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Artisanal small-scale mining, farm labour attraction and household welfare in Ghana

Franklin Nantui Mabe [a,*], Ayuba Dauda [b], Ebenezer Owusu-Sekyere [c]

[a] Centre for Agricultural Productivity and Policy Studies, University for Development Studies, Tamale, Ghana
[b] Department of Agricultural and Food Economics, Food and Consumer Sciences, University for Development Studies, Tamale, Ghana
[c] Department of Environment and Sustainability Sciences, University for Development Studies, Tamale, Ghana

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ABSTRACT

The discourse on the impact of artisanal small-scale mining (ASM) has often concentrated on land degradation, and surface water pollution. How ASM is increasingly attracting farm labourers (FL) in mining communities is rarely discussed. Drawing insight from selected mining communities, which combines the perspectives and experiences of small-scale miners, farmers, academics, and policymakers, this article uses the endogenous switching regression model to identify the determinants of FL attraction to ASM as well as the drivers of labour welfare. The model estimated the impact of labour supply on consumption expenditure per adult equivalent. The results show that FL decision to shift to ASM sector is constructed around welfare incentives. For instance, FL who joined ASM increased their consumption expenditure per adult equivalent by 66.6 percent. The article established that ASM provides crucial livelihoods to rural households. Meanwhile, if proper incentives such as fertilizer subsidy and agriculture extension intensification are not put in place, the labour attraction by ASM will have detrimental effects on food security. Therefore, proper regulatory frameworks should be enforced by duty-bearers to regulate the activities of ASM as it provides welfare improvements to farmers. Lastly, further studies should investigate the decency of labour supply services to ASM.

1. Introduction

One livelihood activity in Ghana that scholars do not exactly know when it commenced but has persisted with economic significance is Artisanal and small-scale mining (ASM) of gold. Historical records indicated that the activity is older than the day of the arrival of the Portuguese adventurers in 1471 (Ofosu-Mensah, 2017). The growth and popularity of ASM in Ghana has been attributed to dwindling investment in the mining sector, and limited job opportunities amid rising population growth (Mark-Anthony, 2015). ASM has developed from the artisanal stage of using basic tools such as shovels, pickaxes, and sluice boards to semi-mechanised operations involving the use of modern equipment such as excavators, bulldozers and washing plants as it is currently being practiced (Minerals Commission, 2015). Characteristically, less capital investment is required as a start-up and is often carried out by local people with little or no education (Worlanyo et al., 2022). ASM, according to the revised Minerals Commission, 2015 is defined as gold mining operation by any efficient and effective process that does not encompass substantial expenditure by an individual or group of persons not exceeding nine people or by a co-operative society made up of ten or more persons. ASM in Ghana can be categorized according to their registration status. Those who are legally registered and thus permitted to carry out their functions under the current Minerals and Mining (Amendment) Act, 2019 (Act 995), and those who are operating illegally due to economic, social, political, and regulatory lapses (Owusu et al., 2019).

Artisanal small-scale mining is undertaken in rural communities where the mainstay of the people is agricultural activity (Mabe et al., 2021). The framing of the engagement between ASM and agriculture sector presents the two sectors of the economy as playing complementary roles: the agriculture sector is anticipated to provide the needed food items, livestock, and semi-processed food to supply the dietary needs of the miners while the ASM sector is expected to provide a ready market for the agriculture product and attract surplus labour during the 'lean' season. According to Ofosu et al. (2020), the rapid proliferation of extractive activity such as ASM can lead to Dutch disease where there is a shift of labour from the agriculture sector to the ASM sector. The literature indicates however that the expected mutual relationship has

* Corresponding author
E-mail address: mfnantui@uds.edu.gh (F.N. Mabe).

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not worked over the years (Mark-Anthony, 2015; Ofosu-Mensah, 2017) and that the agriculture sector has lost a chunk of farm labour (FL) to the ASM. The key question is for what reason(s) could FL abandon the agriculture sector for ASM even though the ASM sector is plagued with risks of monumental proportion and what welfare gains do such FL stand to gain? This paper answers this question by assessing the determinants of FL attraction to licensed ASM as well as its welfare effects in selected mining communities in Northern Ghana using the endogenous switching regression model.

