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Natural Resource and Local Communities: Evidence from Ghana's offshore oil and gas

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Abstract

In 2007, Kosmos Energy and Tullow Oil found Ghana's most significant column of high-grade offshore oil and gas. In this paper, I use geocoded household data to examine the socio-economic effects of this oil and gas discovery on the local communities. I conduct two quasi-experimental analysis and find that oil and gas discovery increased real income for households close to the fields, with the benefits being larger for households in districts with a high proportion of skilled workers and limited to non-poor districts. However, there is no apparent effect on employment, total consumption expenditure and poverty.

Keywords: natural resources; oil and gas; local economic impacts; household welfare; spatial difference-in-differences; Ghana

JEL codes: Q33; O13; R11; D31; C21

1 Introduction

Natural resource has the potential to stimulate economic development. Exports of natural resource generate fiscal revenue which can be used to make investments that further economic growth. Nevertheless, it is often seen that resource abundance results in low economic performance, corruption, conflict, and inequality (Sachs & Warner, 1997). This could be due to

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The views expressed in this paper and all errors are my own.

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the Dutch disease[1], civil war, volatility in commodity prices or poor institutions. While the cross-country effects are well explored, there is little evidence of how resources interact with the local economies. Resource extraction tends to stimulate local demand for labour, increase the revenue of the local government and induce agglomeration effects. On the other hand, natural resources could have adverse effects on the local population by increasing the incidence of conflict, violence and corruption, raising local prices and causing environmental pollution.

This paper addresses the question of how natural resources affect income, consumption expenditure, employment and poverty status of the local population. Additionally, I investigate how the gains from resource extraction are distributed among various subgroups. These are important for understanding the mechanisms through which resource abundance impacts local communities and to develop policies that will address potential effects on a local scope. In this paper, I use the Ghana living standard Survey (GLSS) dataset to analyse the effect of a significant offshore oil and gas discovery in 2007 in Ghana. I perform two quasi-experimental analyses (difference-in-differences and synthetic control) to investigate the effect of the oil and gas discovery. The identification strategy exploits spatial and temporal variations in oil extraction and compares households living close to the oil fields to households farther away before and after the oil and gas discovery. I proxy distance to the offshore oil and gas with distance to the nearest city. The offshore oil field is located near the Takoradi city in the Western region. Takoradi's proximity to the oil and gas field facilitates my analysis because of the increase in its economic activities since the oil was discovered.

I find that the offshore oil and gas discovery increased real income. Specifically, the oil discovery led to a 45% increase in the real income of households located close to Takoradi. The results show that the rise in income is higher among households whose heads are skilled workers and only significant for non-poor households. The increase in income did not translate into a rise in total consumption expenditure or a poverty reduction . However, households

[1]The Dutch disease refers to the causal relationship that exists between natural resource boom and the decline of sectors like the manufacturing sector or agriculture

living close to Takoradi experienced a rise in food and housing expenditure after the oil and gas discovery. The results are robust to using other measures of distance such as continuous distance and including region fixed effects. Finally, I provide evidence that there is a heterogeneous exposure (by distance) to the effects of the oil and gas discovery and that these effects are insignificant beyond 80km from Takoradi.

The paper contributes to an emerging literature on the effect of natural resources on local community development. The impact of natural resources is unlikely to be uniformly distributed in a country. Many effects such as pollution, population displacement and labour demand shocks have local geographical scope. The impact or its degree may vary depending on factors such as the location of the resource or labour mobility. Resource boom in a community can draw labour and capital from surrounding areas which results in economic and geographical disparities (Weber, 2014). The findings from Fleming and Measham (2015), Marchand (2012), and Weber (2012) show that regions where gas is produced have higher gains in total earning and employment.

This research is closely related to Aragón and Rud (2013), Knutsen et al. (2017), and Kotsadam and Tolonen (2016). They study the local impact of natural resources by exploiting spatial and temporal variations in extractive activities. They found that the effect of resource abundance diminishes with distance to the extractive areas. Households located close to these areas had a comparative advantage in job acquisition. However, they had a higher risk of exposure to pollution, emissions and injuries associated with resource extraction. Following this methodology, I adopt an identification strategy that exploits distance to the oil field, comparing households living close to the oil field to those living farther away. The empirical results from my research are consistent with the findings from Adofo et al. (2019), Black et al. (2005), Fleming and Measham (2015), and Weber (2012) who found that activities associated with natural resource extraction increase the income of the local population.

In Ghana, Adofo et al. (2019) compared households in oil districts with those in other districts and found that oil exploration was associated with increased real income and employ-

ment. My paper differs from the work of Adofo et al. (2019) in two ways: First, I adopt a different identification strategy that exploits distance to the oil field. The findings from Aragón and Rud (2013) suggests that resource extraction increases the local demand for input which results in a positive effect on real income. However, these effects are only present in the supply market and surrounding areas, diminish with distance and are close to zero at 100km from the mine. Second, I complement my results by conducting a synthetic control analysis.

The rest of the paper is structured as follows: Section 2 presents the overview and the history of oil exploration in Ghana. Section 3 provides a brief review of the mechanisms through which natural resource extraction affects the local population. Section 4 discusses the data, methodology and identification strategy. Section 5 reports the main empirical results. Section 6 explores robustness and section 7 concludes.

