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ECONOMIC MULTIPLIERS AND SECTORAL LINKAGES: GHANA AND THE NEW OIL SECTOR

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Abstract

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The study seeks to assess the structure of the economy of Ghana in terms of changes in the economic structure before and after the production of oil in commercial quantities. This is viewed with regards to economic multipliers, sectoral interdependence and trade concentration. The results show that changes occurred with regards to multipliers and sectoral interdependence. The output multipliers of most sectors have declined. The results also show that the agricultural sector experienced an initial decline in its growth while industry experienced an increase. The performance of the services sector was relatively stable for the period covered by the study. There is a decline in the level of trade concentration though on a whole the concentration index is still high. The study employed input-output modeling techniques and the data was obtained from the Ghana statistical service and the World Development Indicators.

Keywords: oil and gas, multipliers, sectoral linkages, trade concentration, input ratios, input-output table, Ghana

INTRODUCTION

The economy of Ghana has for a long time depended on narrow range of exports which included: gold, cocoa and timber. This made the economy vulnerable to shocks in the global market, since these products were exported in their raw state and commanded low value. The discovery and production of oil in commercial quantities in 2010 brought an addition to the export portfolio of the country. The impact of this resource in transforming the economy cannot be underestimated. Though it is also exported in its unprocessed state, the enormous proceeds received by the state are important for the desired economic turn-around.

To investigate the impact the oil resource has had on the structure of the economy, the study employed input-output modeling techniques. It basically focused on the changes with regards to economic multipliers and sectoral inter-dependence. It also assessed the performance of tradtional sectors in terms of output growth and contribution to Gross Domestic Product (GDP). The level of trade concentration was also emphasized.

Several researchers have employed input-output modeling techniques in the analysis of economic structure, and on the opportunities and challenges of various economies. Professor Leontief (1936), who pioneered input-output model and made a critique of Keynes. In particular, Leontief emphasized that Keynes (1936) underplayed the importance of the role of investment. He noted that investment should be viewed as a productive input, and not just as a component of demand.

Extensions to his works were made by Miller and Blair (2009), to take care of obsolete assumptions. The new topics covered include social accounting matrices and their connection to input output data, structural decomposition analysis, multiplier decompositions, identifying important coefficients, and international input–output models. Wang *et al.* (2013) in their paper detected the industrial linkages of eight iron and steel producing countries, including China, USA, Japan, Germany, Italy, Brazil, Korea, and India. They concluded that the induction effect of export demand on steel industry in China is shown to be less than several OECD countries, such as Japan.

San Cristo'bala and Biezma (2006), in their paper showed three subsectors as key sectors: the mining of coal and lignite and extraction of peat in Germany; mining of metal ores in Sweden; and other mining and quarrying in Austria, Denmark and Spain. They also concluded that these sectors were more stimulated by overall industry growth than other sectors and have greater impacts in terms of investment expenditures on the national economy than other sectors. Sabiroglu and Bashirli (2012), concluded that a marginal change in final demand has a significant impact on mining and quarrying of energy producing materials. The impact of this sector on total output and total supply is relatively low. This can be explained by a limited capacity of this sector to directly generate wealth and employment opportunities on a large scale.

Stilwell *et al*. (2000) analyzed the impact of mining on the South African economy using input-output analysis. Their results show few linkages between the mining sector and the rest of the economy. Aroca (2001) applied it to the mining sector of the Chilean region. This paper shows that a significant amount of resources generated by the mining industries in the Region of Antofagasta goes to other regions in wages earned by commuters who have decided to work in this region but live in another. Lenzen (2001) analyzed the interdependence of industries in the Australian economy in terms of environmental pressure and resource depletion. Karkacier and Goktolga (2005) analyzed the structural interdependence of the agricultural sector and energy sectors in Turkey. Their results show the interdependence between several agricultural subsectors in the economy of Turkey. Kawk *et al*. (2005) examined the role of the maritime industry in the Korean economy and highlight the importance of backward linkages and production-inducing effects within the South Korean the marine sector.

Miller and Blair (1985) showed how a comparison of the strengths of backward and forward linkages for sectors in a single economy provides mechanism for identifying "key" sectors.