Contextually, this study explains FL attraction as the movement of the labour force from the agriculture sector to ASM. FL attraction has generally become a major challenge for farming communities where ASM activities are thriving (Mabe et al., 2021). Apart from robbing the agriculture sector of a large labour force, skilled and experienced farm labour is also lost perpetually. For smallholder farmers, such attraction affects the growth of the sector and places additional stress on the few FL and their families as they attempt to plough large tracts of land (Hilson, 2016).

There are weather differences between northern and southern Ghana. Whilst southern Ghana has a bimodal rainy season for rain-fed agriculture, northern Ghana has a monomodal rainfall. The prolonged dry season in northern Ghana and high ASM activities in southern Ghana is the push and pull factors for farmers in the former jurisdiction to travel to the latter to provide labour services to mining activities during the dry season. These farmers return to northern Ghana to cultivate crops when the rains set in. The trend is however changing as mineral deposits have been discovered in some communities in northern Ghana. Artisanal small-scale mining which is composed of the licensed and unlicensed (*galamsey*) is now heavily seen in some rural communities in northern Ghana. It is important to advance that due to the prolonged period of drought in the north, it is expected that farmers will have more time to provide labour services to mining activities to earn more income. Meanwhile, during the time of the study, the government put a moratorium on unlicensed ASM. Therefore, this current study focused on licensed ASM.

This study makes a significant contribution to the literature on the welfare impacts of FL attraction to ASM communities in Africa. The study is particularly significant as it is expected to come out with policy recommendations which when adopted will help shape both the agriculture and ASM sectors in Ghana. Finally, the study used a state-of-the-art econometric model, endogenous switching regression (ESR) to minimize all biases associated with similar estimations thereby providing a more nuanced understanding of the existing relationship between ASM and smallholder farming (exact welfare impact of FL attraction) in sub-Saharan Africa.

This study is based on two theories. The first one is the reasoned action theory. The theory postulates that smallholder farmers' actions and attitudes are undistinguishably linked. Therefore, farmers' attitudes will warrant their actions of providing labour services to ASM activities. This means that farmers will develop favourable attitudes toward the ASM despite the effects of their activities on livelihoods (Borges et al., 2015). Another important theory underpinning this study is the capability theory. It is a normative theory developed by Sen (1999) to explain and evaluate the wellbeing or welfare of any economic decision maker (Kronlid and Lotz-Sisitka, 2014). The capability theory looks at the opportunities and choices available to humans and their ability to make decisions and back them with actions to attain valuable functioning (Mackenzie et al., 2014). According to Sen (1999), functioning represents the various things an individual can achieve. Herein the current study, the opportunities available to farmers are the ASM which demand for farmers' labour services. Farmers then have two choices namely the option of supplying their labour services to ASM or otherwise. The action of supplying the labour is based on whether they can do strenuous work involve in mining. It is important to note that capability theory has been numerous academic and policy research including that of United Nations estimations of Human Development Index (HDI).

2. ASM and agriculture sector symbiosis: a literature perspective

The synergies between the agriculture sector and ASM has been amplified in the literature. Dondeyne and Ndunguru (2014) have argued that in Mozambique, the benefits from small-scale gold mining from rural Chazuka are used by farmers who engaged in small-scale mining to purchase fertilisers and farm inputs. Other scholars in Ghana have alluded to the synergies between agriculture and ASM in the form of flows of capital and labour in the Northern ecological zone (see Okoh and Hilson, 2011). In Cameroon, the literature indicates that poor markets for agricultural products have compelled farmers to resort to ASM to supplement household incomes (Bakia, 2014; Schure et al., 2011). Indeed, available evidence overwhelmingly indicates that smallholder farmers and ASM complement each other in a yearly circle. It has been estimated that in rural Mozambique, about 30% of inhabitants engage in ASM to supplement incomes from agriculture (Mondlane and Shoko, 2003). Similar research in Zimbabwe, Mali and Ghana is conclusive that farmers engage in ASM because the yield from farming is unable to sustain their families throughout the year (Hilson and Garforth, 2012).