2 Overview of oil in Ghana

There are four petroleum basins in Ghana[2] (see figure 1). These are the Tano - Cape three point basin/Western basin, the Saltpond basin/Central basin, the Accra or Keta basin/Eastern basin and the Voltaian basin [3]. Oil was first discovered in 1896 in the onshore Tano basin in the Western region (GNPC, 2009). Onshore oil continued until 1970 when the first offshore oil was discovered and drilled in Saltpond[4]. In subsequent years, exploration for oil and gas was intensified and several wells were drilled but production and commercialization were on a small scale until 2007 when the Jubilee field was discovered.

In June 2007, Kosmos Energy and Tullow Oil found Ghana's most significant column of high-grade offshore oil in the Mahogany-1 (M-1) and Hyedua-1 (H-1) exploration wells. The site, named Jubilee Field, commenced oil production in December 2010[5]. The field's total

[2] Eni, 2018.

[3] The Western, Eastern and Central basins are offshore. The Voltaian basin is onshore

[4] In 2018, the government gave a directive to decommission the Saltpond oil field due to safety and environmental concerns

[5] In July 2009, the Minister of Energy approved the Phase 1 development project. This involved the use of a Floating, Production, Storage and Offloading (FPSO) vessel, capable of processing 120,000 barrels of crude oil per day

reserves are 3 billion barrels and daily production was approximately 150,000 barrels in 2019 (Tullow Oil, 2019).

Figure 1: Ghana petroleum basins

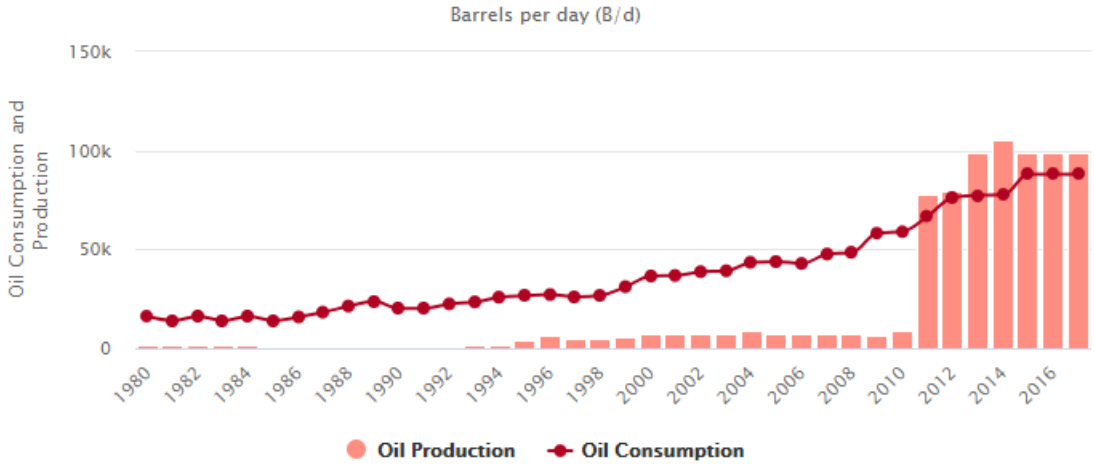


Figure 2: Ghana oil consumption and production (barrels per day)

Figure 2 shows the history of oil production and consumption in Ghana. It shows how

significant the Jubilee field discovery is in the country's history of petroleum exploration[6]. From 2007 to 2013, follow-up appraisals have made 23 additional discoveries in the Deep water Tano (The Petroleum Commision, 2022). The offshore oil fields are located between the Deep water Tano and West Cape Three Points blocks, about 60km off the nearest Ghanaian coast in the Western Region [7]. The region where the oil field is located is largely rural, with 57.6 % of the population living in rural areas (GSS, 2012). Takoradi is the capital of the Western region. It has the highest share of the population (23.5 percent) with about 445,205 inhabitants. Most of the basic infrastructure required for the oil and gas industry is obtained in Takoradi as it is the city closest to the Jubilee field.

The port of Takoradi, Ghana's second largest and oldest seaport was selected as the location for the support base for offshore service vessels as it is the nearest Ghanaian port that can meet the capacity requirements (Tullow Oil, 2019). It is the main conduit for oil from the Western region and has recently been expanded to accommodate the rise in its business volume since the oil discovery [8]. The oil supply vessels call the port to load and discharge equipment, chemicals and other supplies that are stored in port sheds as well as private warehouses near the port. The onshore logistics base facilities used for storage, warehousing, office accommodation, and logistics support for the offshore operations are located in Takoradi (ADB, 2009).

Takoradi's proximity to the oil fields facilitates my analysis because of the increase in its economic activities since the oil was discovered. I will implement a geographic difference–in-difference analysis using the offshore oil discovery as treatment and comparing households located close to the Takoradi City to households farther away before and after the oil discovery.

The oil fields are owned collectively by Tullow Oil, Kosmos Energy, Ghana National Petroleum Corporation (GNPC), EO Group and Anadarko Petroleum Corporation. The government receives 35% as petroleum income tax[9] and 5% as royalty[10] from the oil industry (PIAC, 2019).