Ciarreta and Nasirov (2012) concluded that there is the need for diversification of the economies in natural resource endowed countries by strengthening services and the non-oil sector, to raise agricultural productivity, to invest in the electricity sector, to increase the effectiveness of public expenditure planning. Rayner and Bishop (2013) conclude that under certain assumptions for relative prices, the spillovers from the resource sector (oil sector) to activity in other industries appear to be large.

MATERIALS AND METHODS

A symmetric input-output table was derived from the "Supply and Use table" using the approach of Soklis (2009) and Kazemier (2012). The data was obtained from the Ghana Statistical Service. It is a system of national accounts data with details of transactions among sectors in the economy. It is static and covers the period from 2010 and below. Estimates were used to upgrade in the case of higher years (2010 and above). Developing economies such as Ghana have relatively slow reaction of supply to changes in demand hence the input ratios used in the calculations of the tables were assumed stable. The constructed input – output table has several parts; the intermediate consumption, the final demand, the value added and total output. The intermediate consumption comprised all the sectors in the economy including households and the new oil sector. They include: Agriculture, Mining, Manufacturing, Electricity and Water, Construction, Distribution and Catering, Transport and Communication, Business and Finance, Public Administration, Education, Health and Social works, Other community services as well as Oil and gas. The output of sectors was measured in millions of Ghana cedis (GH¢). Final demand included: government consumption expenditure, investment and exports. Value added comprised: imports, compensation of employees, taxes and subsidies, capital consumption allowance.

The analysis made comparison of two scenarios: a twelve sector model excluding the oil sector and the second was a 13 sector model including the oil sector.

An industry by industry approach was employed in the construction of the model. The basic IO (input-output) model consists of rows and columns. Rows show the disposal of an industry's output for the given year among the sectors of the economy. Vertically, columns show the amount of inputs used by a sector in production for the given year.

The Output Per Sector and the Input Coefficients

The relationship between the inputs used by the industries and the total output produced was given by the input coefficients

$$A_{ij} = \frac{x_{ij}}{X_j}, \tag{1}$$

where X_j is the total output of sector j and x_{ij} represents the inputs used. Given the nature of the Ghanaian economy, typical of developing economies, technical coefficients were assumed to be stable and thus fixed. The economy was therefore represented by the following set of homogenous linear equations.

$$X_1 = A_{11}x_{n1} + A_{12}x_{n2} + A_{13}x_{n3} + \ldots + A_{1i}x_{ni} + \ldots + A_{1m}x_{nm},$$

$$X_2 = A_{21}x_{n1} + A_{22}x_{n2} + A_{23}x_{n3} + \ldots + A_{2i}x_{ni} + \ldots + A_{2m}x_{nm},$$

$$X_3 = A_{31}x_{n1} + A_{32}x_{n2} + A_{33}x_{n3} + \ldots + A_{3i}x_{ni} + \ldots + A_{3m}x_{nm},$$

$$X_m = A_{m1}x_{n1} + A_{m2}x_{n2} + A_{m3}x_{n3} + \ldots + A_{mi}x_{ni} + \ldots + A_{mm}x_{nm}.$$

This shows how employment, output and income depend on final demand in an economy. The term

$A_{i2}x_{n2}$ represents the part of i^{th} sector's output that is dependent on the inputs x_{n2} of industry 2. The magnitude depends on the technical input coefficients of all industries. Thus output of a sector is computed as

$$x_{i1} + x_{i2} + \ldots + x_{ij} + y_i = X_i, \tag{2}$$

where x_{ij} represents purchases by the sector j of the output produced by sector i, y_i represents the sales from sector i, to final demand and X_i is the total output of sector i.