Hilson (2016) investigated how seasonality affects the balance between agriculture and mining in Sub-Saharan Africa. He observed that farmers in mineral-rich rural areas in Sub-Saharan Africa venture into mining to supplement their income. This implies that there are competing interests for farmers' labour. If a farmer decides to supply his or her labour to ASM operations, he or she will not get enough labour for the agriculture value chain activities. Conversely, during dry seasons, farmers offer labour services to mining activities just to earn some income for the household. Income from these many activities can also be used to accumulate some assets for the family (Osei, 2017). Consequently, Haddaway et al. (2018) and Worlanyo et al. (2022) revealed in their research that the presence of a mine in a particular location provides opportunities for the inhabitants to earn some benefits in diverse ways. They intimated that mining creates jobs and enhances infrastructure and basic services such as adult literacy instruction and primary healthcare provision. All these are expected to improve the livelihood and welfare outcomes of those who are engaged in mining.

Over the years, the ASM sector has emerged as a strong force that is providing jobs, and creating wealth and driving the economy of some developing countries where the gold ore abound. For instance, Bansah et al. (2018), posit that the sector employs around 1,000,000 persons directly while at least twice that many are employed indirectly. Other studies indicate that over 4.5 million Ghanaians are directly and indirectly employed by the sector (McQuilken and Hilson, 2016).

Further, artisanal, and small-scale mining facilitates development by exploiting otherwise uneconomical and overlooked mineral reserves and, perhaps most significantly, it can provide an important source of foreign exchange and gold reserves for a poorly funded government. If properly regulated and appropriately supported, it has the potential to generate consistent incomes for hundreds of thousands of people and drive economic growth for Ghana's rural entrepreneurs Artisanal and small-scale miners and subsistence farmers are one and the same. During the rainy season the rains make it dangerous and difficult to mine whilst conversely this is the busiest period on the farm. During the dry season the opposite is true, and mining is the preferred livelihood activity, and with its far greater economical returns the profits made from mining can be reinvested in agriculture. As with many artisanal operations, ASM has destroyed large tracts of agricultural lands and deprived the agriculture of the needed labour. As a way of navigation through the labour attraction challenges imposed by ASM smallholder farmers in mining communities have adopted diverse livelihood strategies including agricultural intensification, livelihood diversification and migration as suggested by Scoones (1998) but the returns from such investments are not enough to offset the gains speculated to be accruing from ASM. In Ghana, many smallholder farmers who live in mining areas are therefore compelled to provide their labour services to ASM because of the

supposed financial attraction that often outweighs the environmental risk (Maponga and Ngorima, 2003; Hilson and Garforth, 2012).

3. Methodology

3.1. The study area

Northern Ghana is the study area. The area is made up of five regions namely Northern, North East, Savannah, Upper East and the Upper West. The dominant economic activity in the area is small-scale agriculture, though discoveries and mining of mineral resources is gaining grounds in some parts. Two regions were chosen for this research (ie. Savanna region and Upper East region). The research was conducted in two districts: Bole in the Savannah area and Bawku West in the Upper East region. The districts were chosen strategically because of large number of people engaged ASM activities in Northern Ghana. The two districts annual rainfall amount between 820 mm and 1200 mm. The main economic activities of the communities within these districts are farming and animal husbandry. Among the crops grown are cowpea, groundnuts and other crops with short gestation period. The long period of drought (usually six months) that follows the short period of rainfall have often compelled farmers to seek alternative livelihood activities in the dry season when agriculture activities become unattractive. The mineral deposits especially gold have been heralded as the opportunity to boost the local economy, which has been agriculture dependent. Apart from attracting migrants from all walks of life, especially those from China and some parts of southern Ghana who are believed to have the expertise and the needed resources for the mining industry, the indigenes, mostly farmers have found it an avenue to earn extra income through the supply of their labour. Due to this, the indigenous and settler farmers have resorted to providing their labour services for mining activities thereby relegating agriculture production to the background.

3.2. Research design and data

A quantitative research design was use for the study. The study used primary cross-sectional data which was obtained with the help of a structured questionnaire through face-face interviews. It is important to choose the right sample size so that the conclusion and recommendations made will reflect the total population under study. Accordingly, the sample size (N) of the study was inspired by the formula of Green (1991), who indicated that the sample size (N) should be equal to or more than 50 + 8(m), where m is the number of the explanatory variables used in the model. Given that 16 explanatory variables were expected to be used in the models, the sample size was therefore determined as, N = 50 + 8 (16) = 128. However, the sample size was increased to 200. A stratified sampling technique was used to divide Northern Ghana into regions with and without ASM and two regions (Savannah and Upper East) with ASM activities were selected. The districts in these regions were divided into districts with and without ASM activities using stratified sampling technique. One district each with ASM activity was chosen from each designated region. The communities in the selected districts were divided into two groups: those with and those without ASM. Using a simple random sampling technique, four villages with ASM were selected from each district. For each ASM community to have enough representation in the final sample, 25 households were chosen from each ASM community. We source data on socioeconomic factors and household consumption expenditure.