[6] *Source: https://www.worldometers.info/oil/ghana-oil/*

[7] A region is the largest sub-national administrative division in Ghana. It is divided into districts, municipalities, metropolitan and towns/cities. Ghana has 16 regions, 216 districts and 260 Metropolitan and Municipal Assemblies

[8] *Source::://african.business/2012/11/energy-resources/china-deal-to-rescue-takoradi-port/*

[9] Profit-related revenue received by the government

[10] Royalties are levied on the gross production of oil regardless of the operation's profitability

There is no windfall allocation from the government to the local authorities or households. The only mechanism through which local communities benefit from government revenue is through the provision of infrastructure (Adofo et al., 2019).

3 Local impact of natural resources

Natural resource interacts with the local economies in several ways. The main mechanism is through income (Adofo et al., 2019; Allcott & Keniston, 2018; Michaels, 2011). The extraction and processing of natural resources often creates job opportunities. This can lead to increased employment and wages, especially in regions where the resource is produced. Additionally, resource industries may increase the procurement of inputs from local suppliers which can increase income. The increase in income or employment can spill over to workers in non-mining sectors or it could be concentrated among workers in the extractive industry, causing a decline in other sectors. The decline of other sectors illustrates how the natural resource boom might lead to the Dutch disease within a country.

Resource extraction can also impact the local economy by influencing conflict, corruption, and illegal activities. The inflow of income from extractive industries can increase rent-seeking behaviour, political corruption and violence (Berman et al., 2017; Knutsen et al., 2017). Resource abundance provides financial opportunities for insurgent groups through the changes in employment opportunities. According to Angrist and Kugler (2008), coca growing areas in Columbia experienced a high incidence of violent deaths because coca production increased labour supply and self-employment income of boys. On the other hand, changes in employment opportunities can lead to less crime because a rise in employment increases the opportunity cost of criminal activities (Axbard et al., 2021). In addition to providing financial opportunities for individuals, resource abundance also increases local government revenue. This increase in revenue can boost the incentive to stay in power at all costs hence, threatening democracy (Graham et al., 2020). Brollo et al. (2013), Caselli and Michaels (2009), and Vicente

(2010) found that larger transfer of windfall revenue to local authorities increases vote buying and decreases the quality of the mayoral candidate, especially in regions with weak institutions.

Another channel through which natural resources affect the local population is through health. Resource extraction can cause pollution, environmental degradation, work-related injuries which can either reduce or offset the benefit from higher income. Von der Goltz and Barnwal (2019) found that mineral mining increased asset gains. However, these gains are offset by the high incidence of anaemia in women and stunted growth in children. Potential environmental impact of oil extraction such as emissions and spillage of waste into water and soil resources exposes residents to higher a prevalence of cancer, skin irritation, liver damage and diarrhoea (Johnston et al., 2019). Despite pollution risks, resource abundance can lead to a reduction in infant mortality and incidence of diarrhoea and cough by providing an opportunity for households to afford better healthcare and have access to the media for health information (Benshaul-Tolonen, 2019; Benshaul-Tolonen et al., 2019).

4 Data and Method

4.1 *Data*

This analysis uses micro-data from the Ghana Living Standard Survey (GLSS) for the years 1999, 2006 and 2013. The data is repeated cross-section. I link the households with their geographic identifiers (GPS coordinates) obtained from the Ghana Statistical Service (GSS) [11]. GPS coordinates are available on the cluster level. A cluster includes 10 to 15 households located geographically close to each other. I use the GPS coordinates to calculate the measure of distance. Distance is calculated as the length of the shortest path between a household's location and the Takoradi city. I focus on households living less than 300km from Takoradi.

[11] The data on the geographic identifiers was shared by Benshaul-Tolonen et al. (2019)

Moreover, I restrict my analysis to households in which the household head is less than 50 years old [12]. My sample consists of 7,327 households.

The main outcome variable is income. This includes wages, agricultural income, income from non-agricultural enterprises and rental income. I deflate the income variable with the regional price index[13]. The summary statistics for the household data are presented in Table 1.

Table 1: Summary Statistics

Variables	Observation	Mean	Std. dev.
Household head			
Age	7,327	35.980	8.130
Years of Education	7,327	3.032	2.490
Proportion Male	7,327	0.722	0.448
Proportion in Agriculture	4,381	0.320	0.467
Proportion in Manufacturing	4,381	0.185	0.388
Proportion in Services	4,381	0.495	0.500
Household			
Nominal income	7,327	5,637.664	19,040.98
Nominal expenditure	7,327	3,000.13	4,658.927
Number of household members	7,327	3.836	2.304
Proportion Urban	7,327	0.526	0.500
Proportion Poor	7,327	0.484	0.500
Distance to Takoradi (km)	7,327	172.091	67.672

Notes: Income and expenditure are measured in Ghana cedis.

