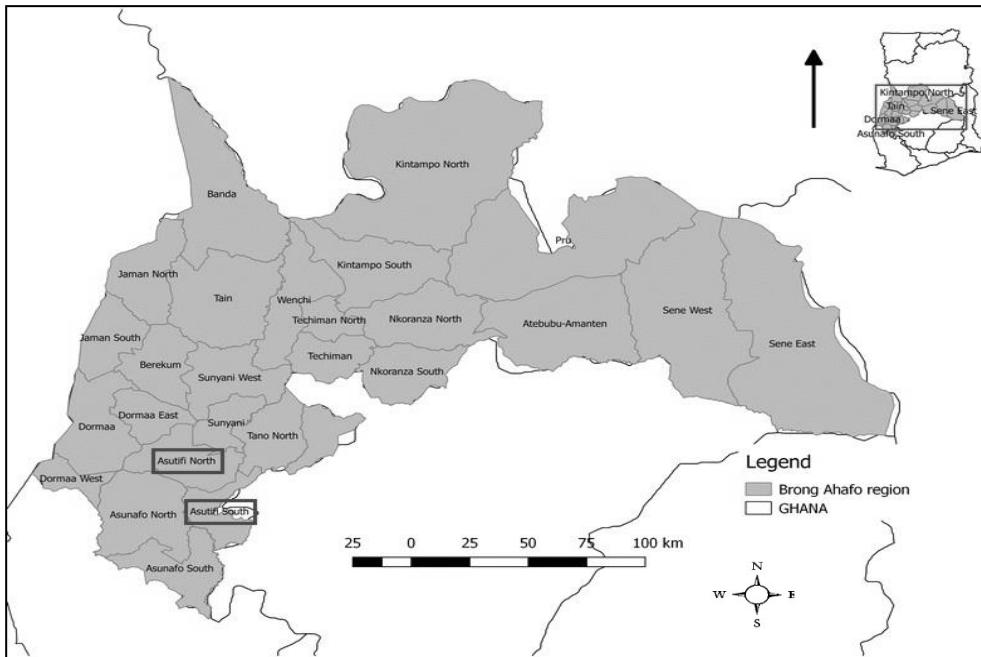

Figure 1: Map of Brong Ahafo Region of Ghana
Source: Geography Department, University of Ghana

With an arable land area of 23,734 km^2 (60 % of land area) and land under cultivation being 9,746 km^2 (41 % of arable land area), opportunities exist to expand cultivated land and improve productivity (MOFA, 2006; MOFA, 2013). Agriculture plays a very important role in the region's economy as it engages 61 % of the population. The various farming systems/methods practiced by the farmers in the region include; shifting cultivation, continuous cropping, mixed cropping, mono cropping, inter cropping, land rotation and bush fallows. Some of the major crops cultivated include yam, cassava, maize, cocoyam, rice, potato, pepper, plantain, garden eggs, okra, watermelon, ground nut, cowpea, and other tree crops such as cocoa, cashew and mango. Some non-traditional farming activities practiced by the farmers include grass cutter rearing and bee-keeping. Gold mining is also one of the economic activities in the region with Newmont Gold Ghana Limited (NGGL) being the largest gold mining company situated in the Asutifi North and South Districts (Ghana Statistical Service 2010; Ghanadistrict.com 2014).

Figure 2: The map of Africa showing Ghana
Source: https://www.pinterest.com/pin/157414949459332821/

2.3 Data collection

A pretested structured questionnaire was used to collect data on output, input and relevant socioeconomic variables of cocoa farmers from January to February 2015 and covered both the major and minor seasons of 2013/2014 cropping year. A multi-stage sampling technique was employed in this household survey. Purposively, Asutifi North and South districts were chosen because its land area falls within the forest agro-ecological zones of the Brong Ahafo region where cocoa production is concentrated and all the communities located close to the operational areas of Newmont Gold Ghana Limited (NGGL) involved in cocoa production. Respondents were farmers in both the mining and non-mining areas. The farmers in mining areas were farmers who have their farms around the operational area of NGGL. The farmers in the non-mining communities were farmers with their farms located at least 10 kilometres from the operational area of NGGL such that they do not experience any direct impact or effect of mining operations, such as hauling through or around their farms and dust from mining operations settling on their crops. Finally, a simple random sampling of cocoa farmers from each community was employed, resulting in 110 cocoa farmers. Table 1 shows the distribution of respondents by communities (69 from the mining areas and 41 from the non-mining areas).