3.3. Estimation procedure for welfare implications of labour to ASM

The research adopted the ESR model because welfare implications of labour to ASM involve twosteps. The first step is for farmers to recognise the need to supply labour and indeed take action by offering their labour services to ASM (Tilahun and Bedemo, 2014). The second step is the estimation of the impacts of labour supply on household welfare. Meanwhile, these estimations create a sample selectivity problem since only those who have the ability to do the strenuous work can supply labour to ASM. Similarly, other intrinsic factors may affect the decision of farmers to offer labour services to ASM thereby resulting in sample selectivity bias. What it means is that, farmers may select themselves to supply labour to ASM (self-selection), depending on the observable and unobservable factors (Castellacci and Tveito, 2018; Zheng and Ma, 2021). These biases were dealt with using ESR model.

ESR model estimates a selection model and an outcome model. The selection model which is the first stage estimation is given as

$$SLS_i = Z_i \propto + \varepsilon_i \quad (1)$$

Where SLS is the binary decision variable, supply of labour services which is equal to 1 if the farmer supply labour services to ASM and 0 if otherwise; Z is a vector of household demographics, socioeconomic, farm-level and policy variables; $\propto$ is a vector of parameters to be estimated; and ε is an error term.

The second stage of ESR has the ability to separate farmers into suppliers and non-suppliers of labour services to ASM.

$$\text{Suppliers of labour services to ASM} : Y_{1i} = \beta_1 X_{1i} + e_{1i} \text{ if } SLS_i = 1 \quad (2a)$$

$$\text{Non} - \text{suppliers of labour services to ASM:} Y_{2i} = \beta_2 X_{2i} + e_{2i} \text{ if } SLS_i = 2 \quad (2b)$$

Where Y_{1i} and Y_{2i} are outcome variables for farmers who supply labour services to ASM and those who do not supply labour services to farmers respectively. The outcome variable is household welfare which is proxied in this study as per capita consumption expenditure (Gh'); X_1 and X_2 vector of household demographics, socioeconomic, farm-level and policy variables for suppliers and non-suppliers of labour services respectively; β_1 and β_2 are paramenters to be estimated for suppliers and non-suppliers of labour services respectively; e_1 and e_2 are error terms for suppliers and non-suppliers of labour services respectively.

The condition for identification of ESR model was checked. ESR model is identified if the variables in the selection model (equation (1)) contains at least one excluded variable in the outcome model (equations 2a and 2 b) (Shiferaw et al., 2014). This, therefore requires that a falsification test is conducted to ensure that the instrument selected is valid. A valid instrument has effects of the supply of labour but not on the household welfare (Di Falco and Veronesi (2013). In this study, distance to nearest mining sites was used as instrument considering the fact that it significantly influences farmers' labour supply decision but not welfare. The ESR model was estimated using the full information maximum likelihood (FIML) estimation approach since it has the ability to simultaneously estimate the selection and outcome equations and provide efficient estimates. From the coefficient of the ESR estimates, the average treatment effect on the treated (ATT) and the average treatment effect on the untreated (ATU) were estimated by comparing the expected consumption expenditures supply and non-supply of labour services to ASM in actual and counterfactual scenarios.

4. Results and discussions

4.1. Inferential statistics of the socioeconomic variables of respondents

The respondents considered in this study are grouped into suppliers and non-suppliers of labour services to ASM activities. The test shows whether or not there are statistical significant differences in socioeconomic factors between suppliers and non-suppliers of labour services to ASM. As shown in Table 1, all the continuous variables except active labour force is not statistically significant. Whilst farmers who supply labour to ASM have an average age of 38.1 years, their counterparts who do not supply labour are relatively older with an average age of 51.9 years. This is a truism as ASM operations require more energetic people

Table 1
Inferential statistics of suppliers and non-suppliers of labor.