4.2 *Identification Strategy*

The baseline regression is:

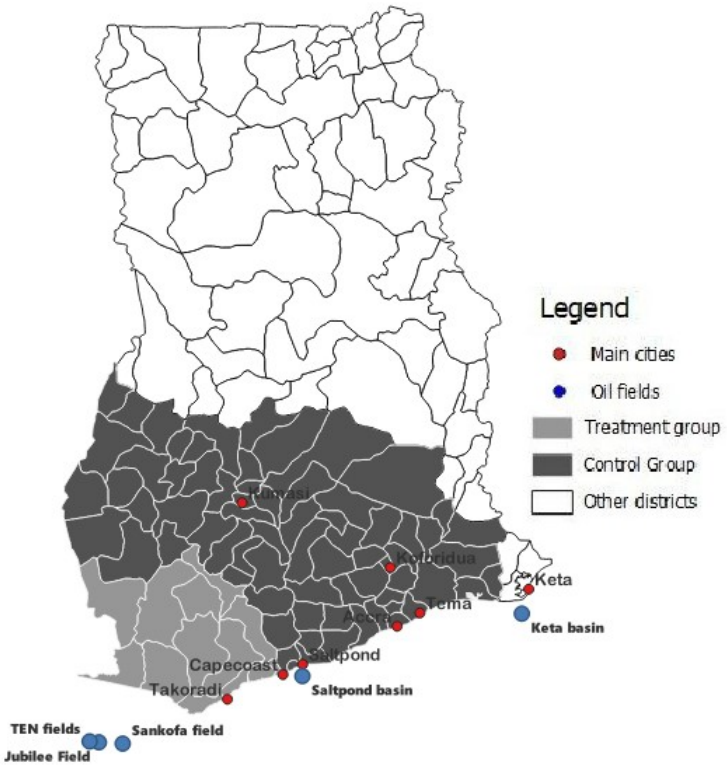
$$Y_{hcdt} = \alpha + \delta_d + \rho D_h + \gamma Post_t + \beta D_h * Post_t + \eta X_{hcdt} + \epsilon_{hcdt} \quad (1)$$

where Y_{hcdt} is the outcome variable (income, consumption expenditure, poverty or employment) of household h in cluster c in district d in year t. D_h is a dummy variable that takes the

[12] This is because they are young enough to respond to the shock from the oil discovery

[13] The price index is from the Ghana Statistical Service. It is calculated as an average of the relative prices of a given basket of goods in each region for a particular period

Figure 3: Districts in sample: by distance to Takoradi city

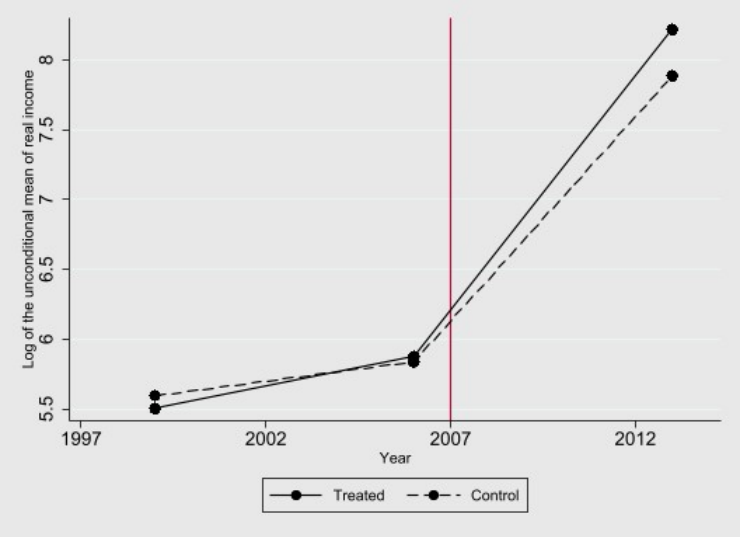


value one if a household is in the treatment group and zero otherwise. The treatment group consist of households located less than 80km from Takoradi (see figure 3). The assignment of the treatment group was done in 2 ways: First, I split the households into separate distance bands and group them in blocks of 20km. The first group consists of households located less than 20km from Takoradi, the second group consists of households located between 20km to 40km from Takoradi and so on. Second, I estimate the baseline regression to explore spatial heterogeneity. I find that after 80km, the effect of the oil discovery becomes insignificant. The detailed result is presented in Section 5.1.

$Post_t$ is a dummy variable that takes the value one in the post oil discovery period (2007). δ_d is district fixed effects[14]. X_{hcdt} is a vector of household- level control variables such as age, gender and years of education of household head, number of household members, and an

[14]The results are robust to the use of region fixed effects

Figure 4: Mean of real income



indicator of urban household [15].

The identification strategy assumes that households in areas both close and far from Takoradi would experience similar performance in the absence of the oil discovery. I provide support for the validity of the identification strategy in two ways: First, Figure 4 plots the log of the mean of real income for the treated and control groups. It shows that the two groups experienced similar trends in real income prior to 2007. After 2007, there was a higher increase in the income of households located close to Takoradi. Second, Table A.1 in the appendix presents the baseline characteristics between the treated and control groups. The table shows that, except for the age of the household head, there are no significant differences in the mean of the covariates between the treated and the control group in the pre-treatment period.

5 Main Results

5.1 Difference-in-differences analysis at the household level

In this section, I present the empirical results using the differences-in-differences analysis.

