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Oil extraction and spillover effects into local labour market: Evidence from Ghana

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Abstract

This paper investigates the effects of oil extraction on local labour market outcomes. Using household-level data from the Ghana Living Standard Survey, we employ a difference-in-differences approach to show that oil extraction has negative spillover effects on employment but no significant effect on average income. However, the effects vary by migration status, gender and employment sector. Specifically, we observe that migrants, men and agricultural workers experienced significant income spillovers from the oil boom than locals, women and workers in other sectors. In addition, the oil boom resulted in a negative welfare impact as it widened inequality for individuals close to the extraction areas.

Key words: Oil extraction; Spillover effects; Employment; Resource booms; Migration; DID estimation

JEL Codes: O13, O15, Q32, Q33, R11, R23.

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1 Introduction

A natural resource boom can, directly and indirectly, affect labour markets in resource and non-resource sectors. The indirect effects are usually termed spillovers (see Marchand & Weber 2018). Much of the existing literature on natural resources have focused on quantifying the direct effects natural resources have on economic growth and development at the macro-economic level using aggregate data (Sachs & Warner 1995, Gylfason 2001). These studies find positive effects for developed economies and negative effects for developing economies. The conclusion is that resource endowments alone are not enough to guarantee economic development but coexist with a stable government, strong institutions and better infrastructure. The absence of the aforementioned factors could explain the so-called 'natural resource curse' phenomenon, i.e., countries that have not developed, despite abundant natural resources (see Sachs & Warner (1995), Michaels (2011), and Smith (2015)).

Studies on oil extraction spillovers using disaggregated data have been increasingly popular as they provide a more complete picture of the consequence of resource endowments on the economy. The evidence of resource spillover effects, however, varies in empirical studies. Black et al. (2005) examine the impact of coal boom and bust in the US in the 1970s and 80s using county-level data and find a positive spillover effect of coal on income and migration, but a negative effect on employment. Brown (2014) analyses the effect of shale gas production in the US on employment and income using county-level data and finds a moderate positive spillover on employment in the manufacturing sector and income in all sectors.

Much of the extant evidence, including more recent work by Jacobsen & Parker (2016), Feyrer et al. (2017), Allcott & Keniston (2018), Guettabi & James (2020), Jacobsen et al. (2021), focus on developed economies and are predominantly US-centric. With the exception of Jacobsen et al. (2021), the studies mentioned above use aggregated state or regional level data, which makes the study of spillover effects difficult to capture as such effects are largely experienced at the individual level in a district or region. However, there has been increasing interest in examining the effects of natural resource impact in developing countries (Aragón & Rud 2013, 2015, Tolonen 2015, Kotsadam & Tolonen 2016, Smith & Wills 2018, Mamo et al. 2019, Von der Goltz & Barnwal 2019). One particularly relevant study is Aragón & Rud (2015) who examined the role of mining in Ghana and found that mining lowered agriculture productivity by almost 40%. However, these studies have focused on gold and coal mines, which have been shown to have different impacts, compared to oil extraction for countries (Marchand & Weber 2018).

In this paper, we take advantage of recent oil extraction in Ghana and the availability of detailed information on individuals and their household characteristics to examine oil spillover effects on labour market circumstances in non-oil sectors. Specifically, we examine the following outcomes: income and employment in non-oil sectors. Ghana discovered one of the largest oil reserves in West Africa off the coast of the Western region in 2007 and started extraction in 2010. Using this extraction as a potential exogenous shock to the oil sector, we employ a difference-in-differences estimation by assigning treatment status to individuals residing in the coastal districts in the Western region of Ghana, and control group to regions further away from the Western region. The treated individuals in the districts are in the immediate vicinity of the oil extraction area, and the control group is based on similarities with the region in the treated group.

Our results indicate that there are significant spillover effects of oil extraction on non-oil sectors. Specifically, we find negative spillover effects on employment. Moreover, we find no statistical significant spillover effect on income in the combined sample, but a statistical significant effect on income for migrant workers when the sample is separated by migration status. Furthermore, these effects vary across gender and employment sectors. In particular, the effect on income is more prominent for males and workers in the agricultural sector. On the other hand, the employment effect is higher for males and among individuals working in the services sector. While we observe an overall negative spillover effect on employment, the retail sector showed some potential growth, primarily for migrants.

Our results also indicate that our outcomes were not significantly different between the treated and control districts prior to oil extraction. The identification strategy of the difference-in-differences relies on the assumption that any difference in our outcomes is attributable only to the new oil extraction. We show that the spillover effects of oil extraction on our outcome variables are identified only for individuals at immediate coastal districts of the Western region, as we use as a control group, other regions in Ghana. However, a potential source of bias arises from not having controlled for unobserved individual heterogeneity. To address this, we use the approach proposed by Oster (2019) to show that the included covariates in our regressions are informative enough in explaining the spillover effects of oil extraction. Hence any potential bias due to omitted and confounding factors is minimal.

To relate the study to existing analytical frameworks or theories, the findings in this study are in line with the spillover theory, which postulates that an expansion of a sector has a ripple effect on other sectors of the economy. This theoretical foundation dates back to Corden & Neary (1982) and Moretti (2010) who argue that the extraction of natural resources will increase the demand for workers in upstream and downstream industries associated with the natural resource industry and the income and/or employment of non-natural resource industries. Although our empirical evidence suggests an overall fall in employment in non-resource sectors, there is an increase in employment in the retail sector (thus corroborating the theoretical prediction).

The study is also in line with the economic geography literature that explains how focused the spillover effects of the natural resources may be (see Vaughn 1994, Fujita et al. 2001). A natural resource boom in a specific locality is sudden, significant, and can affect local market outcomes. The theory further explains that the effects decrease with proximity from the natural resource location. We find empirical evidence of this with a higher spillover effect at immediate districts and a decreasing effect further away from the extraction point. To an extent, this finding explains why studies on aggregated economies might not always show the heterogeneous spillover effects of natural resources in developing economies.

The study contributes to the literature in the following ways. First, we mentioned above that the study of oil discovery and extraction is of independent interest and is distinct from other types of natural resources. Earlier research that studies the impact of oil extraction in developing countries use aggregated regional or district level data (see, e.g. Caselli & Michaels 2013, Aragón & Rud 2013, Loayza & Rigolini 2016). By contrast, our study uses individual household-level data, thus, allowing for more heterogeneous variations in the sample. A closely related study is Kotsadam & Tolonen (2016) who combine household-level data with information on mines at the district level and find the opening and closing of mines impact women employment in Sub - Saharan Africa. The study finds little to no effect of mines on women employment in the manufacturing sector. The conclusion drawn from this study differs considerably from ours and reinforce the notion that different natural resources affect the economy in different ways (Marchand & Weber 2018).

The rest of the paper is organised as follows. Section 2 provides a background to the Ghanaian economy and gains from the oil extraction and the data used in the study. Section 3 discusses the identification strategy adopted. Sections 4 and 5 present the results and their robustness. Section 6 discusses the results. Section 7 concludes.

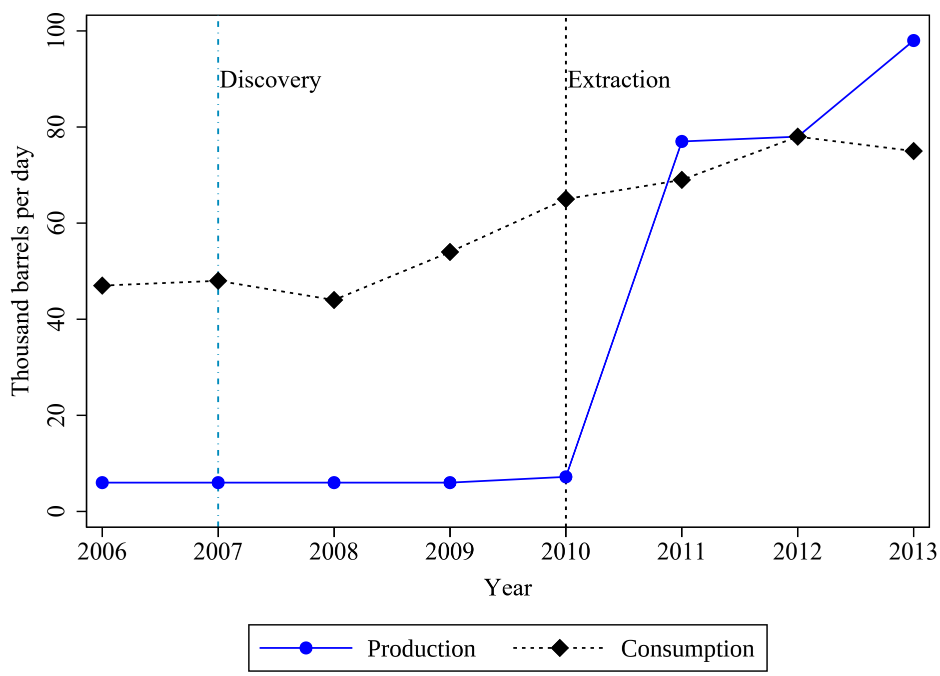
2 Background and Data

2.1 Oil Production in Ghana

The Government of Ghana in 2004 sold licences to foreign oil extracting companies to explore and produce oil offshore of Ghana. These companies discovered oil reserves at

Cape Three Points, off the coast of the Western Region, in 2007. The area was named Jubilee Fields and was estimated to have between 600 million and 1.8 billion barrels of oil, making it one of the largest oil reserves discovered in West Africa (Ayelazuno 2014). Extraction and production started in 2010, and it was found that the oil from the Jubilee Fields commanded competitive prices in the world market given its unusually light and sweet characteristics (Ayelazuno 2014).[1] As shown in Figure 1, production of crude oil increased significantly from an average of 10,000 barrels per day before 2010 to an average of 78,000 barrels per day from 2011 to 2013.