Variables	Mean for SS	Mean for non-SS	*t*-test
Continuous variables			
Age (years)	38.14	51.93	7.09***
Distance to ASM site (km)	1.5	4.14	9.15***
Farm size (acres)	5.89	7.03	2.30**
Distance to site (km)	1.5	4.14	9.15***
Education (years)	4.9405	2.5172	−2.99***
Asset value (GH')	17493.13	11911.65	−4.39***
Farming experience (years)	17.57	29.57	7.74***
Spouse education (years)	1.29	1.21	−0.1637
Non-ASM income (Gh')	8497.46	8687.56	
Household size	8.58	12.43	4.21***
Infants (1–3 years)	0.95	1.03	0.57
Children (4–14 years)	3.05	4.86	4.10***
Infants at adult equivalent	0.32	0.34	0.27
Children at adult equivalent	2.03	3.24	0.57
Adults (>15 years)	4.58	6.53	3.20***
House size at adult equivalent	6.93	10.12	4.12***
Per capita consumption expenditure at adult equivalent (Gh')	13099.36	9935.99	−4.76***
Discrete variables			
Remittance (yes)	0.2	0.42	3.45***
Credit access (yes)	0.07	0.03	−1.42
Cash crop (yes)	0.3	0.53	3.46***
Agricultural extension (yes)	0.14	0.36	3.71***
Land ownership (yes)	0.79	0.56	−3.49***
Region (Savannah)	0.67	0.38	−4.18***
Fertilizer subsidy (yes)	0.26	0.50	3.55***
Bank account (yes)	0.15	0.35	3.33***

NB: *, ** and ***, denotes 10%, 5% and 1% significant levels respectively.

and hence the reason why the youth are ready to provide their labour services as compared to the elderly. The results in Table 1 clearly shows that respondents who stayed closer to ASM site are engaged in mining as compared to those who stayed far from the site. Farmers who are 4.1 km and farther away from the mining site do not supply labour for mining operations. Also, farmers who have relatively larger farm size do not engage in ASM activities. Farmers who have farm size of 7.0 acres do not provide labour services for ASM activities. Meanwhile, the counterparts with average farm size of 5.9 acres supply labour services to the miners. Conversely, farmers who have 4.9 years of formal education supply labour to ASM and this is statistically significantly different from those who do not provide labour to ASM as they have 2.5 years of education. This does not meet a priori expectation. For value of assets, suppliers of labour have higher value of asset than non-suppliers of labour. The suppliers of labour services to ASM have an average value of GH'17,493.13 as against non-supplies with an average asset value of GH'9893.71.

As shown in Table 1, except for credit access, all variables are statistically significant. The proportion of farmers who supply labour services to ASM and receive remittances are 20% whereas those who do not supply labour services and remittances are 42%. Whilst cash crop farmers who supply labour services to ASM are 30% and those who do not supply labour services are 53%. Also, there is significant difference in proportion of farmers who own lands between the labour suppliers and non-labour suppliers. Whilst 79% of the labour service suppliers own land, the percentage of their counterpart who do not supply labour to miners but have their own lands is 56%. Though this does not meet a prior expectation but might make sense if one considers that earnings from ASM were used to buy the agricultural land.

4.2. Determinants of labour supply to ASM and welfare outcomes: ESR results

Endogenous switching regression was used to investigate the effect of labor supply decisions on welfare outcome. Table 2 shows the detailed information for maximum likelihood estimates of the determinants of labour supply (selection equation) and consumption expenditure per adult equivalent in each of the regimes (outcome equations). According to Lokshin and Sajaia (2004), the selection equation should have at least one variable (instrument) that is not included in the outcome equation. In this study, the suitability of the instruments was tested using a falsification test proposed by Di Falco (2014). Following the falsification or exclusion restriction criterion test, distance of respondents' house to nearest ASM site was found to have statistical significant influence on labour supply but otherwise in the outcome model. The negative direction of effects meets the expected economic intuition that nearness to ASM site increases the probability of supplying labour to ASM operations. Therefore, the admissibility condition of the instrument is

Table 2
Determinants of labour supply and consumption expenditure.