[15] For robustness, I include controls for distance to old oil fields and the capital city, Accra

5.1.1 *Effects on income*

Table 2 presents the results from estimating the effect of offshore oil discovery on real income. I use the log of real income as the outcome variable. Columns 1 and 2 use dummy distance as the treatment indicator. This is the main measure of distance in my analysis. The results show that the offshore oil and gas discovery increased the income of households located close to Takoradi. The magnitudes of the effects suggest that the oil and gas discovery led to a 45% percent increase in real income. Columns 2 and 3 include all the control variables while column 1 is without controls. The results remain unchanged irrespective of whether or not I include controls.

Table 2: Effect of offshore oil discovery on real income

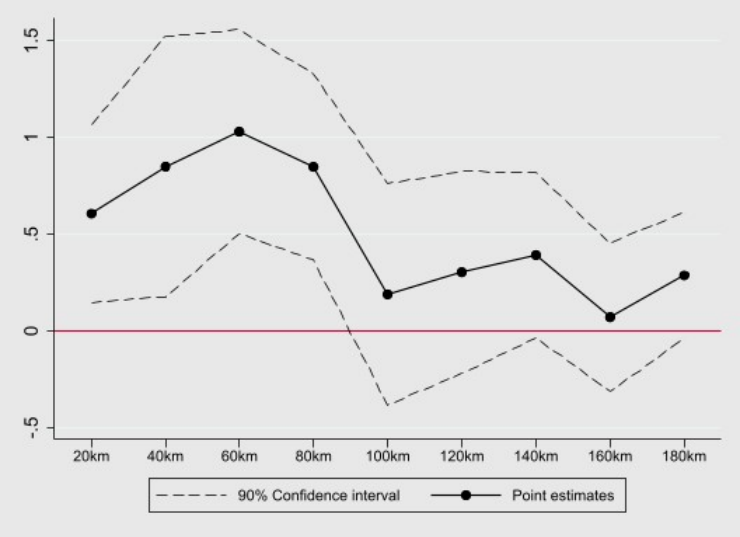
	(1)	(2)	(3)
Post * distance < 80km	0.455***	0.455***	
	(0.163)	(0.156)	
Post * continuous distance			-0.178*
			(0.084)
Includes controls	No	Yes	Yes
Observations	6,886	6,886	6,603
R-Squared	0.385	0.474	0.479

Notes: Column 1 does not include controls. Columns 2 and 3 control for age, gender and years of education of household head, number of household members, an indicator of urban household, distance to old oil fields and the capital city, Accra. Columns 1 and 2 use dummy distance as the measure of distance. Column 3 uses continuous distance measured in hundreds of kilometres. Robust standard errors, clustered at the cluster level are in parenthesis.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

5.1.2 *Heterogeneous effect by distance*

The approach I use in this analysis assumes that there is a heterogeneous exposure (by distance) to the shock from the oil discovery. I test this assumption in two ways: First, Column 3

Figure 5: Effect of offshore oil discovery on real income: by distance to Takoradi



in Table 2 uses continuous distance in hundreds of kilometres as the measure of distance. I estimate equation 1 using the interaction between the oil discovery and the continuous measure of distance. The estimate is negative and significant. This implies that the closer a household is to Takoradi, the higher their gain in income. Households living 100km closer to Takoradi experienced a 18% rise in their real income after the oil and gas discovery.

Second, I use spline distance as the measure of distance by splitting the households into 9 separate distance bands and grouping them in blocks of 20km. The first group consists of households located less than 20km from Takoradi, the second group includes households located between 20km to 40km from Takoradi and so on. Then, I estimate equation 1 using the interaction between the oil discovery and each distance dummy. Figure 5 plots the estimated parameters and the 90 percent confidence interval[16]. The estimates are positive and significant for households located near Takoradi. After 80km, the estimates become insignificant. These results provide support for the choice of threshold used for the dummy distance in Table 2.

[16]The regression results are presented in Table A.2 in Appendix

5.1.3 *Who benefits from offshore oil discovery*

Section 5.1.1 shows evidence of a positive effect of the oil discovery on households near Takoradi. However, these income gains may not be evenly distributed across different subgroups of the local population. I investigate these heterogeneous effects by examining human capital (measured by education) and poverty status at the district level. Since these variables can be influenced by the oil and gas discovery, I use their pre-discovery values to define a district's status. Highly skilled districts are defined as those where a large proportion of household heads had educational attainment above the median level observed across all districts before the discovery. Poor districts are those with poverty levels above the median. The results are presented in table 3. I find that the rise in real income is higher for households in districts with a large proportion of skilled workers. Furthermore, the oil and gas discovery increased real income only in non-poor districts.

Table 3: Effect of offshore oil discovery on real income (By district-level education and poverty status)

	Education		**Poverty status**	
	Small % skilled	Large % skilled	Small % poor	Large % poor
Post * distance < 80km	0.360**	0.734**	0.419**	0.416
	(0.181)	(0.357)	(0.196)	(0.265)
Observations	3,672	2,540	3,744	2,735
R-squared	0.469	0.288	0.465	0.437

Notes: All regressions control for age, gender and years of education of household head, number of household members, an indicator of urban household, distance to old oil fields and distance to the capital city. Highly skilled districts are defined as those where a large proportion of household heads had educational attainment above the median level observed across all districts before the discovery. Poor districts are those with poverty levels above the median. Robust standard errors, clustered at the cluster level are in parenthesis.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

5.1.4 *Effects on other measures of well being*

I replicate equation 1 using other measures of standard of living. Table 4 displays the results for the effect of oil and gas discovery on household head's employment. I find that the oil and gas discovery had no apparent effect on household head's employment. This implies that the increase in real income observed in section 5.1.1 may be due to a rise in wages and not through employment.