Output and Income Multipliers

D'Hernoncourt *et al.* (2011), defined Type I output multipliers for a particular industry as the total of all outputs from each domestic industry required in order to produce one additional unit of output. Income multipliers were also defined as the increase in income from employment (IfE) or compensation of employees that results from a change of GH¢1 of income from employment in each industry. Economic multiplier effects were calculated in terms of output and income. From equation (1) we have

$$x_{ij} = A_{ij}X_j. \tag{3}$$

Using simple matrix notation, where A represents technical coefficients matrix, X is the vector of output, Y is the vector of final demand, we rewrite (2) by

$$AX + Y = X. \tag{4}$$

Therefore

$$(I - A)\,X = Y, \tag{5}$$

where I is the identity matrix $(1 - A)$ and is called Leontief matrix. Equation (5) can be written as

$$X = (I - A)^{-1}Y. \tag{6}$$

The matrix $(1 - A)^{-1}$ is called the Leontief inverse matrix or the matrix of partial output multipliers.

The solution of the input-output model is therefore obtained from equation (6). Total output multipliers (OM) will be given by the column sums of B_{ij} and interpreted in Ghana cedis (GH¢).

Let

$$B_{ij} = (I - A)^{-1}. \tag{7}$$

The output multipliers (OM) were therefore calculated as

$$OM = \sum_i B_{ij}\,. \tag{8}$$

The total income multipliers (IM), also measured in Ghana cedis (GH¢), were given by

$$IM = \sum_i \frac{v_i B_{ij}}{v_j}\,, \tag{9}$$

where v refers to the ratio of income from employment to total output of the industry.

Intersectoral Linkages and Interdependence

Intersectoral linkages describe the output and input relationships among the given sectors of production. These linkages were categorized into two: backward and forward linkages. Backward linkages describe how a given sector depends on other economic sectors for input supply. Forward linkages on the other hand refers to how a sector supplies its output to other sectors to be used as intermediate inputs of production. The backward (U_{wj}) and forward (U_{wi}) linkages were respectively calculated as

$$\sum_i U_{wj} = \frac{\frac{1}{n}\sum_i w_i B_{ij}}{\frac{1}{n^2}\sum_{ij} w_i B_{ij}} \tag{10}$$

and

$$\sum_i U_{wi} = \frac{\frac{1}{n}\sum_j w_j B_{ij}}{\frac{1}{n^2}\sum_{ij} w_j B_{ij}} \tag{11}$$

with w being the chosen weight (either α or β) and B_{ij} being the elements of the Leontief inverse.

Export Concentration

Export concentration reflects the degree to which a country's exports are concentrated on a small number of products or a small number of trading partners. A country that exports one product to only one trading partner has a perfectly concentrated export portfolio. Conversely, a country whose exports are comprised of a larger number of products and that trades with a larger number of trading partners has a lower export concentration ratio (ECR), i.e., has more diversified exports. The Export Concentration Ratio (ECR), also known as the Herfindahl-Hirschmann index, is a measure of the degree of market concentration. It has been normalized and given by

$$H_i = \frac{\sqrt{\sum_{i=1}^{n}\left(\frac{ex_i}{EX}\right)^2} - \sqrt{\frac{1}{n}}}{1 - \sqrt{\frac{1}{n}}}, \tag{12}$$

where

$$EX = \sum_{i=1}^{n} ex_i \tag{13}$$

and H_i is the country's index, ex_i is the value of exports of product i, and n is the number of products and EX is the total exports. The ECR measures merchandise exports and does not include exports

of services. It ranges from 0 to 1, with 0 reflects the least concentrated export portfolio and 1 the most concentrated.

The data for the input-output model was obtained from the Ghana Statistical Service. The data for trade concentration and diversification was obtained from the United Nations Conference on Trade and Development (UNCTAD).

RESULTS AND DISCUSSION

This section discusses the results from the equations given in the methodology. Equations (1) through (7) will result in the solution of the leontief inverse matrices (see Tabs. I and II) for the two scenarios: before and after oil production. The content of the output displayed in both tables represent the partial output multipliers which is defined as the amount of output required from other sectors or industries for every given unit change in production. The numbers from 1 to 12 or from 1 to 13 represent the respective sectors of production: agriculture (1), mining (2), manufacturing (3), electricity and water (4), construction (5), distribution and catering (6), transport and communication (7), business and finance (8), public administration (9), education and health (10), other services (11). The household sector is represented by 12 or 13 depending on the number of sectors in each table. In a 12 sector table such as Tab. I, household is represented by 12. In a 13 sector table such as Tab. II, household is represented by 13 and the oil sector is represented by the number, 12.