Variables	Supplying of Labour to ASM		Consumption expenditure			
			Non-suppliers of labour		Suppliers of labour	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age (years)	−0.035*	0.018	77.797**	39.476	−84.054**	37.004
Household head education (years)	−0.051**	0.024	47.975	77.363	31.092	59.224
Spouse education (years)	−0.049	0.043	150.599	130.049	−190.700	131.670
Agric Extension (1 = yes)	−0.658*	0.337	3853.131***	883.925	−1124.317	1208.381
Land ownership (1 = yes)	0.302	0.394	1469.438	1319.882	−581.715	1143.999
Farm size (acres)	−0.069*	0.041	116.390	140.866	−145.454	185.071
Cash crop (1 = yes)	0.105	0.301	1952.692*	1181.234	3990.257***	1157.009
Fertilizer subsidy (1 = yes)	−0.084***	0.024	1466.22*	1244.12	1189.343***	381.44
Bank account (1 = yes)	0.180***	0.035	−1017.921	1343.693	1644.69***	433.56
Farming experience (years)	−0.026	0.020	−29.828	57.263	186.834***	63.304
Remittance (1 = yes)	−0.654**	0.299	1607.173*	954.297	2054.151*	1139.279
Region (1 = Savannah)	0.006	0.406	−4000.183***	1364.003	−256.344	1507.162
Asset value (Gh')	2.94E-5	2.36E-5	0.114**	0.055	0.250***	0.064
Non-ASM income (Gh')	−5.88E-5**	2.74E-5	0.191*	0.103	−0.080	0.090
Distance to mining site (Km)	−0.379***	0.063				
_cons	2.109**	0.932	1511.553	3178.786	17670.200***	5841.877
/lns1	8.001	0.039		sigma_1	2983.915	115.634
/lns2	8.178	0.022		sigma_2	3561.195	78.219
/r1	−0.385	0.304		rho_1	−0.367	0.263
/r2	−0.192	0.424		rho_2	−0.190	0.409

Wald test of indep. Eqns.: $chi^2(1) = 1.73$ Prob > $chi^2 = 0.1888$; Number of obs = 200.
Wald $chi^2(14) = 121.01$; Log pseudolikelihood = −1968.9929 Prob > $chi^2 = 0.0000$.
NB: *, ** and ***, denotes 10%, 5% and 1% significant levels respectively.

satisfied.

The rho is a measure of the correlation coefficients between the error terms of the selection and outcome equations. From the results, the *rhos* are not statistically significant suggesting that self-selection is not present. It implies that selectivity bias was not present and the coefficients are the true effects of the explanatory variables on adult equivalent per capita consumption expenditure. The Wald Chi-Square (likelihood ratio) test of independent equations is not statistically significant. This implies that the three equations are independent and could be estimated separately using PSM or other models. Despite this, ESR was employed in this study to help us estimate impacts of labour supply to ASM on consumption expenditure per adult equivalent at counterfactuals. It also allowed us to separate factors that influence consumption expenditure per adult equivalent for both labour suppliers and non-suppliers simultaneously.

The results of the first equation of ESR showing determinants of farmers supplying their labour to ASM is evinced in columns two and three. The factors that have statistical significant effects on labour supply are age, years of education of household head, access to agricultural extension service, farm size, access to fertilizer subsidy, having bank account, receiving remittances, value of non-ASM income. As shown in the results, age of the household head indicates that younger farmers have high probability supplying labour to ASM. This is plausible since most of the activities of ASM require more energy. The activities of ASM is very labour intensive, laborious and energy demanding. These findings confirmed the work of Osei (2017) that youth are heavily involved in ASM activities. It also collaborated the findings of Osei et al. (2021) that ASM is a vital sector that provides opportunities for young people to build their livelihoods and assets.

Also, as years of education decreases by 1, the probability of supplying labour to ASM increases by 5.1%. Though, the direction of effects of education of labour supply is ESR model is contrary to that of the results in *t*-test (Table 1), it meets the a priori expectation. Also, results from *t*-test should not be relied on since it failed to factor in other factors that affect one's decision to supply labour to ASM. It is evident in the work of Osei et al. (2021) that majority of people engage in ASM have not been to school or have low level of education. The study of Osei et al. (2021) revealed that the people enter ASM sector because of their inability to complete or attain higher formal education. Access to agricultural extension service discourages one's participation in ASM activities. This means that agricultural extension as a policy is critical in reducing farmers desire to supply labour to ASM operation. Extension officers advise farmers on improved farming innovations and technologies. This goes a long way to incentivize them to concentrate on agriculture value chain activities rather than using their precious time to engage in mining activities which are harmful to their health. Sometimes, the agricultural extension officers educate farmers on health implication of mining on the environment, farming and humans.