Table 5 shows that the increase in income did not translate into an increase in total consumption expenditure for households located close to Takoradi. However, there is an 18% and a 31% increase in food and housing expenditure respectively [17]. I use household poverty status as the outcome variable and estimate equation 1 using a linear probability model. The estimates suggest that there is no significant decrease in poverty associated with the discovery of oil and gas. A possible explanation for this result is that, as discussed in Section 5.1.3, the income of poor households was not significantly affected by the discovery of oil and gas. Finally, I find a rise in access to pipe-borne water for households living close to Takoradi.

Table 4: **Effect of Offshore Oil Discovery on Household Head's Employment**

	All workers	Agricultural	Manufacturing	Service
Post * distance < 80km	-0.019	-0.032	0.059	-0.027
	(0.085)	(0.079)	(0.054)	(0.073)
Observations	7,315	4,229	4,229	4,229
R-squared	0.166	0.409	0.073	0.276

Notes: All regressions control for age, gender and years of education of household head, number of household members, an indicator of urban household, distance to old oil fields and distance to the capital city. Robust standard errors clustered at the cluster level are in parentheses.
*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

[17] Housing expenditure includes rent, expenses on fuel used in the house and expenses on maintenance of dwelling

Table 5: **Effect of Offshore Oil Discovery on Household Welfare**

	Ln(Total Expenditure)	Ln(Food)	Ln(Non-food)	Ln(Housing)	Poor	Access to pipe-borne water
Post * distance < 80km	0.115	0.180*	0.058	0.310***	-0.084	0.177**
	(0.089)	(0.107)	(0.095)	(0.111)	(0.069)	(0.090)
Observations	7,314	7,297	7,327	7,327	7,327	7,327
R-squared	0.454	0.297	0.508	0.734	0.259	0.532

Notes: All regressions control for age, gender and years of education of household head, number of household members, an indicator of urban household, distance to old oil fields and distance to the capital city. Poor households are those with expenditure below the median level. Robust standard errors clustered at the cluster level are in parentheses.
*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

5.2 Difference-in-differences at the individual level

The baseline estimation strategy captures household level effects. To explore individual level effects of the oil and gas discovery, I re-estimate equation 1, only now the treatment group are individuals living less than 80km from Takoradi. On the household level, total income included wages, agricultural income, income from self-employment and rental income. However, on the individual level, there is data on only wages. I use wage as the main outcome variable to investigate heterogeneity at the individual level. I deflate the wage variable with the regional price index. Table 6 presents the regression results. I find that the oil and gas discovery led to a 43% increase in real wages of workers living close to Takoradi.

There is a possibility of bias if my results are driven by migration or the compositional changes in the population. For example, if the oil discovery attracts only individuals in their prime years to Takoradi, the increase in income could be as a result of this compositional change in population rather than the treatment. I address this concern in two ways: First, I investigate the effect of the oil and gas discovery on migration. I define migrants as people living in villages other than their place of birth[18]. I use migration as the outcome variable and re-estimate the baseline regression using a linear probability model. I find that there is no significant effect on migration to Takoradi and its surrounding areas in the period considered in my analysis.

[18]The GLSS data includes details on individuals' place of birth and duration of stay in their current residence. Utilizing this information, I construct a variable representing the year of migration. This variable helps identify whether an individual migrated before or after the period of oil and gas discovery

Second, I investigate whether the oil and gas discovery led to changes in observable characteristics such as years of education and an indicator of an individual in prime years (between 20 and 40 years old). The results show that there are no significant compositional changes in the labour force. Taken together, the results suggest that the effect of the oil and gas discovery on real income is not driven by migration or changes in observable characteristics.

Table 6: **Effect of offshore oil and gas discovery (Individual level analysis)**

	Ln(real wages)	Migration	Years of education	Prime age
Post * distance < 80km	0.433*	-0.047	0.222	-0.007
	(0.237)	(0.037)	(0.213)	(0.029)
Observations	6,829	20,941	21,085	21,085
R-squared	0.237	0.133	0.173	0.033

Notes: All regressions control for age, gender and years of education of household head, number of household members, an indicator of urban household, distance to old oil fields and distance to the capital city. Wages include wages and bonuses. Prime age are individuals between the ages 20 and 40. Robust standard errors, clustered at the cluster level are in parenthesis.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

6 Robustness Checks

I conduct two robustness checks: First, I explore the sensitivity of the results to the use of region fixed effects rather than district fixed effects. The results are shown in Table A.3 in the appendix. They are similar to the inclusion of district fixed effects.