Tab. I shows the results without the oil sector and Tab. II shows the results with the inclusion of the oil sector. The values in each table represent the partial output multipliers. A decline in values is observed from Tab. I to Tab. II. The drop in partial output multipliers is inline with the findings of Rayner and Bishop (2013) who concluded that spillover effect of natural resource sectors is large and negative on other sectors.

The total output and income multipliers were then calculated. Output multipliers for a particular sector are defined as the total of all outputs from each domestic sector required in order to produce one additional Ghana cedi of output. They were derived from equation (8). The income multipliers show the increase in income from employment or compensation of employees that result from a change of one Ghana cedi of income from employment in each sector. These were derived in equation (9). The results were compared for the two scenarios; before and after the new oil sector. See Tabs. III and IV.

The results from Tab. III show that households had the highest output multipliers. Manufacturing has the second highest. The sector with the least output multiplier before oil production is the other community social services. It must be mentioned that the economy of Ghana is agrarian and thus expected to have a high output multiplier. As observed most households are employed in agriculture. The multiplier value of agriculture is affected by the households participation as a sector of production.

It can however be observed that with regards to income, the agricultural sector has the highest multiplier effect. Households have the least income multiplier which applies in the explanation provided above. Mining and manufacturing also have high income multipliers.

Tab. IV shows the results for both income and output multipliers after oil production. The oil sector is seen to have the highest about multiplier of 2.67. It is followed by manufacturing before households and agriculture.

The agriculture sector however still maintains its highest income multiplier effect though the value is lower than the period without oil production. The income multipliers of most sectors also declined. Such declining performance in non-oil related sectors are typical of countries that fail to ensure balanced sectoral development. This trend was observed by Ciarreta and Nasirov (2012) in their study of the oil sector of Azerbaijan.

I: *Leontief inverse matrix before oil production*

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.87	0.12	0.48	0.07	0.11	0.23	0.13	0.08	0.11	0.20	0.11	0.58
2	0.02	1.64	0.17	0.06	0.05	0.03	0.03	0.01	0.02	0.03	0.02	0.07
3	0.20	0.43	2.19	0.27	0.46	0.32	0.41	0.17	0.19	0.36	0.21	0.89
4	0.01	0.05	0.03	1.61	0.01	0.02	0.01	0.02	0.03	0.03	0.03	0.06
5	0.00	0.01	0.01	0.08	1.58	0.00	0.01	0.01	0.02	0.01	0.01	0.03
6	0.02	0.08	0.05	0.03	0.02	1.77	0.06	0.06	0.09	0.10	0.05	0.27
7	0.02	0.05	0.03	0.02	0.01	0.08	1.57	0.07	0.08	0.10	0.06	0.27
8	0.01	0.25	0.06	0.03	0.02	0.05	0.07	1.50	0.05	0.04	0.04	0.08
9	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	1.38	0.02	0.01	0.06
10	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.03	1.30	0.28	0.08
11	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	1.01	0.09
12	0.02	0.07	0.05	0.04	0.03	0.05	0.11	0.11	0.19	0.34	0.16	1.08

II: *Leontief inverse matrix after oil production*

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.74	0.02	0.22	0.02	0.02	0.11	0.03	0.02	0.03	0.06	0.04	0.07	0.23
2	0.01	1.26	0.07	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.07	0.01
3	0.12	0.13	1.59	0.12	0.16	0.13	0.15	0.05	0.05	0.11	0.09	0.36	0.31
4	0.01	0.02	0.02	1.32	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.15	0.02
5	0.00	0.04	0.04	0.12	1.29	0.01	0.01	0.01	0.01	0.01	0.01	0.85	0.02
6	0.01	0.02	0.01	0.01	0.00	1.46	0.02	0.02	0.03	0.03	0.02	0.01	0.11
7	0.01	0.01	0.01	0.01	0.00	0.04	1.30	0.03	0.03	0.03	0.03	0.01	0.11
8	0.01	0.09	0.02	0.01	0.00	0.02	0.03	1.30	0.02	0.01	0.03	0.01	0.03
9	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.23	0.01	0.00	0.00	0.03
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.20	0.25	0.00	0.04
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.01	0.00	0.04
12	0.00	0.05	0.05	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02	0.01
13	0.01	0.03	0.03	0.03	0.01	0.02	0.05	0.07	0.11	0.22	0.13	0.10	1.03