Farmers who have small farm size have higher propensity to engage in mining by supplying their labour. This is economically intuitive and supports the results in the *t*-test. This is because, such farmers have ample time to spare. This ample time is then used in helping miners to gain some income for the household. It can also be explained that such farmers do not reap enough income from the farming activities and hence rather see labour supply to ASM to be more profitable. This conforms to the studies of Osei et al. (2021), Hilson and Maconachie (2020) and Labonne (2014) that people engage in mining to earn income and accumulate assets. Also, farmers who have access to fertilizer subsidy and receive remittances have 8.4% and 65.4% lower probility of engaging in ASM operations. This makes economic sense. Those who have access to fertilizer subsidy are able to expand their farms. They apply the fertilizer and are likely to have higher yield thereby getting enough income for the household needs. Lastly on the labour supply decisions, farmers who have low value of non-ASM income have higher probability of supplying their labour to ASM. This confirmed the studies by Zvarivadza and Nhleko (2018) and Osei (2017) that poverty is a key driver of ASM.

There are significant differences between determinants of consumption expenditure of suppliers and non-suppliers of labour to ASM operators. From Table 2, the factors that significantly determine consumption expenditure per adult equivalent for both suppliers and non-suppliers of labour are age, cultivation of cash crops, access to fertilizer subsidy, receipt of remittances, and asset value. Whilst access to agricultural extension service, regional dummy and non-ASM income have statistical significant effects on consumption expenditure per adult equivalent for non-suppliers of labour, having a bank account and farming experience affect consumption expenditure per adult equivalent for suppliers of labour to ASM.

As the age of household head increases by one year, the consumption expenditure per adult equivalent for non-suppliers of labour increases by Gh'77.80. It is consistent with the a priori expectation. Ordinarily, farmers' welfare decreases with age increment because as farmers age increases, it is difficult for them to partake in labor intensive work to get enough income to take care of household expenditure. Also, older farmers find it difficult to adopt new agriculture technologies which results in low yield thereby translating into low household welfare. Unlike the younger farmers who engage in many non-farm and/or off-farm economic activities to earn extra income to improve household welfare, the older farmers are not able to do this. This results confirmed the empirical studies by Çağlayan and Astar (2012) that as age increases the consumption expenditure of rural folks decreases. Conversely, a year increase in one's age results in Gh'84.05 decrease in consumption expenditure per adult equivalent for non-suppliers of labour. This does not meet the a priori expectation.

The coefficient of access to agricultural extension service implies that farmers who have access have Gh'3853.13 consumption expenditure per adult equivalent higher than those who do not have access. Consistent with the a priori expectation, farmers who have access to extension services have better welfare than their counterparts who do not have access to extension services. It can be explained that when agriculture extension officers visit farmers, it is expected that farmers will be well informed on new agriculture technologies and adopt them to increase yields thereby improving welfare (consumption expenditure). Farmers who cultivate cash crop have higher consumption expenditure per adult equivalent than their counterparts for both suppliers and non-suppliers of labour. Also, access to fertilizer subsidy increases adult equivalent per capita consumption expenditure.

As expected, suppliers and non-suppliers of labour who respectively receive remittances have Gh'2054.15 and Gh'1607.17consumption expenditure per adult equivalent higher than their counterparts who do not receive remittances. These direction of effects meets the a priori expectation. This is because, remittance received are used to improve the household welfare. It confirms the findings of Twumasi et al. (2021) that remittances improve household welfare. Additionally, Cuong and Linh (2018) opined from their study that remittances increase per capita income and per capita expenditure and reduce poverty of receiving households. For non-suppliers and suppliers of labour, a unit increase in total asset value of household respectively increases the consumption expenditure per adult equivalent by Gh'0.11 and Gh'0.25. Assets such as motorbike, bicycle, houses, tractor etc were included in the measurement. Motorbike and bicycle are major means of transportation in the rural setting and hence, farmers who own motorbike will be able to convey their agriculture produce to the nearest market for better pricing and income to improve welfare. Meanwhile, a buildup in assets has a little positive impact on welfare as observed in the results. Also, the results from the non-suppliers of labour shows that a household from Upper East Region has consumption expenditure per adult equivalent of Gh'4000.18 more than those from Savannah Region. For the suppliers of labour to ASM, a one-year increase in farming experience increases consumption expenditure per adult equivalent by Gh'186.83. This is plausible since farming experience may yield credence to specialization thereby resulting in improve yield and welfare.