Second, I perform a synthetic control analysis to complement the results from the difference-in-differences analysis. I construct the synthetic control group as the weighted combination of control districts that closely resemble the treatment districts in terms of selected predictors[19] (see table A.5 in the appendix). The predictor variables I use are the age and years of education of the household head, number of household members, real household expenditure and real

[19] districts with synthetic control weights equal to zero are dropped from the sample

household income. Figure A.1 in the appendix plots the standardized percentage bias across predictors[20]. It shows a reduction in the bias between the treated and synthetic control group as compared to the bias between the treated and the actual control districts.

Figure A.2 plots the trends in real income for households living in districts close to Takoradi and their synthetic equivalent. Notice that, Figure A.2 shows an improvement in the pre-trends as compared to Figure 4. However, both figures show a divergence in real income after the oil and gas discovery. For robustness, I perform the leave-one-out robustness check by iteratively re-estimating the model. In each iteration, I exclude one control unit from the donor pool. The results are displayed in Figure A.3. It shows that irrespective of the districts included in the donor pool, the treatment and synthetic control groups experienced a divergence in real income after the oil and gas discovery.

The empirical analysis replicates equation 1 and compares households living close to Takoradi to those in the synthetic control group. The estimated parameters are presented in Table A.4 in the appendix. The results complement those from the difference-in-differences analysis.

7 Conclusions

This paper examines the socio-economic effect of offshore oil and gas. Using geocoded data, I perform a difference-in-differences and synthetic control analysis to explore how natural resources interact with the local economy. I find that oil and gas discovery led to an increase in the real income of households located close to the oil and gas fields. These gains in real income are higher for skilled workers and concentrated in non-poor districts.

The results indicate that the impact on real income is driven by an increase in wages rather than employment. This likely explains why the positive effect on real income is more pronounced for skilled workers and is observed exclusively in non-poor districts. Government and policy makers can invest in skills training and education as a tool to increase employment.

[20] Bias occurs when there is a covariate imbalance between the treated and control group

Investing in education and skills development programs can empower individuals from poor households to participate in the workforce. This can become an important mechanism through which oil extraction benefits poor households, especially if the oil and gas industry requires specific skills that can be developed locally.

The main limitation of this research is that I examine events occurring only a few years after the oil and gas discovery. Findings in this paper should be considered as short-term effects. Future research can consider adding a more recent wave of the GLSS data to investigate the long-term effects. Further analysis can also explore alternate mechanisms such as fiscal revenue windfall and prices of goods and services as a channel through which natural resources affect the local population.

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Appendix

Table A.1: Baseline household characteristics between treatment and control groups

Variables	Mean Control	Mean Treated	Difference
Household head			
Age	35.297	36.199	0.901***
Years of Education	2.882	2.854	-0.028
Proportion Male	0.730	0.767	0.037
Household			
Number of household members	3.804	3.969	0.165
Proportion Urban	0.512	0.484	-0.028
Proportion poor	0.472	0.470	-0.001

Notes: The mean is calculated using sample weights and clustered at cluster level.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table A.2: Effect of offshore oil discovery on real income: by distance to Takoradi

	Ln(real income)	
Variables	Coefficient	Standard error
Post * distance $<$ 20km	0.606**	0.279
Post * 20km to 40km	0.850**	0.409
Post * 40km to 60km	1.03***	0.320
Post * 60km to 80km	0.848***	0.292
Post * 80km to 100km	0.189	0.347
Post * 100km to 120km	0.302	0.317
Post * 120km to 140km	0.393	0.260
Post * 140km to 160km	0.070	0.233
Post * 160km to 180km	0.287	0.198
Observations	4,428	
R-Squared	0.385	

Notes: All regressions includes district fixed effects. Robust standard errors are clustered at the cluster level.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table A.3: **Effects of oil and gas discovery on living standards: region fixed effects**

Panel A	**Employment**			
	All workers	Agricultural workers	Manufacturing workers	Service workers
Post * distance < 80km	-0.011	0.051	-0.006	-0.044
	(0.051)	(0.054)	(0.045)	(0.049)
Observations	7,315	4,505	4,505	4,505
R-squared	0.139	0.357	0.032	0.236
Panel B	Ln(real income)	Ln(consumption expenditure)	Poor	Access to pipe-borne water
Post * distance < 80km	0.341***	0.013	-0.011	0.068
	(0.125)	(0.070)	(0.050)	(0.071)
Observations	7,014	7,453	7,467	7,467
R-squared	0.452	0.418	0.222	0.449

Notes: All regressions control for age, gender and years of education of household head, number of household members, an indicator of urban household, distance to old oil fields and distance to the capital city. Poor households are those with their expenditure below the median level. Robust standard errors, clustered at the cluster level are in parenthesis.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table A.4: **Effects of oil and gas discovery on living standards: Synthetic control analysis**

Panel A	**Employment**			
	All workers	Agricultural workers	Manufacturing workers	Service workers
Post * distance < 80km	-0.114	0.026	0.021	-0.047
	(0.121)	(0.002)	(0.072)	(0.083)
Observations	3,616	2,227	2,227	2,227
R-squared	0.196	0.398	0.056	0.252
Panel B	Ln(real income)	Ln(consumption expenditure)	Poor	Access to pipe-borne water
Post * distance < 80km	0.406*	-0.034	0.033	0.215*
	(0.234)	(0.099)	(0.083)	(0.117)
Observations	3,317	3,471	3,478	3,478
R-squared	0.553	0.524	0.260	0.482