Table 1: Communities and number of cocoa farmers sampled

District	Community/Town	Mining	Non-mining	Total
Asutifi North	Kenyasi	40	0	40
	Ntotoroso	29	0	29
	Obengkrom	0	19	19
	Sub-Total	69	19	88
Asutifi South	Amanfrom	0	5	5
	Achirensua	0	11	11
	Nkasiem	0	6	6
	Sub-Total	0	22	22
	Total	*69*	*41*	*110*

Source: field survey, 2015

TFPIP 1.0 software developed by Coelli (1997) was employed to estimate the transitive TFP indices. The variables used in the estimation include the output and output prices as well as input and input cost of cocoa produced in 2013/14 production year. Cocoa output (2013/14 production year) was measured in kilograms and output price is measured in Ghana Cedis per kilogram. Labour is captured based on the total man-days employed by the i-th farm during the production year. One man-day for labour is calculated as one adult male working for one day (8 hours); one female working for one day (8 hours) equals 0.75 man days. Seedling is the quantity of seedling used by the i-th farmer for the production year, measured in number for cocoa seedlings and price per seedling is measured in Ghana Cedis. Total quantity of weedicide, fungicide and insecticide used by the i-th farmer measured in litres. The price per litre is measured in Ghana Cedis.

$$Zcal = \frac{\overline{y}_2 - \overline{y}_1}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$$

where $\overline{y}_1$ and $\overline{y}_2$ are the mean TFP index of the mining and non-mining areas respectively, s_1 and s_2 are the standard deviations of the two samples, n_1 and n_2 are the sizes of the two samples.

2.5 Statement of hypothesis

H_0: $\overline{y}_1 = \overline{y}_2$ there is no significant difference between the mean TFP index of farmers in mining and non-mining areas

2.4 Productivity differences among farmers in mining and non-mining areas

The assumption underlying the differences in cocoa productivity is that productivity should be the same for farmers in the mining and non-mining areas in the absence of gold mining since they are in the same agro-ecological (transitional) zone, experience similar environmental and climatic conditions and encounter the same input market and cocoa output market arrangements and challenges. To determine whether there is productivity difference, the study adopts and performs a number of z-tests (of equality of means) to analyse whether farmers in the non-mining communities are more productive than those in mining communities. The mean values of the Tornqvist TFP, inputs and output indices are estimated and their mean differences are statistically examined. In the determination of the differences in the values of the means in the two areas, the z-test used for the analysis is given as:

(12)

H_1: $\overline{y}_1 < \overline{y}_2$ the mean TFP index of farmers in mining area is significantly less than the mean TFP of farmers in non-mining area

This hypothesis is repeated for the output and input indices. The decision rule is that if z_{cal} is greater than (in absolute terms) the z_{crit}, then we reject the null hypothesis (H_0) in favour of the alternate hypothesis (H_1).

3 RESULTS AND DISCUSSION

3.1 Socio-demographic characterisation of respondents

Males represent the majority (68 %) of the respondents which affirms the dominance of males in cocoa production, mostly because of the laborious and cost intensive nature of cocoa farming which discourages most females from investing into cocoa production. Also, in Ghana, land is mostly owned and controlled by the male head of the household which also gives them an advantage. From Table 2, the age of cocoa farmers ranges between 20-85 years with a mean age of 50 years. The majority of cocoa farmers (51) fall between 41 to 50 years, representing 46 % of the respondents. One can infer from these results that most cocoa farmers in the study area are in their economically active (15-60

years)[1] ages and this implies that quality of labour is good which may positively affect their productivity. Diverse age groups cultivate cocoa therefore improvement in cocoa productivity will positively affect livelihoods. The majority (41 %) of the respondents have completed middle school or junior high educational level. However, 28 % of the farmers had no formal education at all. In general, about 72 % of the farmers had access to some level of formal education. The educational level of farmers is known to affect farming activities. The majority (67 %) of the respondents have a household size between 5 and 9 and one household (1 % of the respondents) has a household size of 15 people. The mean household size is seven (7). A greater percentage (40 %) of the farmers in the study

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[1]Ghana Statistical Service (GSS) (2012) definition for economically active age

area had farm sizes less than 2.02 ha. This suggests that the majority of the farmers are peasant and small-scale farmers. However, as shown in Table 2, very few cocoa

farmers cultivated between 6.47 – 8.09 ha (8 %) and above 8.09 ha (3 %).