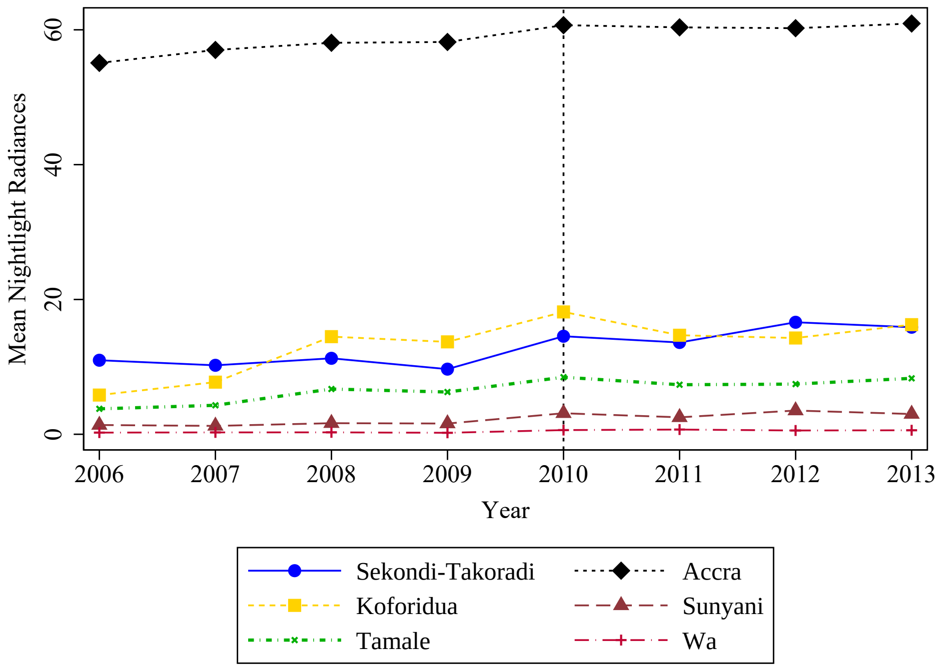
Figure 1: Crude oil production in Ghana: 2006-2013



The discovery of oil contributed significantly to oil rents and GDP growth in Ghana (Figure A.1 in the appendix). GDP growth increased considerably after 2010, to an average of 9.6 per cent between 2010-2013 from an average of 6.5 per cent in 2006-2009. This led the World Bank to reclassify Ghana as a lower-middle-income economy in 2011

[1] An American Petroleum Institute, API Gravity is a measure of petroleum heaviness. Oil with an API of more than ten is considered lighter than water. Another measure of petroleum quality is its sulphur content. Oil with a sulphur content of less than 0.5 weight per cent (wt%) is considered sweet (Demirbas et al. 2015). Ghana's oil has an API Gravity of 37.6 degrees and sulphur content of 0.25 wt%

Figure 2: Nightlight luminosity



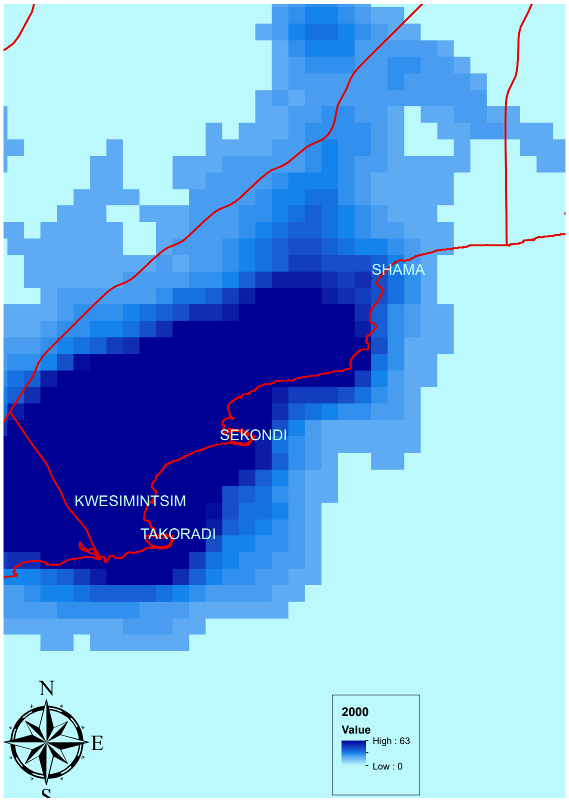
(World Bank 2011). Oil production also boosted the level of economic activity.

Figure 2 depicts nightlight luminosity – the amount of man-made light observed from space at night that is often used as a proxy of economic activity. We observe that from 2010 to 2013, there is a rise in luminosity in the Western regions compared to other districts as depicted in the regional capitals.[2]

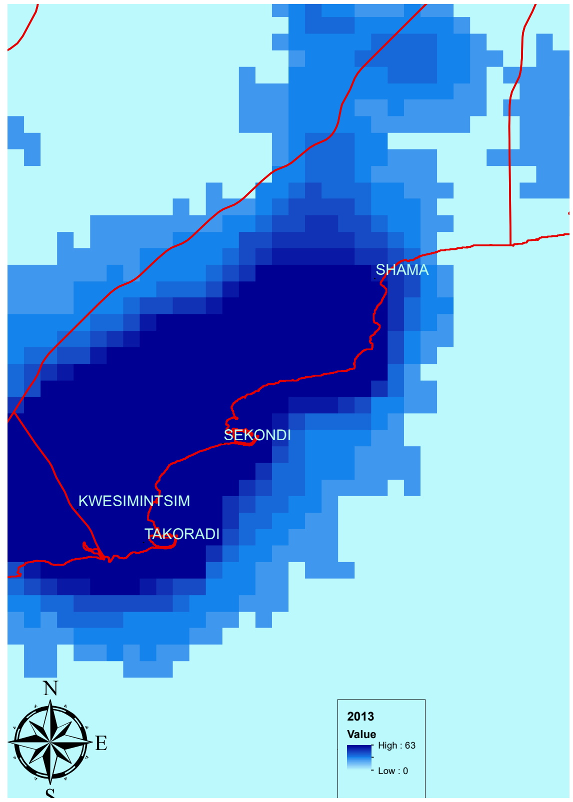
Figure 3 presents the intensity of nightlight in the Sekondi-Takoradi Metropolitan Area. Figure 3a shows that before the new oil extraction, the intensity was largely at Sekondi-Takoradi. The luminosity in the north and south of the area increased in 2013, indicating a high level of economic activity as shown in Figure 3b.

[2]The capitals of the regions (in brackets) are as follows Sekondi-Takoradi (Western), Accra (Greater Accra), Koforidua (Eastern), Sunyani (Brong Ahafo), Tamale (Northern) and Wa (Upper West).

Figure 3: Nightlight luminosity in Sekondi-Takoradi metropolitan area



(a) Nightlight luminosity in 2000



(b) Nightlight luminosity in 2013

Notes: Figures (a) and (b) plot the nightlight variations for Sekondi-Takoradi metropolitan area in the Western region for the years 2000 and 2013.

2.2 Data

We use data from the Ghana Living Standard Survey (GLSS) Rounds 4, 5 and 6 conducted in 1998, 2006 and 2013. This is a nationally representative survey and one of the most extensive repeated cross-section data collection in Ghana. The 1998 round surveyed 5,998 households, and the 2006 and 2013 rounds surveyed 8,687 and 16,772 households, respectively (Ghana Statistical Service 2016). The survey collects detailed information on demographic (gender, age, ethnicity) and socio-economic (education, income, employment) variables. We use individuals in the households as the unit of observation. Our key outcome variables of interest are monthly income and employment. We use monthly income that is derived from the primary job of workers. We do not include income from secondary jobs, given the number of missing observations in the data. We follow the convention in the literature and use the logarithm of monthly income. The employment variable is a binary indicator for individuals who have done work for pay during the last 7 days. [3] The remaining control variables are gender, age, marital status, ethnicity, own education (in years), parents' education (in years) and household head status.

The lowest administration level in Ghana is the district. These districts make up a region. The GLSS is carried out at the district level in all 10 regions of Ghana (See Figure 4). The regions differ in their economic environment and ethnic composition. Northern Ghana, which comprises of Upper East, Upper West and Northern regions; is considered the most deprived part of Ghana, with large differences in the level and standard of living compared to the south (World Bank 2011, Ghana Statistical Service 2016). Southern Ghana is seen as the most vibrant and developed even before the discovery and extraction of oil. The oil extraction is about 60 kilometres off the coast of the Western region and 225.3 kilometres from the nation's capital, Accra. Figures 4 & 5 show the regions in Ghana and the oil extraction area, respectively. Our empirical strategy involves examining the effect of oil extraction with districts in closer proximity to areas with oil compared with districts further away. This is implemented in a difference-in-differences framework which we will elaborate further in Section 3.