III: *Output and Income Multipliers before oil production*

Sector	Output multipliers	Income multipliers
Agriculture	2.17	4.02
Mining	2.71	3.27
Manufacturing	3.08	3.11
Electricity and water	2.22	2.40
Construction	2.31	2.68
Distribution and catering	2.57	2.86
Transport and communication	2.43	1.90
Business and finance	2.08	1.69
Public administration	2.20	1.57
Education, health and social works	2.56	1.39
Other community services	1.99	1.74
Households	3.55	0.82

IV: *Output and Income multipliers after oil production*

Sectors	Output multipliers	Income multipliers
Agriculture	1.93	3.00
Mining	1.68	1.80
Manufacturing	2.06	1.95
Electricity and water	1.78	1.71
Construction	1.52	1.62
Distribution and catering	1.82	1.92
Transport and communication	1.61	1.42
Business and finance	1.52	1.37
Public administration	1.53	1.30
Education, health and social works	1.70	1.23
Other community services	1.64	1.62
Oil and gas	2.67	1.68
Households	1.98	0.35

Backward and Forward Linkages

The results of linkages (see Tabs. V and VI) show that the manufacturing sector had the highest forward linkages excluding the oil sector, followed by agriculture and distribution and catering. It is also observed that agriculture sector had a very weak backward linkage, which is explained by its low requirement of inputs from other sectors for production. All other sectors within the economy had higher backward linkages than forward linkages. There is however the need for higher backward linkages among the sectors to expand production in each sector. The development of agro-industries will have many beneficial feedback effects on agriculture Tesafa (2014). Though mining has a high contribution to GDP in Ghana, its forward linkage with other sectors in the economy is very low. This conclusion is inline with the findings of Stilwell *et al*. (2000) in the South African economy.

It is also observed that the construction, distribution and catering as well as transport and communication sectors had changes in both backward and forward linkages after the commercial production of oil. The construction sector had more oil sector inclusive forward linkages than backward linkages. Distribution and catering had more backward linkages with the inclusion of the new sector. The forward linkages of transport and communication improved and were higher than its backward linkages. Though the minning sector has high total output in the economy, its linkage with other sectors is very low and this is similar to the results from Sabiroglu and Bashirli (2012). See Tab. VI.

The results of most input-output models are similar and reflect similar assumptions. Results based on general joint-product models as was inspired by Neumann (1945) and Sraffa (1960), of the Supply and Use tables is recommended as the way out of any inconsistencies.

Growth Performance and Contributions to GDP

A shift of resources away from traditional (tradable) activities into the oil sector would imply a change in the contribution of each sector to non-

V: *Linkages after oil production*

Sectors	Backward Linkage	Forward Linkage
Agriculture	0.87	1.64
Mining	1.09	0.86
Manufacturing	1.24	2.46
Electricity and water	0.89	0.77
Construction	0.93	0.71
Distribution and catering	1.03	1.04
Transport and communication	0.98	0.95
Business and finance	0.83	0.89
Public administration	0.88	0.61
Education, health and social works	1.03	0.69
Other community services	0.80	0.47
Households	1.43	0.91