Table 2: Socio-demographic characteristics of the respondents

| Socioeconomic variables | Item | Cocoa Farmers | | | | | |
		Mining area	Percent	Non-mining area	Percent	Total	Percent
Sex	Female	23	20.91	12	10.91	35	31.82
	Male	46	41.82	29	26.36	75	68.18
Age (years)	20-30	5	4.55	1	0.91	6	5.50
	31-40	10	9.09	12	10.91	35	31.80
	41-50	22	20.00	8	7.27	51	46.40
	Above 50	32	29.09	20	18.18	18	16.40
	(Minimum = 25 Mean = 49.8 Maximum = 85)						
Education	No Schooling	18	16.36	13	11.82	31	28.18
	Primary	7	6.36	7	6.36	14	12.73
	JHS/MSLC	28	25.45	17	15.45	45	40.91
	SHS/O/A Level	14	12.73	3	2.73	17	15.45
	Technical/Vocational	1	0.91	1	0.91	2	1.82
	Tertiary	1	0.91	0	0.00	1	0.91
Household size	1-4	7	6.36	7	6.36	14	12.73
	5-9	48	43.64	26	23.64	74	67.27
	10-14	14	12.73	7	6.36	21	19.10
	Above 14	0	0.00	1	0.91	1	0.90
	(Minimum = 1 Mean = 7 Maximum = 15)						
Land size (ha)	<5	26	23.64	18	16.36	44	40.00
	6-10	23	20.91	11	10.00	34	30.91
	4.45 – 6.07	13	11.82	7	6.36	20	18.18
	6.47 – 8.09	4	3.64	5	4.55	9	8.18
	Above 8.09	3		0	0.00	3	2.73
	(Minimum = 0.5 Mean = 7.2 Maximum = 55)						

Source: field survey 2015

3.2 Perceived effects of gold mining on crop production

The majority (83 %) of cocoa farmers in mining areas (69 farmers) indicated that gold mining has affected their crop production. According to them, the channels through which they have been affected included high

cost of farmland, high cost of labour, and relocation of farm/residence, illegal small-scale gold mining, land disputes, and settlement of dust on their crops. As shown in Figure 3, Relocation of farm/residence (32 %) and high cost of farmlands (26 %) were the major channels through which gold mining has affected cocoa

farmers. This confirms a study by Taphee et al. (2015) on the economic efficiency of cocoa production which concluded that high cost of production per hectare was a major problem to cocoa farmers in Ondo State, Nigeria. The same reasons were given by Schueler et al. (2011) on the study of the impacts of surface gold mining on land use systems in Western Ghana where farmers described their livelihood situation after relocation as worse, due to the loss of their traditional farmlands and

inadequate compensation schemes from mining companies. Another 4 % and 9 % of cocoa farmers in the mining areas mentioned illegal small-scale mining and settlement of dust on their crops respectively as impacting negatively on cocoa productivity. Dust settlement on cocoa leaves inhibit the growth as well as injuring the plants and thereby reducing the productivity.
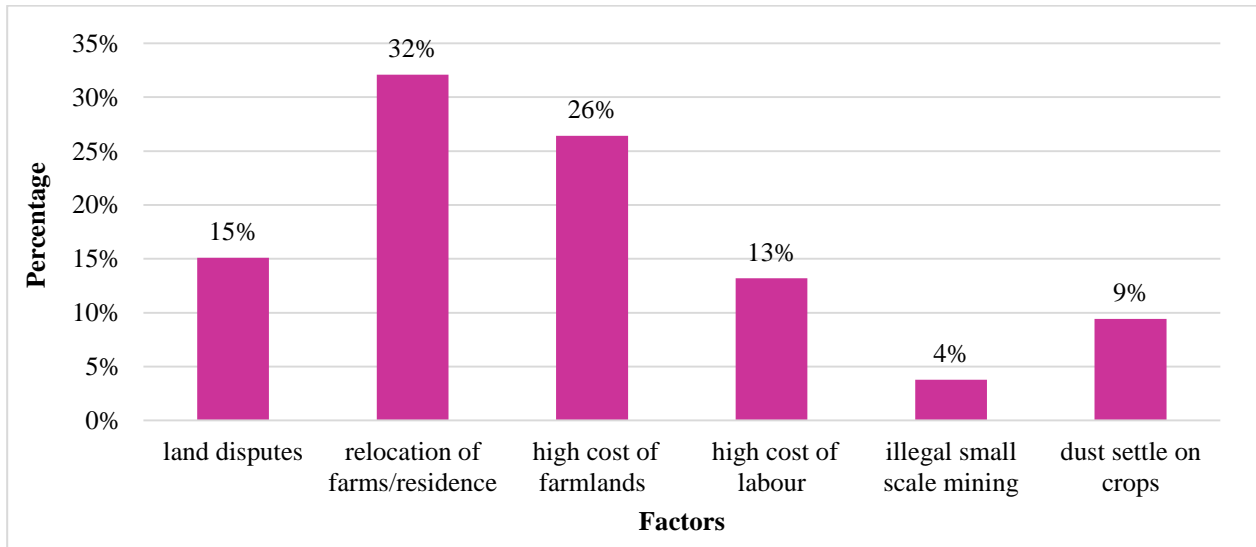