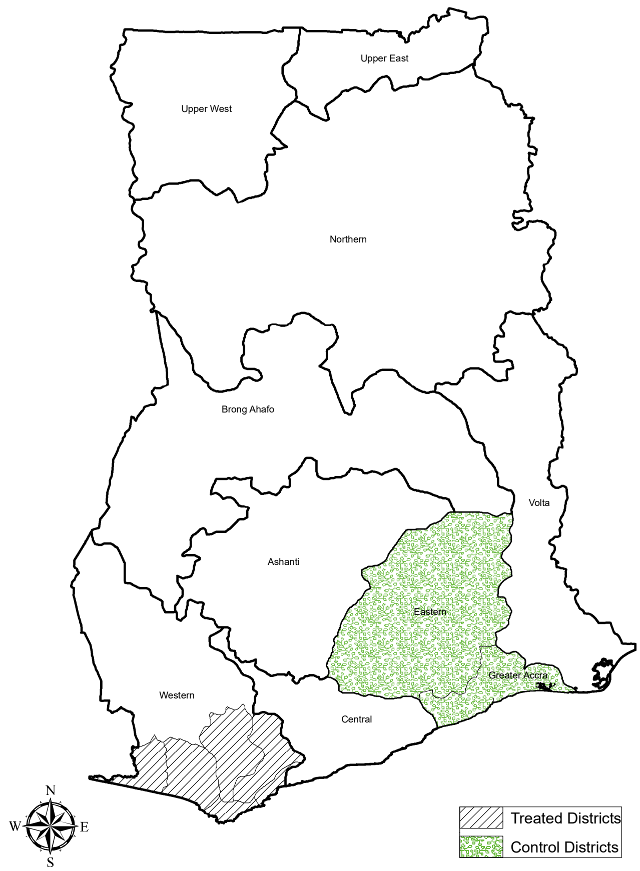
To this end, we use districts in the immediate coast of the Western region as the treated group.[4] The challenge, however, is in choosing a comparable control group for the treated sample. To do this, we compare economic indicators (average of sources of household income, proportion of migrants, household size and proportion of educated adults) from the GLSS survey reports of the 10 regions in Ghana, as shown in Table A.1 in the Appendix. The indicators show that the Eastern, Greater Accra, Ashanti and Volta

[3]The income variable is a response to the question 'What is the amount received for the work done?', employment is to the question 'Did (NAME) do any work for pay during the last 7 days?' and Migration is to the question 'Where was (NAME) living previously?' The frequency (daily, weekly, monthly, yearly) at which the income is paid is also reported.

[4]We use immediate coastal districts —Jomoro, Ellembelle, Nzema East, Ahanta West, Sekondi-Takoradi,Tarkwa Nsuaem, Shama, Wassa East and Mpohor— in the Western region as a treated group and all districts in Eastern and Greater Accra regions as a control group.

regions are similar to the Western region.

Figure 4: Treated and control districts in Ghana



To test for the absence of confounding factors, A descriptive summary of the variables used for the treated and control samples is presented in Table A.2 in the Appendix.

2.2.1 Dependent variables

We look at the effect of oil extraction on non-oil income and employment. Income is estimated as the monthly income from any economic activity within the country. We use a monthly frequency given that is the most preferred payment for most formal work. However, payments that are done on daily, weekly, or biweekly frequencies are

Figure 5: Location of oil extraction area

Source: Eni S.p.A (2015)

converted to monthly to ensure consistency.

Employment measure is a dummy for whether someone is gainfully employed at the time of the survey. The industry in which one finds him or herself still holds even if such an individual is unemployed. Respondents were asked to identify which industry they identify with, making it possible to disaggregate the estimation of employment levels by various industries.

2.2.2 Explanatory variables

To identify the spillover effects, we control for other factors that may explain the variations in our outcome variables. Gender, marital status, age, own and parent education, and household head status can significantly impact the outcome variables; not accounting for these impacts will result in a biased estimate.

3 Empirical Strategy

3.1 Specification

Our objective is to identify any spillover effects on income and employment in the immediate coastal districts in the Western region. To do so in non-oil sectors, we employ a difference-in-differences regression with the following specification

$$Y_{ihr} = \beta_1 + \beta_2 \mathtt{Dist}_{ihr} + \beta_3(\mathtt{Dist}_{ihr} \times \mathtt{PostOil}_t) + X'_{ihr}\gamma_c + \alpha_t + \epsilon_{ihr}, \quad (1)$$

where Y_{ihr} is the outcome variable — log of monthly income, dummy for employment status — of individual i in household h in district r. $\mathtt{Dist}_{ihr}$ equals 1 for the treated districts (immediate coastal districts) in the Western region and 0 otherwise (districts in Eastern and Greater Accra regions). $\mathtt{Dist}_{ihr} \times \mathtt{PostOil}_t$ is the key variable, and β_3 the key coefficient of interest; it captures the difference-in-differences estimate or spillover effect of oil extraction in the treated districts. X_{ihr} is a set of covariates, gender, age, years of education of individual *i* that may explain the variation in the outcome with coefficient vector, γ_c. α_t is the time (survey year) fixed effects and ϵ_{ihr} is the usual error term.

The identification of the spillover estimates is conditional on controlling for district fixed effects. This unobserved factor captures any differences in the outcome variables resulting from, for instance, local government administration projects across the survey period. The inclusion of individual and household characteristics capture any factors that may influence the outcome variables. Gender, age and years of education, and household size may determine an individual's decision to work and not move away from a particular district. Furthermore, the inclusion of survey year fixed effects also captures year-specific trends that could impact the outcome variables during the period analysed. The year fixed effects would account for other government policies that were introduced to boost economic growth alongside the discovery of oil, thus also affecting the outcomes we study. Not accounting for these factors may wrongly attribute any changes to the new oil boom.

The timing of the 3 surveys is essential for our analysis, given that there are two periods before (1998, 2006) and one period after oil extraction (2013). Thus, we have three years post-oil extraction, giving room for the possibility of measuring any effect from the extraction. In our sample, we include all members in the household beyond 15 years in the model estimation.[5] Standard errors are bootstrapped with 1000 replications. In addition, we report the p-values from the wild bootstrap technique to ensure the significance of the estimates (MacKinnon & Webb 2018, Roodman et al. 2019).

3.2 Threats to Identification

In equation (1), the spillover effect of oil extraction on the outcome variables, captured by β_3, represents the difference in log of monthly income, employment or migration between the treated and control districts, before and after oil extraction began. The identifying assumption is that changes in the outcome variables in both the treatment and control districts are the same before or without oil extraction.

To test the identifying assumption and rule out the possibility that the economic situation is changing for regions in the treatment group compared to the control group before the discovery of oil, we conduct a parallel trend test, following Muralidharan & Prakash (2017) and present the results in Table 1. We interact an indicator for 2006 with the treatment districts. We include this as a regressor, along with the complete set of covariates, on the outcomes we study. Our results show that income and employment are not changing at different rates before 2010, supporting our parallel trends assumption.

We also use individuals in different districts in other regions as treated and control groups to investigate any possible economic shock other than the oil extraction (See

[5]Household members aged 15 and under are excluded as the International Labour Law postulates that working at age below 15 years of age is considered child labour.

Table 1: Parallel trend assumption test

	Income	Employment
District× Post Oil_{2006}	-0.377	-0.135
	(0.251)	(0.076)
Wild t (p-value)	-1.50 (0.26)	-1.78 (0.18)
Controls	Yes	Yes
Observations	1320	1320
Adjusted R^2	0.310	0.621

Note: Outcomes are for non-oil sectors. The year 2006 is considered as the period after oil discovery and extraction. The regressions include the full set of covariates; demographic and socio-economic controls. Bootstrapped Standard errors clustered at the district level in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Section 5.1). This is of particular importance as the shocks that may have contributed to the rising economic growth in Ghana could have also explained the differences in outcomes between the treated and control districts, thus confounding the spillover effects of oil extraction.

4 Results

This section first examines the unconditional average effect on the outcome variables for the treated and control districts and further presents the results for all estimates, including the controls. Table 2 presents the average outcome of the treated and control districts before and after the oil extraction. Row 1 shows higher average outcomes for individuals in the treated districts before oil extraction. Row 2 shows higher income but lower employment likelihood averages for the treated districts. The difference in the average in these two-time points shows an increase in income and employment for treated and control individuals, as shown in Row 3. A test of differences between the treated and control districts shows that income increased, but employment fell for individuals in the treated districts. These estimates show the expected results. However, these differences are subject to change upon the inclusion of controls.

We, hereafter, present the complete sample estimates of the spillover effects (Section 4.1). We then examine how these effects vary across migration status, gender and sectors (Section 4.2).

Table 2: Unconditional average spillover effect

	(1) Monthly income		(2) Employment	
	Treated	Control	Treated	Control
1) Before oil extraction	2.895	2.607	0.708	0.661
	(0.102)	(0.112)	(0.016)	(0.025)
2) After oil extraction	5.675	5.109	0.921	0.970
	(0.076)	(0.072)	(0.003)	(0.007)
3) Rows (2) - (1)	2.780	2.502	0.213	0.309
	(0.121)	(0.158)	(0.015)	(0.026)
4) T - C	0.278		-0.096***	
	(0.199)		(0.030)	
Observations	5,334		5,334	
Adjusted R^2	0.249		0.237	

Note: Outcomes are for non-oil sectors. T and C are the difference between treated and control districts. Treated are individuals in treated districts in the Western region, and control are individuals in the Eastern region. Standard errors clustered at the district level in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

4.1 Spillover Effects of Oil Extraction

Table 3 presents the estimated spillover effects of oil extraction on the outcomes of individuals in the immediate coastal districts. The columns report the difference-in-differences estimates for each outcome variable when a different set of covariates are used. Column (1) reports the model with no covariates, columns (2)-(3) present the estimates after accounting for demographic and socio-economic factors. We will refer to column (3) as the controlled baseline effect.