VI: *Linkages after oil production*

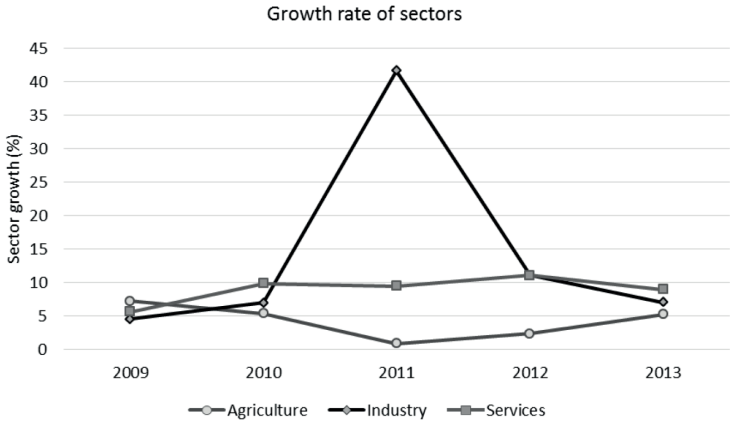
Sectors	Backward Linkage	Forward Linkage
Agriculture	1.07	1.44
Mining	0.93	0.82
Manufacturing	1.14	1.87
Electricity and water	0.99	0.89
Construction	0.85	1.34
Distribution and catering	1.01	0.99
Transport and communication	0.89	0.90
Business and finance	0.84	0.88
Public administration	0.85	0.71
Education, health and social works.	0.94	0.84
Other community services	0.91	0.60
Oil and gas	1.48	0.70
Households	1.10	1.02

oil GDP over time and also a change in growth performance. See Figs. 1 and 2.

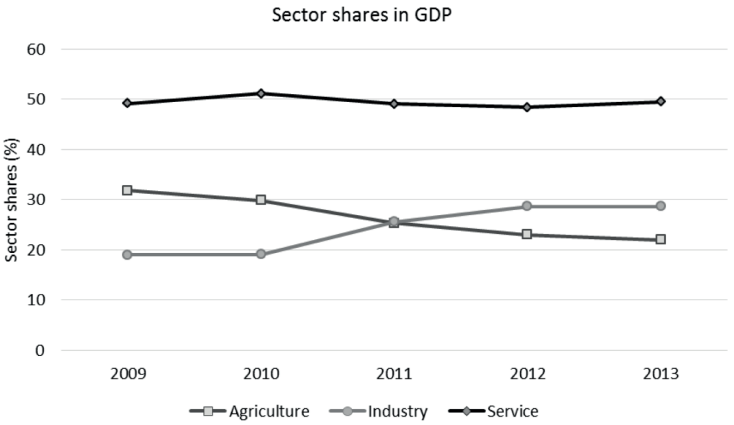
The contributions of the traditional sectors to GDP were observed over a period starting from 2009. The results (see Fig. 2) show that the services sector contributes the highest even before the oil production and still maintains that position. The agricultural sector however witnessed a decline in its share starting from 2010. At the same period, the industrial sector where the new oil sector is categorized experienced a rise in its share as it now overtakes the agricultural sector.

Trade Concentration and Diversification Ratios

Tab. VII shows the trade concentration and diversification ratios. An economy is less concentrated and more diversified in terms of trade, the closer the concentration ratio to zero and the diversification ratio to 1. The vice versa is true ceteris paribus. Given this analogy, Ghana's trade is less concentrated. This is in the right direction given the recommendation by Ciarreta and Nasirov (2012) about the economy of Azerbaijan.



1: *Growth rate of sectors*
Source: Ghana Statistical Service



2: *Contribution to Gross Domestic Product*
Source: Ghana Statistical Service

VII: *Trade concentration and diversification*

Year	Commodities	Trade concentration	Trade diversification
2007	185	0.436	0.773
2008	188	0.424	0.820
2009	196	0.475	0.849
2010	205	0.492	0.792
2011	210	0.388	0.751
2012	199	0.394	0.762
2013	228	0.386	0.741

Source: UNCTAD

CONCLUSION

The study assessed the performance of the economy of Ghana with the introduction of the new oil sector. It was viewed in terms of economic multipliers and inter-sectoral linkages. It also focused on the growth performance of sectors and their shares in Gross Domestic Product. The last but not the least is the issue of trade concentration and diversification after oil production.

Input-output techniques were employed to investigate the changes in multipliers and linkages. The normalized Herfindhal index was employed to assess the level of trade concentration and diversification.

The results show that the oil resource has affected the performance of certain sectors negatively. This was observed in the decline in output multipliers after oil production. It was also observed that growth rate of agriculture and industry slowed down.

Though the resource has enhanced the export portfolio of the country, the impact is negligible as the country still has narrow range of commodities and few trading partners. The problem is more highlighted by the fact that, all commodities are exported in their raw state.

Subsequent studies will incorporate the impact of oil price volatility on the macroeconomy of Ghana.

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