Figure 3: Factors affecting cocoa farming and productivity
Source: field survey 2015

Figure 4 shows the average reduction in cocoa farm sizes because of the commencement of gold mining operations in the mining areas. About 36 % of cocoa farmers in the mining areas indicated that their farm sizes have not reduced as a result of the gold mining. However, the rest of the farmers (64 %) in the mining areas mentioned various reductions in farm acreages.

About 52 % indicated their farmlands reduced by 0.4 to 1.21 ha. The study by Mumuni et al. (2012) found similar results where an estimated 9,575 individual crop farmers in the Asutifi North and South districts lost 7,500 hectares of farmlands, an average of 0.8 ha per farmer which were annexed by Newmont Gold Ghana Limited for gold exploration.
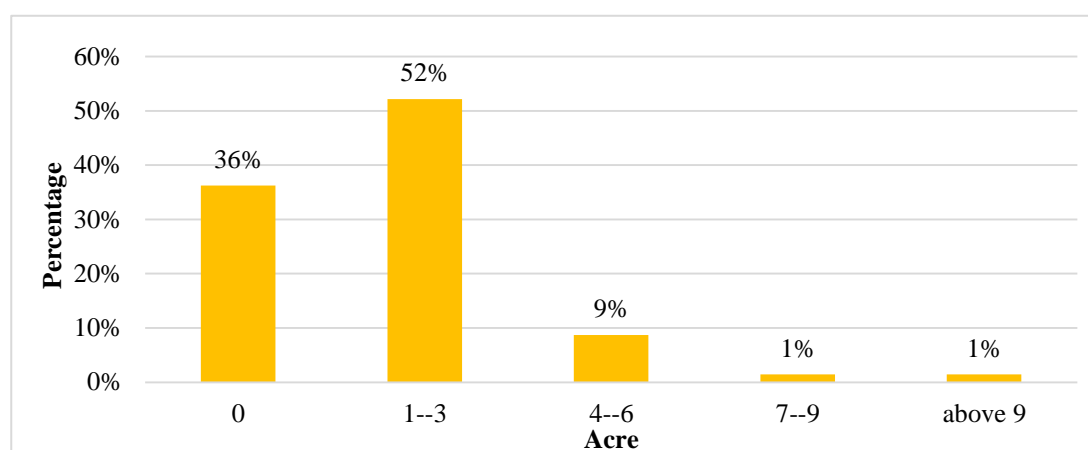
Figure 4: Cocoa farm size lost/reduced through gold mining
Source: field survey 2015

3.3 Total factor productivity (TFP) in mining and non-mining areas

Table 3 presents the summary statistics of the estimated input, output and TFP indices. In general, the study finds that, farmers have higher averages of indices in non-mining areas as compared to the mining areas.