The results for the main specification (see column (3)) show that oil extraction has no statistical significant effect on income. However, we find a statistical significant effect on employment (likelihood of being employed) in non-oil sectors in the treated districts. On average, the new oil extraction marginally decreased the likelihood of employment by

Table 3: Spillover effect on income, employment and migration

	(1)	(2)	(3)
(1) Log of Monthly Income			
Districts × Post Oil	0.228**	0.296**	0.143
	(0.114)	(0.130)	(0.134)
Adjusted R^2	0.517	0.532	0.574
Mean of monthly income	4.443	4.439	4.443
Std dev. of monthly income	1.856	1.860	1.861
Wild t (p-value)	2.47 (0.03)	2.90 (0.03)	1.44 (0.260)
(2) Employment			
Districts × Post Oil	-0.107***	-0.111***	-0.116***
	(0.023)	(0.021)	(0.023)
Adjusted R^2	0.479	0.485	0.495
Mean of Employment	0.861	0.860	0.861
Std dev. of Employment	0.346	0.347	0.346
Wild t (p-value)	-6.02 (0.00)	-5.58 (0.00)	-5.80 (0.00)
Demographic controls	No	Yes	Yes
Socioeconomic controls	No	No	Yes
District level controls	Yes	Yes	Yes
Survey Year controls	Yes	Yes	Yes
Observation	4013	3971	3919

Note: The demographic controls include dummies for ethnic composition and marital status, whereas socio-economic controls include age and square of age, parental completed years of education, own completed years of education and dummy for household head status. Standard errors clustered at the district level in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

0.12 percentage points. The overall negative effect on employment may be due to both micro and macroeconomic factors that are likely to affect various sectors of the economy.

While we observe some minor differences in the difference-in-differences estimates across the different specifications, the estimates are qualitatively similar. We also obtained better goodness of fit and efficiency gains, viz-a-viz robust standard errors using the wild bootstrap p-values for each estimation (Cameron et al. 2008, MacKinnon & Webb 2018, Canay et al. 2019, Roodman et al. 2019).

The income variable measured does not account for inflation over time. Given the possibility of rising prices due to the economic boom, there is a likelihood that the income variable may be mainly due to rising local prices (Aragón & Rud 2013, Ampofo 2019). To address this issue, we thus control for inflation, and Table 4 presents the results from this estimation. While controlling for inflation has affected the size of the spillover effects, we still find no statistical significant impact on income.

Table 4: Spillover effect on real income

	(1)	(2)	(3)
Districts × Post Oil	0.168**	0.191**	0.038
	(0.080)	(0.089)	(0.087)
Adjusted R^2	0.557	0.575	0.622
Mean of real monthly income	4.403	4.399	4.403
Std dev. of real monthly income	1.683	1.685	1.686
Wild t (p-value)	2.10 (0.04)	2.18 (0.03)	0.49 (0.66)
Demographic controls	No	Yes	Yes
Socioeconomic controls	No	No	Yes
District level controls	Yes	Yes	Yes
Survey Year controls	Yes	Yes	Yes
Observation	4013	3971	3919

Note: Outcomes are for non-oil sectors. The year 2006 is considered the period after oil discovery and extraction. The regressions include the complete set of covariates; demographic and socio-economic controls. Bootstrapped Standard errors clustered at the district level in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

4.2 Heterogeneous effects

The above results reflect the overall impact of oil extraction and may not reflect the heterogeneity across gender and sectors. To address this issue, we examine the spillover effects across migration status, gender, and sector of workers.

4.2.1 Migration status

There is a possibility that the spillover effect from oil extraction may vary depending on the migration status of individuals in the treated districts (Gittings & Roach 2020, Guettabi & James 2020). We examine this possibility by undertaking a sub-sample analysis. Table 5 presents the spillover effects on income and employment for migrants and non-migrants. We find borderline statistical significant gains in income for migrants (column 1) but no statistical significant income gain for the local residents (column 2). Moreover, we see that non-migrant residents have a higher likelihood of being unemployed compared to migrants. These findings suggest that migrants have a relatively higher likelihood of being employed given certain unexplained qualities.

Table 5: Spillover effect on income and employment

	Income		Employment	
	Migrant	Non-migrant	Migrant	Non-migrant
Districts × Post Oil	0.258*	0.128	-0.110***	-0.142***
	(0.157)	(0.203)	(0.032)	(0.030)
Adjusted R^2	0.567	0.566	0.461	0.452
Mean of Y	4.439	4.559	0.855	0.855
Std dev. of Y	1.906	1.908	0.352	0.352
Wild t/z (p-value)	2.16 (0.09)	0.97 (0.48)	-4.46 (0.00)	-5.12 (0.00)
Demographic controls	Yes	Yes	Yes	Yes
Socioeconomic controls	Yes	Yes	Yes	Yes
District level controls	Yes	Yes	Yes	Yes
Survey Year controls	Yes	Yes	Yes	Yes
Observation	2903	2486	2903	2486

Note: The demographic controls include dummies for ethnic composition and marital status, whereas socio-economic controls include age and square of age, parental completed years of education, own completed years of education and dummy for household head status. Standard errors clustered at the district level in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

4.2.2 Gender and sectoral variations

There is also a possibility that the spillover effect may differ for males and females and across different sectors of the economy (Kotsadam & Tolonen 2016). Regarding gender, men and women may react differently given their experience, education, commitment or inherent characteristics. Various sectors in the economy may also experience variations given the demand and supply of their products. Table 6 presents the results for the full sample and sub-sample based on migration status. Panel (1) presents the results for females, and panel (2) presents those for males. We find a statistical significant negative spillover effect on the income of female non-migrants but statistical significant income gains for male migrants. Moreover, the likelihood of unemployment is higher for males in general, but the highest effect is observed for male non-migrants. These findings show that the oil extraction have benefited more male migrants in the treated district. Clearly, our results show that migrants are more likely to have income gains in the treated districts compared to non-migrants. In addition, migrants are less likely to be unemployed compared to locals. These can be attributed to unobserved qualities of migrants in the oil extraction area.

Table 6: Spillover effect of oil extraction by gender

	Full Sample		Migrant		Non-migrant	
	Income	Employment	Income	Employment	Income	Employment
(1) Female						
Districts × Post Oil	-0.279**	-0.048	-0.186	-0.034	-0.394**	-0.092**
	(0.140)	(0.032)	(0.155)	(0.039)	(0.178)	(0.039)
Adjusted R^2	0.600	0.555	0.600	0.526	0.614	0.545
Mean of Y	4.390	0.861	4.358	0.852	4.526	0.852
Std dev. of Y	1.732	0.346	1.733	0.355	1.697	0.355
Wild t/z (p-value)	-2.15 (0.04)	-1.76(0.20)	-1.29 (0.32)	-1.06 (0.40)	-2.62 (0.01)	-2.69 (0.02)
Observations	3005	3005	1989	1989	1572	1572
(2) Male						
Districts × Post Oil	0.316**	-0.135***	0.433***	-0.130***	0.304	-0.157***
	(0.153)	(0.022)	(0.166)	(0.028)	(0.200)	(0.029)
Adjusted R^2	0.569	0.516	0.559	0.482	0.558	0.469
Mean of Y	4.407	0.870	4.386	0.867	4.530	0.869
Std dev. of Y	1.894	0.337	1.962	0.340	1.981	0.337
Wild t/z (p-value)	2.77 (0.01)	-6.22 (0.00)	3.15 (0.00)	-5.02 (0.00)	2.01 (0.15)	-5.49 (0.00)
Observations	3363	3363	2347	2347	1930	1930
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Regressions include the complete set of covariates. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 7 and 8 show the oil spillover effect on income and employment across sectors. We find positive spillovers on income of agricultural workers irrespective of their migration status. Additionally, we find that non-migrant Workers in other sectors experienced a negative spillover on their income. Moreover, the likelihood of employment was on the rise for only workers in the retail sector, with employment likelihood in agriculture and services reducing significantly. The opposing effects on income and employment in the agricultural sector may be attributed to a reduction in the size of workers in the sector. The boom in the oil sector makes it attractive for others, especially unproductive farmers, to re-skill in upstream and downstream operations related to oil production. The inability of most workers to keep up with the rising cost of production, due to its high labour intensive nature, has the possibility of driving them out of the sector. Addi-

Table 7: Spillover effect on Monthly income across sectors

	Agriculture	Construction	Manufacturing	Retail	Services
(1)Full Sample					
Districts × Post Oil	0.618***	-0.013	-0.382***	-0.229	-0.278**
	(0.190)	(0.186)	(0.113)	(0.256)	(0.130)
Adjusted R^2	0.551	0.600	0.598	0.601	0.610
Mean of Y	4.287	4.358	4.346	4.392	4.425
Std dev. of Y	1.906	1.755	1.749	1.746	1.738
Wild t/z (p-value)	4.23 (0.00)	-0.03 (0.97)	-2.12 (0.02)	-1.26 (0.22)	-2.20 (0.02)
Observations	2911	2505	2638	2745	2915
(2)Migrants					
Districts × Post Oil	0.759***	0.141	-0.250	-0.101	-0.167
	(0.268)	(0.327)	(0.195)	(0.210)	(0.139)
Adjusted R^2	0.529	0.599	0.597	0.602	0.615
Mean of Y	4.198	4.292	4.279	4.356	4.410
Std dev. of Y	1.990	1.771	1.759	1.755	1.743
Wild t/z (p-value)	4.38 (0.00)	0.33 (0.69)	-1.32 (0.13)	-0.52 (0.63)	-1.21 (0.18)
Observations	1895	1489	1622	1729	1899
(3)Non-Migrants					
Districts × Post Oil	0.616**	-0.193	-0.500**	-0.409**	-0.392***
	(0.259)	(0.315)	(0.198)	(0.206)	(0.130)
Adjusted R^2	0.531	0.622	0.616	0.618	0.633
Mean of Y	4.331	4.514	4.471	4.557	4.604
Std dev. of Y	2.039	1.740	1.731	1.717	1.699
Wild t/z (p-value)	3.26 (0.00)	-0.46 (0.66)	-2.61 (0.00)	-2.05 (0.07)	-2.75 (0.00)
Observations	1478	1072	1205	1312	1482

Note: Standard errors in parentheses. Regressions include the complete set of covariates. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively..

tionally, the increase in the number of retail sector workers could be due to an exodus of workers from the agriculture sector who may take advantage of the increased population to provide easy consumables in order to generate money within a short time.