Notes: All regressions control for age, gender and years of education of household head, number of household members, an indicator of urban household, distance to old oil fields and distance to the capital city. Poor households are those with their expenditure below the median level. Robust standard errors, clustered at the cluster level are in parenthesis.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table A.5: Synthetic control weights

Districts	Synthetic control weight
Accra	0.2610
Asunafo North	0.2250
Asutifi	0.0940
Wassa Amenfi East	0.0790
Dormaa Central	0.0360
Asuogyaman	0.0210
Lower Manya Krobo	0.0180
Gomoa East	0.0160
Yilo Krobo	0.0150
Upper West Akim	0.0140
Suhum / Kraboa Coaltar	0.0130
Akwapim North	0.0130
Akyemansa	0.0110
East Akim	0.0110
Birim Central Municipal	0.0110
Ajumanku / Enyan / Essiam	0.0110
Bosumtwi	0.0110
Bosome Freho	0.0110
Atwima - Kwanwoma	0.0100
Akwapim South	0.0100
Birim South	0.0100
Amansie Central	0.0100
Offinso	0.0080
Kwaebibirem	0.0080
Awutu Senya East	0.0080
Ahafo Ano North	0.0080
Jomoro	0.0080
Upper Manya Krobo	0.0080
Wassa West	0.0080
Keta	0.0080
Asunafo South	0.0070
Adenta	0.0070
Dormaa East	0.0060
Amansie West	0.0050

Figure A.1: Predictor balance

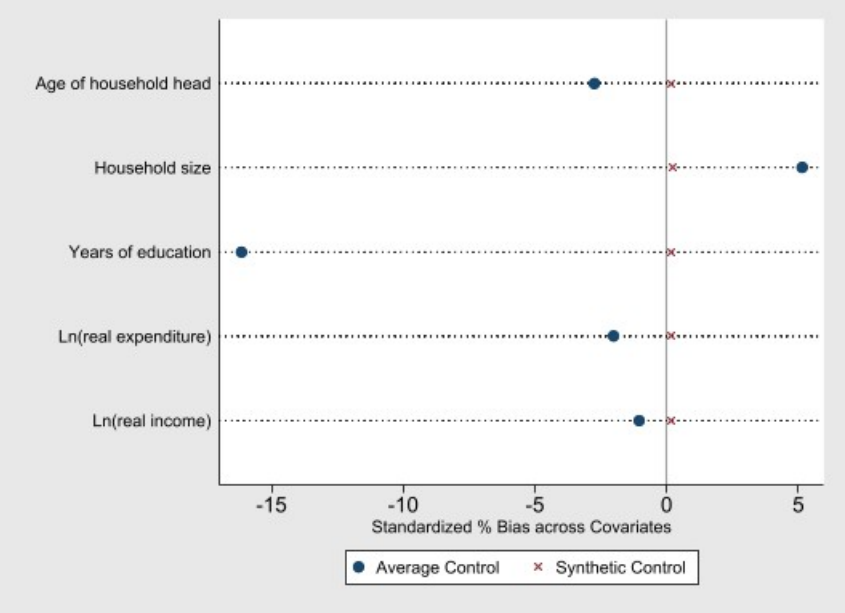

Figure A.2: Actual and predicted outcome

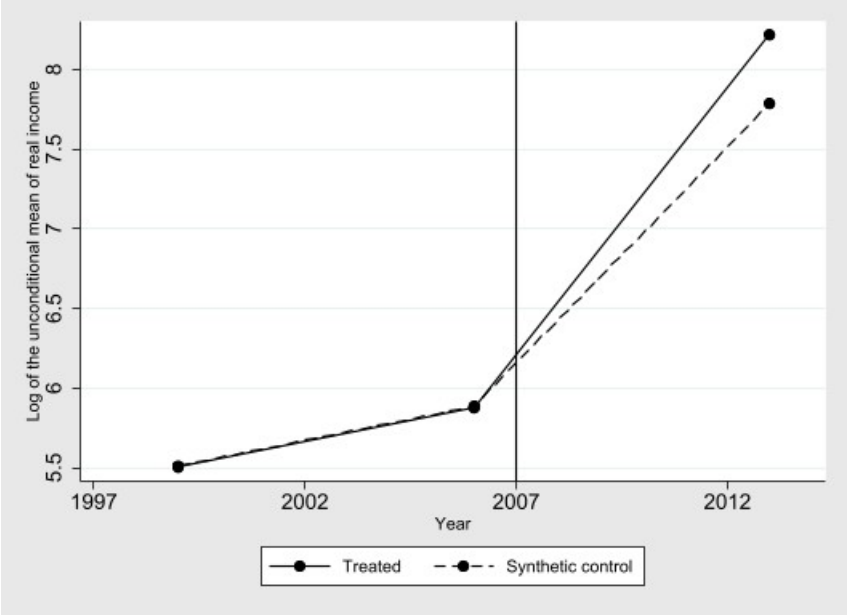

Figure A.3: Leave-one-out robustness test