Table 3: Summary statistics of Tornqvist total factor productivity indices

Observation	Area		Total
	Mining	*Non-Mining*	
Mean TFP Index	0.371	1.404	0.756
Standard Deviation	0.463	1.512	1.106
Mean Output Index	0.430	1.193	0.714
Standard Deviation	0.641	1.610	1.160
Mean Input Index	1.755	1.770	1.760
Standard Deviation	3.068	2.900	2.993

Source: field survey 2015

Table 4 shows the summary of the compared means. The mean difference between the input indices for farmers in the two categories was not statistically different and thus the null hypothesis is not rejected. The reasons may likely be that both farmer groups have access to same input types and prices from same markets and also utilise similar input amounts. For the output and TFP index, the mean differences were statistically significant at 1 % significance level. The Output and Tornqvist TFP indices were higher in non-mining areas than in mining areas (see Table 3). Since there is not any difference between the inputs index between farmers in mining and non-mining areas, the difference in the output and TFP could likely be attributed to the fact that gold mining has significantly contributed to lower cocoa productivities of farms in the mining areas mainly through dust settlement on cocoa trees that impede the growth of cocoa trees and thereby reducing the productivity of cocoa farms in the mining areas. To a lesser effect, the lower use of inputs could also contribute to lower productivities.

Table 4: Mean comparison (t-test) of output, input and TFP indices for mining and non-mining areas

Index	Cocoa TFP	
	T-statistics	*Significance*
Input Index	-0.0256	0.9796
Output Index	-2.8990	0.0056
TFP Index	-4.2564	0.0001

Source: field survey 2015

4 CONCLUSIONS

The study estimated the TFP difference among cocoa farmers in gold mining and non-mining areas using micro-level data from the Asutifi North and South Districts of the Brong Ahafo Region. Based on the findings from the study, it is concluded that gold mining in the study area has a negative effect on productivity of farmers located in mining areas. The adverse impacts are mainly dust settlement on cocoa trees from mining activities, which impedes cocoa growth and thereby reducing the productivity. To lesser extent, the use of relatively less productive inputs contributes to lower TFP for this group of farmers. Cocoa farmers also perceived land disputes, relocation of farms/residence, high cost of farmlands, high cost of labour and illegal small-scale mining as factors contributing to low productivities.

The uniqueness of this study is rooted in the application of Total Factor Productivity (TFP) and not the effect of one single input (i.e., partial factor productivity) on cocoa productivity. Often, qualitative approaches are adopted to highlight the effect of mining on crop production and productivity. Using a quantitative approach, this study has identified and attributed low cocoa productivity in mining areas to mining activities.

The findings of the study are important to inform policy on how to eliminate or reduce the existing negative effect of gold mining on cocoa productivity of rural farmers. A policy of land-for-land should be in place and effectively implemented to ensure that lands lost through mining activities (whether currently in use or lying fallow) must fully be replaced by mining companies to enhance and ensure continuity of livelihoods. In the absence of this, areas devoted to cocoa production will dwindle, labour may shift from cocoa production and productivity may fall (reducing government revenue, household income and livelihood). Secondly, if farmers loose crop lands (tree crop and food crop lands) adequate crop compensations that reflect current economic realities must be paid by mining companies to farmers. Government through the

Land Valuation Board (LVB) must review crop compensation rates to reflect economic realities and must also factor in the sustainability of cocoa trees (projected income flows of the economic life of cocoa trees) when rural livelihoods are at stake. When farms are to be relocated, mining activities need not interfere with crop production activities. The findings of the study also suggest that mining companies should adequately compensate for crops. The farmers in Asutifi were compensated based on the Mining and Minerals Law, 1986 (PNDCL 153). The existing policies and laws relating to mining should incorporate the education of farmers and mining companies on the effect of mining activities on crop productivity.

Thus, key lessons from the study are that: mining activities impact negatively on cocoa productivity and rural livelihoods in spite of its contribution to government revenue. Farmers in gold mining catchment communities perceive mining activities as inimical to their food security situation and livelihoods through the loss of croplands and inadequate crop compensation.

There is a high level of confidence in the study's empirical findings: use of primary data collected from statistically representative cocoa farmers and the use of basic and robust quantitative approach to determine results. In other words, the approaches adopted in the study have provided enough data and information to make informed decisions on the phenomenon under study.

The study employed the use of primary cross-sectional data and therefore recommends that, subsequent research should consider the use of a time series or panel data for the analyses and also to determine TFP growth rates. Moreover, future studies could quantify, in dollar terms, the losses in cocoa productivity and livelihoods resulting from mining activities in catchment communities and compare with cocoa revenues generated from such areas.

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