4.2.3 Distributional variations

There are chances that the spillover effects may vary along the distribution of income. The existence of differences across the distribution will inform the welfare impact of the oil extraction for residence in the treated district. We investigate this by using Firpo et al. (2009)'s unconditional quantile estimation approach. The technique uses the Recentered Influence Function (RIF) approach to estimate quantiles of income. In addition, the approach accounts for not only the variation in the outcome variable but also that of the

Table 8: Spillover effect on employment likelihood across sectors

	Agriculture	Construction	Manufacturing	Retail	Services
(1)Full Sample					
Districts × Post Oil	-0.083***	-0.271	-0.019	0.101***	-0.251***
	(0.025)	(0.178)	(0.051)	(0.037)	(0.031)
Adjusted R^2	0.568	0.590	0.600	0.595	0.509
Mean of Y	0.864	0.873	0.867	0.865	0.879
Std dev. of Y	0.343	0.333	0.340	0.342	0.326
Wild t/z (p-value)	-3.24 (0.00)	-3.37 (0.11)	-0.54 (0.72)	2.81 (0.014)	-9.27 (0.00)
Observations	2911	2505	2638	2745	2915
(2)Migrants					
Districts × Post Oil	-0.069*	-0.248	-0.011	0.121***	-0.261***
	(0.038)	(0.191)	(0.043)	(0.043)	(0.035)
Adj R-Squared	0.544	0.573	0.591	0.584	0.463
Mean of Y	0.858	0.870	0.860	0.858	0.880
Std dev. of Y	0.350	0.337	0.347	0.349	0.325
Wild t/z (p-value)	-0.32 (0.04)	-2.95 (0.14)	-0.29 (0.82)	3.02 (0.00)	-8.32 (0.00)
Observations	1895	1489	1622	1729	1899
(3)Non-Migrants					
Districts × Post Oil	-0.110***	-0.343*	-0.053	0.040	-0.268***
	(0.035)	(0.192)	(0.041)	(0.042)	(0.035)
Adjusted R^2	0.564	0.620	0.631	0.620	0.437
Mean of Y	0.859	0.876	0.862	0.859	0.888
Std dev. of Y	0.349	0.330	0.345	0.348	0.315
Wild t/z (p-value)	-3.20 (0.01)	-3.36 (0.13)	-0.54 (0.67)	2.80 (0.014)	-9.43 (0.00)
Observations	1478	1072	1205	1312	1482

Note: Standard errors in parentheses. Regressions include the complete set of covariates. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

explanatory variables (Firpo et al. 2009).

Figure A.3 in the appendix presents the spillover estimates across the distribution of nominal and real monthly incomes. We present the estimate for the full sample, and separately for migrants and local residents in the treated district. We find positive spillover effects for individuals beyond the median monthly income. This is consistent across the population. In addition, no statistical significant difference exists between migrants and locals as all sub-samples share the same confidence bands. This finding indicates that individuals on low income were the least beneficiary of the oil extraction. Therefore, the oil extraction in the treated district increased the divide between the rich and poor, thus resulting in a negative welfare impact on individuals in the treated district.

5 Robustness checks

5.1 Alternative definition of Treated and Control districts

We check the robustness of our estimates by assigning treatment status to different districts in Ghana. There is a possibility that gains from oil extraction will affect the immediate districts in the Western region and other localities, especially the national capital of Ghana. This, to some extent, may affect the robustness of our estimate. Additionally, residents in major cities in Ghana may benefit from the gains given the possibility of developmental projects embarked on by the central government with rents from the oil leading to an increase in the outcome measures. To ensure that this is not the case, we restrict the intervention to residents in the regional capital of the Western region (Sekondi-Takoradi) and use residents in the national capital, Accra, as an alternative control group. The reason is that Accra is home to various economic activities, and it is the most developed city in Ghana, as observed in the trend in nightlight luminosity (See Figure 2). The estimates presented in Table 9 show that the spillover effects on income are positive and significant in the regional capital of the treated district (Sekondi-Takoradi), indicating that the income growth was higher in the regional capital of the Western region. Surprisingly, the income of locals were higher, indicating that the gains from the oil extraction had a significant impact on local residents in the regional capital. The possible explanation for such finding may be the embarking of developmental projects by the local council in the regional capital with oil rents gained from the extraction. This has a higher possibility of impacting the income of local residents as they stand a higher chance of gaining local government contracts than migrants.

As a further robustness check of our estimates, we use residents in other regions in Ghana as control and false treatment groups. The Western region may also be similar to other regions in southern Ghana based on characteristics– such as co-ethnics, linguistic similarity, or other forms of economic activity as observed in Table A.1. It is, therefore,

Table 9: Oil effect at regional capitals

	Full Sample		Migrant		Non-migrant	
	Income	Employment	Income	Employment	Income	Employment
Districts × Post Oil	1.238**	-0.027	0.281	-0.187***	2.450**	0.283**
	(0.531)	(0.066)	(0.615)	(0.064)	(1.003)	(0.124)
Adjusted R^2	0.524	0.181	0.543	0.231	0.521	0.168
Wild t/z (p-value)	5.15 (0.00)	-0.41 (0.66)	0.83 (0.83)	-2.13(0.01)	5.58 (0.00)	2.42 (0.04)
Observations	1955	1955	588	588	1367	1367
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: Sekondi-Takoradi is the capital city of the Western region. Control group is Accra which is regional and national capital of Greater Accra and Ghana. Bootstrapped Standard errors, clustered at the district level, in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

useful to examine the robustness of our spillover estimates to different control groups.

We use residents in districts in the Ashanti region as a control group for the reason that residents share similar language and the majority in the region belong to the same ethnic group, Akan (see Table A.6 in the Appendix).[6] We also use districts in the Volta region as a control group given they are on the coast and have similar economic activity; fishing, comparable to residents in the coast of the Western region. The expectation is that significant oil spillover effects will still be identified even when different control groups are assigned. The results are reported in Panels 1-2 of Table 10 and the estimates are similar to the baseline findings (Table 3).

We further examine the robustness of our estimates by using as control, all regions assigned weights by the Synthetic Control Approach (SCA) of Abadie et al. (2010). The essence of this approach is to do away with the arbitrariness in choosing the most comparable control individuals for the treated sample. The technique uses a data-driven approach to reduce the mean squared errors in selecting a comparable control group by estimating the weights for each region using the indicators in Table A.1. It is required that we have panel data of individuals in order to undertake the SCA. Given that the GLSS is a cross-sectional survey, we aggregate the data into regions and compute similarities, shown as weights, using data before the oil extraction[7]. It is worth emphasising that

[6]See Easterly & Levine (1997) for the role of ethnicity in ensuring development.
[7]See Table A.3 in the appendix for estimated weights using the approach by Abadie et al. (2010)

the weights estimated from the approach are not used in the difference-in-differences estimation. Table 10 (Panel 3) shows the estimates to be consistent with the baseline findings. Interestingly, the income gains are the same for migrants and non-migrants. However, the gains are more pronounced for the former.[8]

To further examine the presence of economic shocks other than the new oil extraction, we assign placebo (false) treatment to districts in Ashanti, keeping districts in Eastern and Greater Accra regions as the control group. The estimates of the placebo test are shown in Panel 4 of Table 10. All other estimates are not significantly different from zero, thus validating the use of immediate coastal districts as a treated group.

5.2 Further robustness checks

We test for further robustness of our estimates by accounting for omitted variable bias in our model using the approach by Oster (2019). Table A.5 in the appendix presents the estimates for our test. We find that the included covariates have sufficient explanatory power to balance any potential bias due to unobserved confounding factors in our model.[9]

6 Discussion of results

We study the spillover effects of oil extraction on non-oil sector income and employment in districts closest to oil extraction areas in Ghana. For residents living close to oil extraction, we find no statistical significant effect on non-oil sector income in general but greater income gains for local residents in the regional capital. However, we find mixed effects across gender and sectors. Specifically, we find male migrants to have experienced a statistical significant income spillover effect. Furthermore, differences across income

[8]We undertake further robustness checks by including the survey month variable to account for any seasonality in employment and income and household size to account for any restrictions with regards to working hours. See Table A.4 in the appendix. We find our results to be robust to these inclusions.

[9]See section 8 in the appendix for estimation approach used and assumptions.

Table 10: Using alternative treated and control groups

	Full Sample		Migrant		Non-migrant	
	Income	Employment	Income	Employment	Income	Employment
(1) Control: Ashanti						
Districts × Post Oil	0.187*	-0.043*	0.012	-0.111***	0.392**	0.049
	(0.102)	(0.0244)	(0.130)	(0.0317)	(0.164)	(0.038)
Adjusted R^2	0.498	0.177	0.523	0.188	0.473	0.184
Wild t/z (p-value)	2.11 (0.06)	-0.200 (0.06)	0.11 (0.92)	-3.84(0.00)	2.71 (0.03)	1.56 (0.19)
Observations	4865	4865	2835	2835	2030	2030
(2) Control: Volta						
Districts × Post Oil	0.163	-0.062**	0.189	-0.106**	0.225	0.036
	(0.127)	(0.029)	(0.155)	(0.047)	(0.199)	(0.042)
Adjusted R^2	0.487	0.193	0.491	0.181	0.483	0.214
Wild t/z (p-value)	1.40 (0.17)	-2.16 (0.01)	1.25 (0.23)	-1.95(0.05)	1.18 (0.25)	0.86 (0.45)
Observations	3623	3623	2263	2263	1360	1360
(3) Control: SCA regions						
Districts × Post Oil	0.269***	-0.089***	0.251**	-0.098***	0.251*	-0.066**
	(0.086)	(0.018)	(0.126)	(0.024)	(0.138)	(0.027)
Adjusted R^2	0.573	0.538	0.575	0.512	0.566	0.599
Wild t/z (p-value)	3.08 (0.03)	-3.76 (0.08)	2.13 (0.18)	-3.19(0.18)	1.48 (0.18)	-1.95 (0.15)
Observations	15117	15117	7969	7969	7148	7148
(4) Treatment:Ashanti						
Districts × Post Oil	0.346	0.007	0.351	0.007	0.302	-0.008
	(0.215)	(0.037)	(0.235)	(0.044)	(0.234)	(0.035)
Adjusted R^2	0.492	0.188	0.526	0.222	0.462	0.152
Wild t/z (p-value)	2.04 (0.13)	2.56 (0.80)	1.77 (0.17)	0.18(0.87)	1.55 (0.18)	-1.30 (0.76)
Observations	9,104	9,104	4,301	4,301	4,803	4,803
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: In panels 1 and 2, districts in the Ashanti and Volta regions are used as control samples, whereas in panel 3, districts in regions assigned weights by the SCA are used as a control group. The regions in the control group include Ashanti, Brong Ahafo, Eastern, Greater Accra and Volta. In panel 4 we assigned placebo treatment to districts in Ashanti and used Eastern as a control group. Standard errors clustered at the district level in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

distribution also exist, with individuals below the median income level experiencing negative income gains. In addition, the likelihood of employment in the non-oil sector in the treated districts is in general low, while it is high for the retail sector, especially for migrants.