4.3. Effects of labour supply on consumption expenditure

Table 3 depicts results of the impacts of labour supply to ASM on consumption expenditure per adult equivalent for the observed and counterfactual situations. The results show the average treatment effects on the untreated (ATU) and the average treatment effects on the treated (ATT). As shown in the Table and as expected, if the supplier of labour to ASM continue to supply, they are able to obtained GH'14,201.37 adult equivalent per capita consumption expenditure. Meanwhile, if the suppliers of labour decide not to supply the labour to ASM, they will have their consumption expenditure per adult equivalent reduced from GH'14,201.37 to GH'8523.68. Therefore, the benefits in terms of welfare (herein measured as adult equivalent per capita consumption expenditure) to suppliers for supplying their labour to ASM is GH'5677.69. This figure is the ATT. In a nutshell, supplying labour to ASM increases welfare (adult equivalent per capita consumption expenditure) by 66.6%. This result confirmed the findings of Akudugu et al. (2012) that small-scale mining has positive impacts on welfare outcomes. Also, recent study by Worlanyo et al. (2022) pointed to the fact that farmers who participate in land-use conversion (lease of agricultural land to miners for mining) had annual income of GH'189.00 more than the non-participants. The study by Worlanyo et al. (2022) looked at effects of land-use conversion on welfare. The land-use conversion in their study implies farmers leasing their agricultural lands to miners for a period of them. With this, farmers totally lose their land and agricultural produce on it during the period of the lease and hence are likely to be highly affected thereby getting a relatively small gain of GH'189.00 income. Also, the authors used income as proxy to measure welfare. Since people often under declare their income, it is possible that this might have happened thereby resulting in the small gain from land-use conversion. In this current study, we looked at effects of farmers supply of labour to mining activities on their welfare. With the supply of labour, the farmers still have their agricultural lands and produce intact and hence are able to get higher gain compared to those who outrightly sell or rent their lands.

Also, the results in Table 3 shows that the base heterogeneity is positive for both participants (BH11) and non-participants (BH12). Meanwhile, the positive transition heterogeneity (TH_{11}) value of GH'0.32 implies that the impacts of labour supply to ASM is larger for participants than non-participants. Conclusively, people especially the youth supply labour services to mining to earn some income to improve on their livelihoods.

Table 3
Effects of farmers' participation in ASM on Consumption Expenditure.

	Participation decision		Treatment effects (TE)	% change in treatment
	Participating	Non-participating		
Participants	14201.37	8523.68	ATT = 5677.69*** (273.44)	66.61
Non-participants	14200.13	8522.81	ATU = 5677.32*** (273.47)	66.61
Heterogeneity effects	$BH_{11} = 1.24$	$BH_{12} = 0.87$	$TH_{11} = 0.32$	

5. Conclusions

This article took deep-dive research into the factors that influence farmers' decision to shift labour services from farming activity to ASM sector. It also assessed how this decision affects farmers' welfare (using consumption expenditure per adult equivalent as the proxy). The ESR model was used for the analysis. The study unearthed that the motivation for farmers to shift their labour towards ASM activities is based on proximity to ASM mining sites, low level of education, youthfulness, inaccessibility of agriculture extension services, non-participation in fertilizer subsidy, and low income from non-ASM activities. Also, as the farm size of a farmer decreases, the probability of him/her shifting his FL towards ASM increases. These socioeconomic factors need to be considered in the design of any policy to effectively retain some FL in agriculture. Critical to this study, farmers who shift their FL to ASM can increase their welfare (consumption expenditure per adult equivalent) by 66.6%. This implies that ASM profoundly improves farmers' welfare. This discovery is very important from welfare perspective signifying the crucial role played by ASM in the rural economies. Meanwhile, if proper incentives such as fertilizer subsidy and agriculture extension intensification are not put in place, the labour attraction by ASM will have detrimental effects on food security. It is therefore important for duty bearers to regulate the activities of ASM as it provides welfare improvements to farmers through the supply the labour services. Also, further studies should investigate the decency of labour supply services to ASM.

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Declaration of competing interest

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Data availability

Data will be made available on request.

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