The key findings in this paper are in line with earlier studies in the natural resource literature. Michaels (2011) finds an increase in income in all sectors and employment in the manufacturing sector for the southern part of the United States, which is known to be predominately an agrarian economy but endowed with oil. The study attributes the increase in employment to a rise in demand for unskilled labour (as some sectors tend to cut down on costs by replacing highly skilled workers with unskilled ones). Black et al. (2005) estimate the spillover effect of coal mining in the United States and find an increase in income for all sectors but no growth in employment in other sectors. They have attributed the stagnant growth in employment to the high-income growth in those sectors (which makes it difficult for other job seekers to penetrate the workforce). In a recent study, Jacobsen et al. (2021) examine the impact of U.S oil booms and busts on individual households and find positive effects during booms and negative effects during a bust. The study finds an overall negative effect of the oil booms as it failed to generate lifetime income. Gittings & Roach (2020) and Guettabi & James (2020) find that labour market gains from shale booms in Marcellus and Utica, and oil booms in North Slope Borough of Alaska go to migrants or residents in other states, rather than locals. For developing economies, Mamo et al. (2019) find a positive effect of mines discovery on the level of economic activity in Sub-Saharan African economies but find no significant spillover effect. Kotsadam & Tolonen (2016) examine the effect of mines discovery on women employment in Africa and find women to move from the agriculture sector to either the service sector or out of employment.

These findings indicate that natural resources do affect local labour market outcomes.

In our study, the increased likelihood of employment in retail was partly due to an increase in highly skilled migrants with entrepreneurial skills (Guettabi & James 2020). The fall in employment in the agriculture sector may indicate a move towards an innovative economy. The Ghanaian economy has been known to be primarily agrarian in the past. With a gradual shift towards self-employment, there is a higher chance the economy will move towards a more developed face with oil extraction. Moreover, the drop in agriculture employment can be an increase in enrollment for various training in the oil sector. The oil extraction serves as an opportunity for individuals to be skilled in upstream and downstream oil sector careers (Obeng-Odoom 2013).

We note that agriculture income increased due to increased demand for agriculture products and a fall in total productivity leading to a crowding out of small-scale and subsistence farmers. Manufacturing sector income instead had a contraction mainly due to an increased demand for foreign goods. Increased demand for imports has been a challenge for manufacturing firms in Ghana, and especially firms in the treated districts[10]. This demand for foreign goods led to an increase in local trade for such products, leading to an employment increase in the retail sector.

Given that oil extraction is off-shore, we believe the magnitude of the spillover effect will have been larger, especially for the construction sector if extraction was on-shore. More importantly, with discoveries of oil and gas fields in 2017 and the implementation of the Local content bill in 2014, which requires all foreign firms to have a percentage of local workers, the government's goal of ensuring the gains is beneficial to all citizens may be realised. The expectation has seen people enrolled in training and skill development not only in oil but also in other sectors of the economy (Obeng-Odoom 2013). Also, the local leadership of towns and cities in the Western region plan to embark on several policies to improve the lives of residents in the region. This will play a significant role in ensuring more remarkable development for all residents in different sectors of the economy. However, the existing extraction and discoveries off the coast in the Western region set to deepen the disparities within the western region. The boom serves as an avenue for the rich to keep amassing wealth at the expense of the poor. This could further widen inequality in society.

To put our estimates within a time frame, the estimated effects from our study can be considered as a short- to medium-term impact of oil extraction. In comparison to the recent study by Jacobsen et al. (2021) who examined the long-term impact of oil boom on households between 1975-2012, our study focused on the impact of oil extraction just three years after production. This is largely due to the absence of extended data.

[10]See WITS (2018) for more details.

Nonetheless, our findings are similar to Guettabi & James (2020) who found migrants or non-local residents to be beneficiaries of the oil booms in Alaska within a short- to medium-term.

The study, however, is limited. With the available data, the spillover effects are not as expected, for example, the effects in the construction sector. The availability of annual panel data from the time of oil discovery to post-extraction would have made it possible to examine how individuals reacted to such information and how it affected various economic activities, as can be seen in the movement of the night light radiance over the years and possible estimation of long term effects.

7 Conclusions

The study investigates the spillover effect of oil extraction on income and employment of non-oil sector workers and migration into areas close to oil deposits in Ghana. The results show a positive spillover effect on income and migration but a negative effect on employment. In addition, heterogeneous spillover effects are observed across gender, sector of the residents, and proximity to the oil extraction area.

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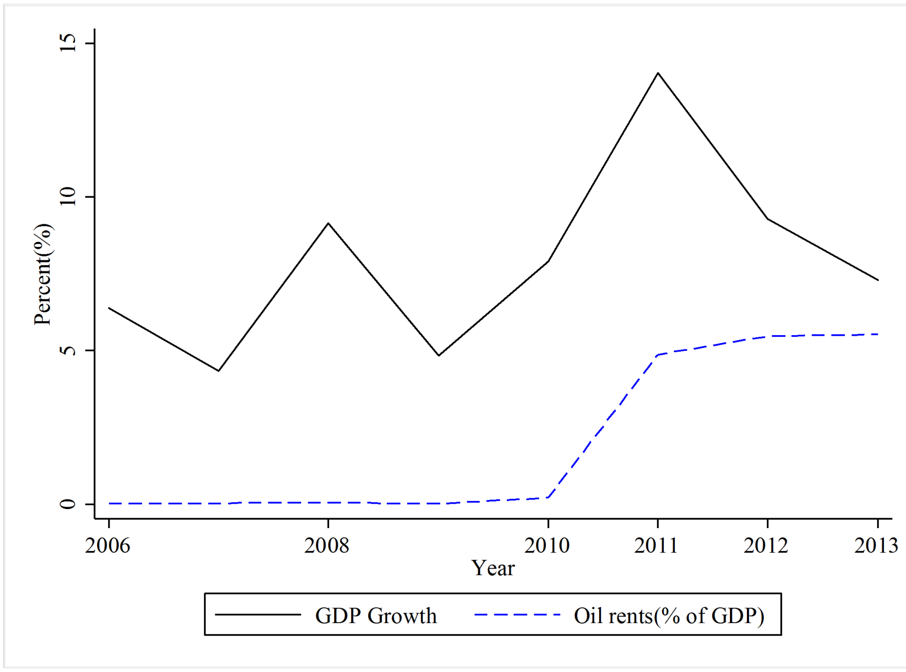
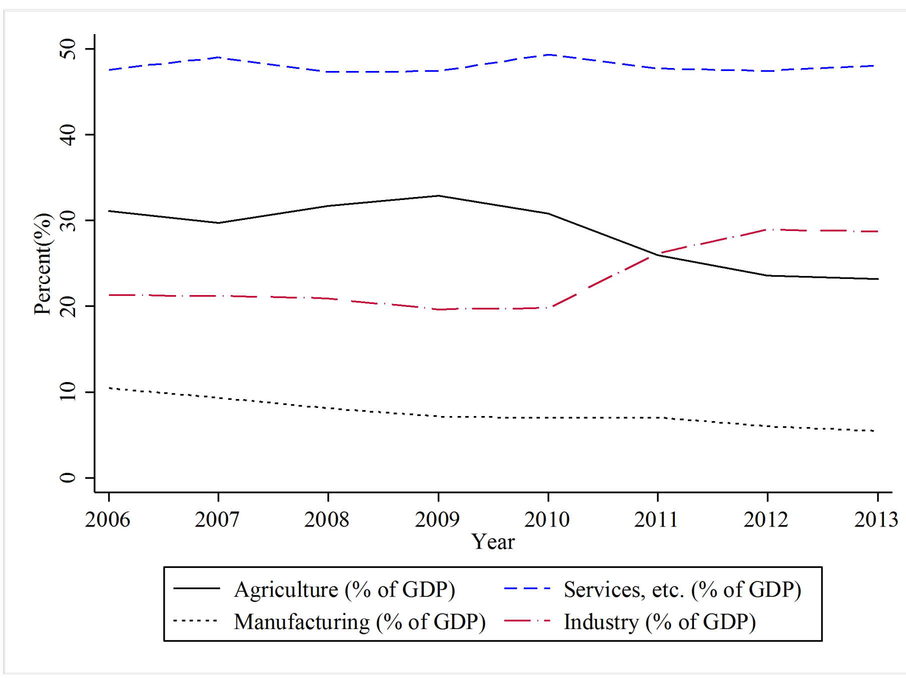
Appendix

Figure A.1: An Outlook of the Ghanaian Economy

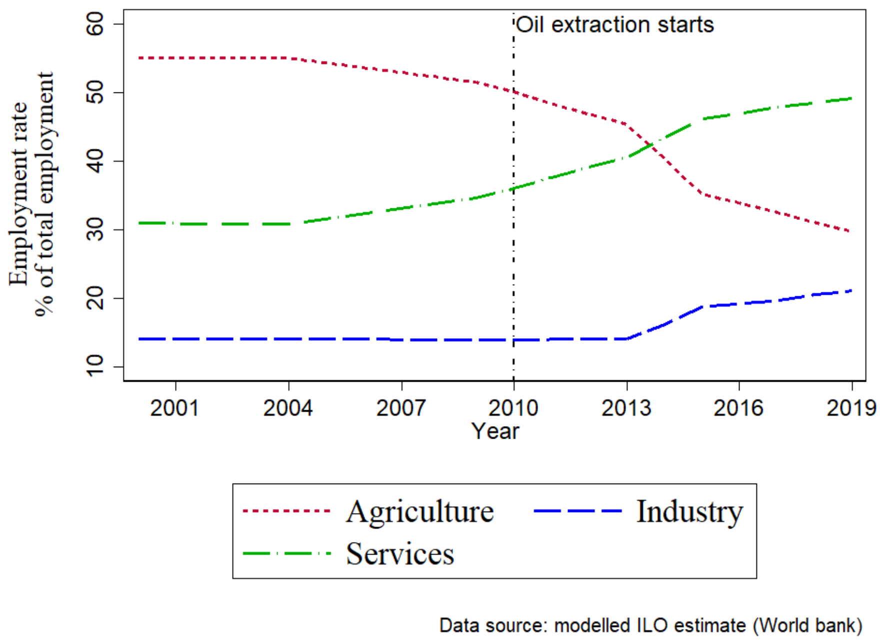


(a) GDP Growth and Oil rent Share

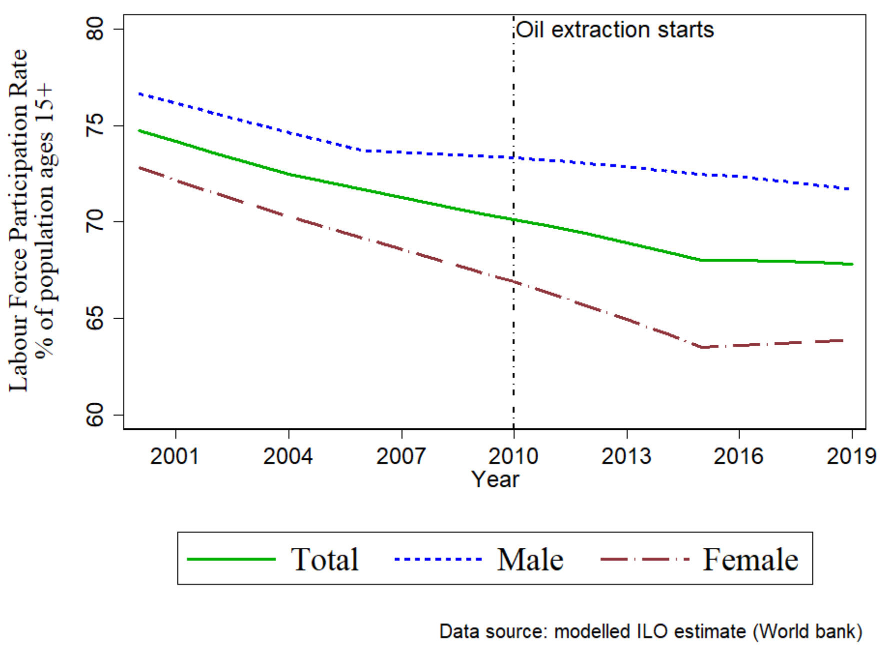


(b) Sector Share of GDP

Figure A.2: Employment and Labour force participation

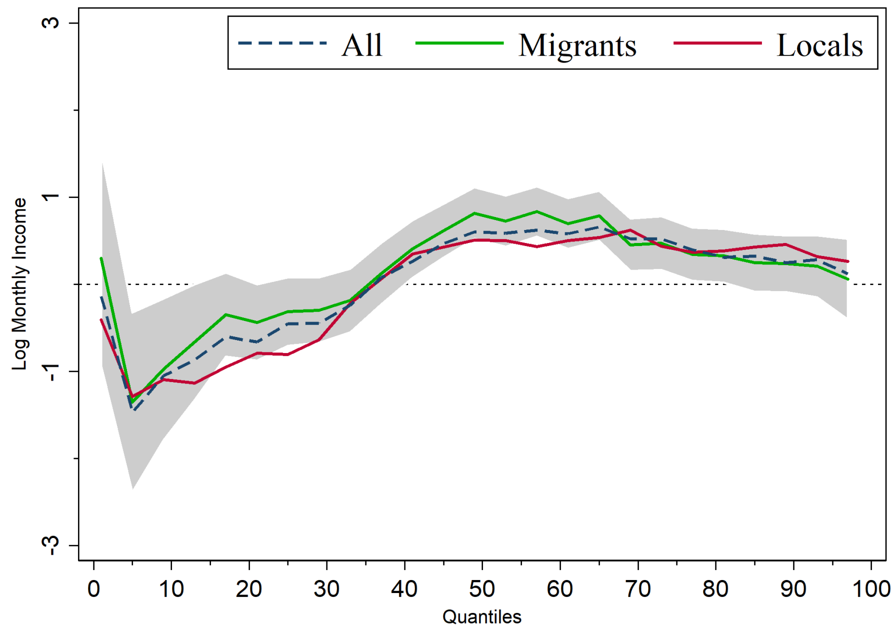


(a) Employment across sectors

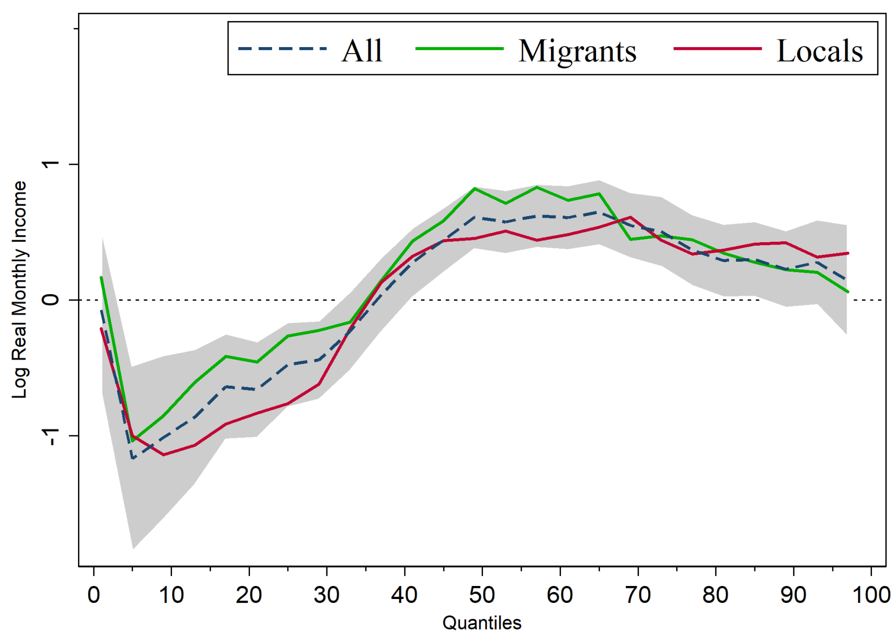


(b) Labour force participation rate

Figure A.3: Quantile estimates of spillover effects on monthly income



(a) Nominal monthly income



(b) Real monthly income

Table A.1: Key indicators of regions in Ghana

Indicators	Western	Eastern	Greater Accra	Central	Volta	Ashanti	Brong Ahafo	Northern	Upper East	Upper West
Pre-Oil extraction										
Mean household income (Ghc)	1,222	1,145	1,529	1,310	913	1,149	1,202	1,452	616	606
Sources of Household income (%)										
Wage	24.3	21.1	56.6	27.2	17.2	26.5	19.8	10.4	11.0	20.1
Agricultural	45.1	42.4	5.0	37.7	40.4	20.9	56.5	68.5	56.9	50.1
Sel-employment	21.1	28.1	24.3	26.1	29.9	34.3	15.5	13.8	26.1	20.8
Other	9.4	8.4	14.2	9.0	12.5	18.3	8.2	7.3	6.0	9.0
Mean household expenditure (Ghc)	393	379	544	464	272	410	443	296	124	106
In Migration (%)	7.4	20.2	38.7	22.7	7.9	25.9	9.7	11.3	6.7	6.1
Proportion of educated adults (%)	78.0	77.0	88.5	78.1	72.3	80.6	68.9	28.0	30.9	29.9
Mean Household size	3.9	3.7	3.4	3.6	4.0	3.9	4.1	5.5	5.3	6.5
Post-Oil extraction										
Mean household income (Ghc)	9,529	7,838	13,303	8,133	8,217	9,489	8,154	7,153	6,210	5,991
Sources of household income (%)										
Wage	25.2	22.4	27.2	59.7	16.6	39.8	31.7	8.5	24.4	23.3
Agricultural	11.1	30.8	7.5	6.6	7.6	4.1	11.9	31.8	14.4	4.6
Sel-employment	43.6	33.4	51.2	22.1	39.8	43.2	35.0	33.2	19.9	57.7
Other	20.1	13.4	14.1	11.6	54.7	12.9	21.4	26.5	41.3	14.4
Mean Household expenditure (Ghc)	3,119	2,555	4,875	2,825	2,508	3,318	2,511	1,790	1,753	1,476
In Migration (%)	11.1	11.3	38.9	24.3	15.6	10.8	18.5	5.8	5.4	4.6
Proportion of educated adults (%)	84.3	83.9	90.4	79.1	74.1	84.7	72.7	38.2	50.4	51.7
Mean Household size	4.0	4.1	3.8	3.8	4.3	3.7	4.3	5.4	4.5	5.5

Notes: Figures are from GLSS 4-6 (1998,2006 and 2013) reports by GSS.

Table A.2: Descriptive Statistics

	(1)	(2)	(3)
		Sample	
	Full	Pre-oil	Post-oil
Monthly income	4.860	3.718	5.333
	(1.739)	(1.835)	(1.457)
Employment	0.851	0.685	0.892
	(0.356)	(0.467)	(0.312)
Migration	0.454	0.546	0.448
	(0.499)	(0.500)	(0.499)
Age	36.30	38.35	35.49
	(10.95)	(11.72)	(10.58)
$Age^2/100$	14.37	16.07	13.71
	(9.224)	(10.47)	(8.613)
Head of Household	0.758	0.889	0.695
	(0.429)	(0.316)	(0.462)
Married	0.677	0.694	0.655
	(0.469)	(0.463)	(0.476)
Education(yrs)	8.825	8.241	8.995
	(3.028)	(3.010)	(3.012)
Father's education(yrs)	5.052	6.389	4.325
	(4.959)	(3.533)	(5.330)
Mother's education(yrs)	3.636	5.787	2.665
	(4.237)	(3.079)	(4.349)

Table A.3: Region with weights

Regions	Weights
Ashanti	0.246
Brong Ahafo	0.181
Central	0
Eastern	0.313
Greater Accra	0.083
Northern	0
Upper East	0
Upper West	0
Volta	0.177

Note Weights are computed using the Synthetic Control Approach of Abadie et al. (2010). These weights are assigned based on the socio-economic indicators in the reports of the 1998, 2006 and 2013 GLSS surveys.

Table A.4: Spillover effect on income and employment: inclusion of further controls

	Migrants				Non-Migrants			
	Income		Employment		Income		Employment	
Districts × Post Oil	0.253	0.304*	-0.110***	-0.087***	0.127	0.175	-0.142***	-0.140***
	(0.156)	(0.162)	(0.032)	(0.031)	(0.201)	(0.210)	(0.030)	(0.030)
Household size	0.027**	0.026**	-0.001	-0.001	0.048***	0.048***	0.002	0.002
	(0.012)	(0.012)	(0.002)	(0.002)	(0.014)	(0.014)	(0.003)	(0.003)
Adjusted R^2	0.568	0.570	0.461	0.474	0.568	0.569	0.452	0.459
Mean of Y	4.439	4.439	0.855	0.855	4.559	4.559	0.855	0.855
Std dev. of Y	1.906	1.906	0.352	0.352	1.908	1.908	0.352	0.352
Month of Survey effects	No	Yes	No	Yes	No	Yes	No	Yes
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey Year controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2903	2903	2903	2903	2486	2486	2486	2486

Note: The demographic controls include dummies for ethnic composition and marital status, whereas socio-economic controls include age and square of age, parental completed years of education, own completed years of education and dummy for household head status. Standard errors clustered at the district level in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

8 Further Robustness checks

8.1 Assessing stability of the spillover effects

Identifying the estimated spillover effects on our outcome variables above is based on the difference-in-differences strategy with the inclusion of covariates. However, there is a possibility that the covariates included in the estimation may not be sufficient in capturing unobserved individual heterogeneity in the sample. This possibility will result in biased estimates of the oil spillover effect. Econometric techniques have been developed in recent years (see Oster 2019) to evaluate the importance of these confounding factors. To assess the robustness of our estimates to omitted variable bias, we follow the methodology of Oster (2019). This approach makes full adjustment to the estimates after the inclusion of controls by exploiting the movements and changes in the coefficients and the R-squared of the model to compute bounding values for the spillover effect.[11] The approach first estimates the degree of proportionality, delta (δ), between observables and unobservables and utilises the degree of proportionality to examine the direction of bias. $\delta = 1$ means that unobservables are as important as covariates in the model, whereas $\delta < 1$ means unobservables are less important in estimating the spillover effect than the included controls. The maximum R-squared, R_{max}, is the total variation in the model after accounting for observables and unobservables. $R_{max} = 1$ means there is no error in the model. To estimate the bias-corrected spillover effects, we first set $R_{max} = 1.3R^2$ and equates δ to the estimated delta value after the inclusion of controls. We then set $\delta = 1$ and $R_{max} = 1.3R^2$ to assume unobservables and observables have the same importance in the model. The next correction sets $\delta = 1$ and $R_{max} = 1$ to assume there are no errors in the model. We bootstrap the model to estimate standard errors for the bias-corrected spillover effects. The Significantly high spillover impact on income and employment may be seen as the highest and lowest bounds of the spillover estimates. Moreover, delta is observed not to have significant importance on the model and the assumption of $\delta = 1$ may be an upper bound of the delta value.

Table A.5 presents the bias-corrected estimates. Column 1 presents the baseline estimates. Column 2 reports the estimated level of proportionality. Columns 3-5 present the bias-corrected estimates for the various specifications. We observe that the degree of proportionality of observed to unobserved variables in the model is less than 1 (i.e. $\hat{\delta} < 1$), indicating smaller importance of unobservables in influencing the stability of the spillover estimates after the inclusion of covariates. For each outcome variable, the bias-corrected spillover effect (column 3), $\tilde{\beta}$, is fairly similar in magnitude to the controlled baseline effect, $\hat{\beta}$. This suggests that the included covariates have sufficient explanatory power to balance any potential bias due to unobserved confounding factors. The spillover effect on income increases significantly when $\delta = 1$ (column 4), but the effect on the likelihood of employment decreases significantly when $R_{max} = 1$ (column 5). Nonetheless, the direction of the effects is the same as the baseline indicating stability in our spillover estimates.

[11] See Oster (2019) on the computation of the bias-corrected estimates. Stata user-written command *PSACALC* is used in estimating biased corrected estimates.

Table A.5: Omitted factor bias correction

Outcomes	**Controlled, $\hat{\beta}_3$**	**Delta, δ**	**Corrected, $\tilde{\beta}_3$**		
			δ, $R_{max} = 1.3R^2$	δ=1, $R_{max} = 1.3R^2$	δ=1, $R_{max} = 1$
(1) Full Sample					
Log Monthly income	0.143	0.026	0.085	3.612***	2.619***
Employment	-0.116***	-0.237	-0.066***	-0.804***	-4.812***
(1) Migrants					
Log Monthly income	0.258*	0.034	0.156	3.055***	2.506***
Employment	-0.110***	-0.145	-0.070***	-1.01***	-5.88***
(1) Non-Migrants					
Log Monthly income	0.128	0.034	0.076	2.834***	2.388***
Employment	-0.142***	-0.145	-0.090***	-1.09***	-5.623***

Note: Controlled effects are baseline estimates with controls. Delta,δ is computed by following Oster (2019) and it indicates how important observables are to unobservables. If $\delta = 1$ it shows unobservables are equally as important as observables whereas if $\delta > 1$ it indicates unobservables are more important than observables. R_{max} shows the maximum R^2 for our model. We present three bias-Corrected effects; observed δ and $R_{max} = 1.3R^2$, $\delta = 1$ and $R_{max} = 1.3R^2$, and $\delta = 1$ and $R_{max} = 1$. ***,** and * indicate significance at 1%, 5% and 10% levels, respectively.

Table A.6: Ethnic Distribution

	Akan		Ga-Adamgbe		Ewe		Guan		Dagbani		Others		Total	
	N	%	N	%	N	%	N	%	N	%	N		N	%
Western	1961	81.54	86	3.576	146	6.071	35	1.455	108	4.491	69	2.869	2405	100
Central	1499	84.74	46	2.600	107	6.049	67	3.787	18	1.018	32	1.809	1769	100
Greater Accra	1282	38.93	980	29.76	653	19.83	88	2.672	158	4.798	132	4.009	3293	100
Volta	51	2.739	28	1.504	1445	77.60	231	12.41	12	0.644	95	5.102	1862	100
Eastern	1626	57.86	504	17.94	422	15.02	127	4.520	49	1.744	82	2.918	2810	100
Ashanti	2885	84.11	37	1.079	119	3.469	45	1.312	163	4.752	181	5.277	3430	100
Brong Ahafo	1073	71.49	27	1.799	66	4.397	58	3.864	138	9.194	139	9.260	1501	100
Northern	20	3.378	7	1.182	25	4.223	59	9.966	355	59.97	126	21.28	592	100
Upper East	11	2.564	1	0.233	3	0.699	2	0.466	292	68.07	120	27.97	429	100
Upper West	20	5.362	4	1.072	4	1.072	7	1.877	247	66.22	91	24.40	373	100
Total	10428	56.48	1720	9.315	2990	16.19	719	3.894	1540	8.341	1067	5.779	18464	100

Table A.7: Proportion of Workers

	Male	Female	Total
Agriculture	4,737	1,339	6,076
Construction	629	113	742
Manufacturing	1,156	940	2,096
Retail Services	1,212	2,432	3,644
Other Services	2,271	3,928	6,199

Table A.8: Proportion of Origin of Migrants in treated districts

	Sample	Male	Female
Ashanti	4.76	4.93	4.46
Brong Ahafo	0.91	1.11	0.56
Central	11.74	11.61	11.98
Eastern	1.52	1.75	1.11
Greater Accra	12.04	12.72	10.86
Northern	1.21	1.43	0.84
Upper East	24.90	23.69	27.02
Upper West	0.20	0.32	0.00
Volta	3.44	4.29	1.95
Western	39.27	38.16	41.23